

# North Coast Rehabilitation Project

## Laguna and Majors Creeks Diversion Facilities

Prepared for:

Santa Cruz Water Department



November 18, 2002

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## INTRODUCTION

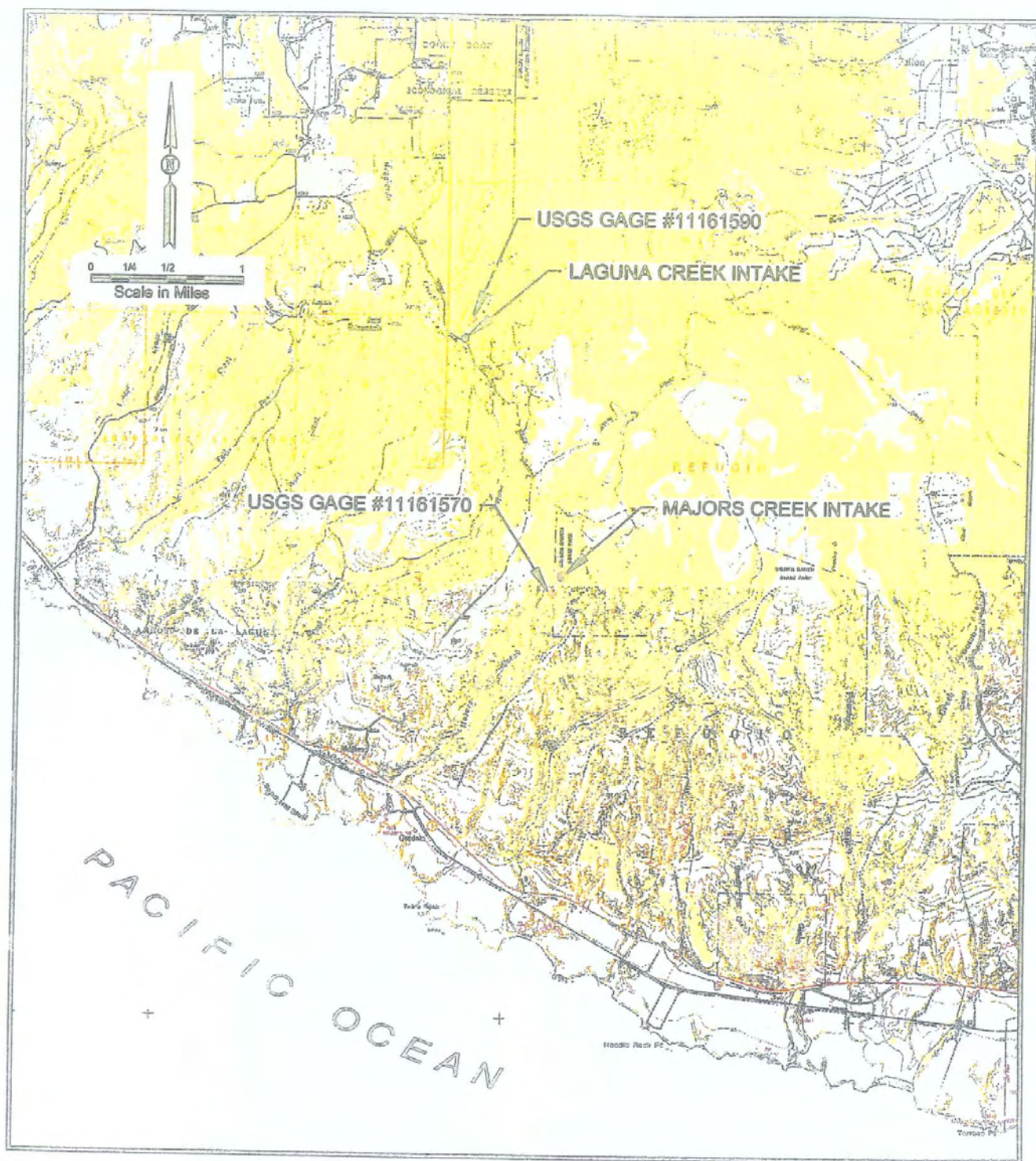
### Project Location

The Santa Cruz Water Department's (SCWD) North Coast system consists of surface water diversions from three coastal streams and a natural spring located approximately six to eight miles northwest of downtown Santa Cruz. The existing Majors Creek and Laguna Creek diversion facilities are located in Santa Cruz County, and are components of SCWD's overall surface water supply. More specifically, the Majors Creek diversion is located within the SE  $\frac{1}{4}$  of Section 6, Township 11 S, Range 2 W, MDB&M, and the Laguna Creek diversion is located within the NW  $\frac{1}{4}$  of Section 31, Township 10 S, Range 2 W, MDB&M. The Majors Creek diversion is located on Major's Creek approximately 2.2 miles upstream of the Pacific Ocean. The Laguna Creek diversion is located on Laguna Creek approximately 0.1 mile upstream of the confluence with Reggiardo Creek and approximately 4.0 miles upstream of the Pacific Ocean. Both facilities span the entire stream channel of the respective creeks as presented on Figure 1.

The Majors Creek diversion was originally constructed in 1878, and relocated upstream in 1924. The Laguna Creek diversion was originally constructed in 1880. The facilities are owned, operated, and maintained by SCWD. The areas surrounding the project sites consist of Wilder Ranch State Park property, riparian sequoia forest, and low-density residential development.

### Project Background

The Majors Creek and Laguna Creek diversion facilities are two of four surface water collection/diversion sources supplying raw water to SCWD's North Coast water supply system. SCWD's North Coast system dates back to the 1880's. The system relies entirely on rainfall runoff and groundwater infiltration to furnish approximately 15-35% of SCWD's overall water production (over a period of record from 1985 to 1999). Each collection/diversion facility diverts and conveys water from its respective stream or tributary



VICINITY MAP

IN: LAGUNA AND MAJORS CREEKS  
 AT: WHERE SHOWN  
 COUNTY OF: SANTA CRUZ  
 STATE: CA

**MAJORS AND LAGUNA CREEKS  
 DIVERSION FACILITIES  
 SANTA CRUZ WATER DEPARTMENT  
 PIPELINE REHABILITATION PROJECT**

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to the main North Coast transmission pipeline, which subsequently delivers the water to pumping, storage, and treatment facilities.

The present-day Majors Creek diversion was constructed in 1924, and consists of a reinforced concrete weir and screened intake structure; two debris/sediment control bypasses with pneumatically-operated gate valves; a pneumatically-operated diversion control valve and propeller-type flowmeter; and an existing control building, formerly used as a chlorine-injection facility to decontaminate water for intermediate coastal customers upstream of SCWD's main water treatment efforts. The diversion directs surface water to the Majors Creek pipeline, which consists of approximately 8,000 feet of 12-inch-diameter ductile iron transmission piping. The Laguna Creek diversion was constructed in 1880, and consists of a concrete and limestone weir; a reinforced concrete intake structure and debris screen; two debris/sediment control bypasses with pneumatically-operated gate valves; a pneumatically-operated diversion control valve and propeller-type flowmeter; and an existing control building, formerly used as a chlorine-injection facility. The diversion directs surface water into the Laguna Creek pipeline, which consists of approximately 20,000 feet of 14-inch-diameter steel transmission piping. Both facilities divert water from the respective streams via gravity to SCWD's River Street Booster Pump Station and ultimately to the Graham Hill Treatment Plant.

SCWD implemented a water survey in 1995, to comply with the requirements of its Surface Water Treatment Rule. In addition, SCWD formed a Management Technical Advisory Task Force in 1999, to oversee preparing a comprehensive Watershed Resources Management Plan. The overall goals of the plan are to preserve and maintain source water quality, quantity, and safety at an affordable rate to the consumer. SCWD follows a variety of procedures and routines to conduct water supply efforts in the most efficient manner. In order of priority, the sources are managed to maintain high water quality while minimizing costs.

Since the North Coast system is the most cost-effective source of all SCWD's water production efforts, SCWD must continue to maximize the use of these resources to the greatest extent possible. The North Coast system is an invaluable contributor of SCWD's overall water supply program, and as demand is projected to increase, SCWD must continue to rely on its current water production facilities. Continued utilization of the North Coast system is imperative to SCWD's operations.

### **Purpose of Alternative Development**

The primary purpose of this report is to identify existing facility deficiencies and to propose permanent modifications that will maintain sediment transport through the impoundments at the existing diversion structures. In addition, modifications are identified that enhance fish protection provisions for non-anadromous game fish at the intakes of the diversion structures. This report delineates modifications to the existing surface water diversion components of SCWD's Majors Creek and Laguna Creek diversion facilities as necessary to fulfill the requirements of SCWD's objectives. The diversion modifications addressed in this report are not designed to increase diversion rates.

### **Existing Facilities**

The existing Majors and Laguna Creek diversion facilities are structured to check surface water within the respective stream to a level whereby water can be diverted through an intake structure, into a transmission main, and ultimately to SCWD's treatment plant. The existing weirs create impoundments to submerge the pipeline intakes for the respective conveyance systems.

The existing Majors Creek diversion facility consists of the following:

- Reinforced concrete weir
- Reinforced concrete intake structure
- Perforated plate fish/debris screen
- Two debris/sediment control bypasses with pneumatically-operated gate valves
- Pneumatically-operated diversion control valve
- Propeller-type flowmeter
- 8,000 feet of 12-inch-diameter ductile iron pipe
- Existing control building



The existing Laguna Creek diversion facility consists of the following:

- Concrete and limestone weir
- Reinforced concrete intake structure
- Woven-wire fish/debris screen
- Two debris/sediment control bypasses with pneumatically-operated gate valves
- Pneumatically-operated diversion control valve
- Propeller-type flowmeter
- 20,000 feet of 14-inch-diameter steel pipe
- Existing control building



## Existing Operations

SCWD maintains pre-1914 riparian water rights to divert water from Majors and Laguna creeks. When surface water is available and the water quality is acceptable, SCWD's North Coast system is operated to maximize delivery into SCWD's overall water supply infrastructure. SCWD's diversion season historically occurred year-round but was subsequently modified to comply with

more stringent water quality standards. Nevertheless, SCWD attempts to divert surface water from the subject diversions to the fullest extent of the year contingent upon availability. During periods of higher instream flows when turbidity exceeds 25 NTU, the systems are temporarily taken off-line until high entrainment of suspended solids subsides.

The permanent weir structures serve to create impoundments at each facility to facilitate diversions. By maintaining an impoundment, each diversion facility maintains inlet conditions necessary to force full-pipe flow through the respective transmission pipelines. The individual pipelines join the North Coast Pipeline at Highway 1, which conveys water to SCWD's River Street Booster Pump Station.

The diversion facilities are operated whereby a gate valve is opened/closed at the inlet of each pipeline insofar as sediment does not fall out in the intake structure and obstruct or block the entrance. Each intake structure is located immediately adjacent to the aforementioned weirs and is used to channel water through a debris/fish screen to the pipeline inlet.

The operating water surface elevation of the Majors Creek diversion facility is at approximate El. 352.0, providing roughly 112 feet of static head to push water through the Majors Creek pipeline and over the high point in the North Coast Pipeline located at approximate El. 240.0. The water ultimately reaches SCWD's River Street Booster Pump Station located at El. 28.0. Due to inherent hydraulic constraints within the Majors Creek Pipeline and back-pressure conditions at its point of confluence with the North Coast Pipeline, the contribution of Majors Creek to the North Coast Pipeline has been historically limited to a maximum flow rate of 1.6 cfs, according to SCWD flow measurement data.

The operating water surface elevation of the Laguna Creek diversion facility is at approximate elevation 620.0, providing roughly 380 feet of static head to push water through the Laguna Creek and North Coast pipelines. Additional surface water is contributed to the Laguna Creek pipeline via the Reggiardo Creek diversion and the Liddell Spring intake facility. The maximum flow the Laguna diversion can divert is 6.3 cfs, according to SCWD flow measurement data.



The most significant issue SCWD has with current facility operations is maintaining the impoundments to prevent obstructing the diversion pipeline inlets. In most years, severe sediment deposition occurs within the impoundments, typically to the top of the weir crests. Since the intake structures are immediately adjacent to the weirs, this condition tends to render the diversion facilities inoperable until the debris is removed. The Majors Creek impoundment tends to capture a smaller grain-sized material comprised mainly of sand, whereas the Laguna Creek impoundment receives a more diverse gradation of material ranging from fines to cobbles. Periodically, SCWD has needed to mobilize heavy equipment to remove settled material within the impoundments prior to operating the diversion facilities, the Laguna diversion being most critical given the large gradation of impounded sediment. The Majors diversion has required less concern since its sediment control bypass has been effective in transporting the predominantly fine-grained sediment downstream, whereas the large grain size material is not bypassed as readily at the Laguna diversion.

Although the diversion facilities include sediment removal bypasses integrated within the weirs, safe access is often compromised when timely action is needed to administer operational adjustments that prevent sediment deposition. Hydrologic conditions are "flashy" in both systems and the effectiveness of the sediment bypass facilities is rather limited because operational adjustments are generally not implemented until the receding leg of the flow hydrograph occurs. The "flashy" hydrographs together with the present configurations make it virtually impossible to utilize the stream energy to maintain sediment mobility through the drainage system.

An ancillary topic is that of fish protection at the intakes. Majors and Laguna creeks are not identified as historical habitat for listed anadromous species, however, they do sustain a population of indigenous rainbow trout. The existing screen barriers are in place primarily to prevent debris entrainment within the diverted water rather than for protecting resident, native trout. The Majors Creek screen is more conducive to preventing fish entrainment given the existing screen material maintains a perforation size of approximately 5/32-inch and a total



surface area of approximately 17.0 square feet. The Laguna Creek screen is oriented more toward preventing debris entrainment given the woven-wire material maintains an opening size of approximately 1/2-inch. The Laguna Creek screen, when submerged, provides approximately 72.0 square feet of surface area. SCWD typically cleans the screens on a weekly basis and has been satisfied with the performance records of the screens to date.

Each diversion facility includes a control building for housing operational equipment. Since the Majors Creek diversion is a remote facility, line power or SCADA capabilities do not exist, however, the Laguna Creek diversion includes both. The pneumatically-operated valves at the Majors Creek diversion are operated via pre-charged nitrogen cylinders whereas the Laguna Creek diversion includes a small air compressor.

## EVALUATION AND PROPOSED MODIFICATIONS

### Evaluation

Wood Rodgers has operated under the guidance of SCWD, Carollo Engineers, and Entrix, Inc., to determine the optimum course of direction for upgrading SCWD's existing diversion facilities. SCWD's objectives are to develop and detail a concept that: facilitates the instream transport of sediment; provides operational flexibility with respect to the quantity and quality of water diverted; offers autonomous operating capabilities for bypass and diversion flow control; requires minimal power provisions; ensures fish protection consistent with regulatory requirements; and is economically and operationally feasible. Upon identifying SCWD's goals, an alternative has been developed that will meet SCWD's objectives (see Drawings in Appendix A).

Wood Rodgers has conducted field-reconnaissance of each site and has reviewed as-built plans, stream hydrologic data, and facility background documentation. Based upon Wood Rodgers' evaluation, modifications can be made to the existing facility to correct current deficiencies and provide added operational and maintenance benefits. Listed below are the primary modifications to the existing structures that will reconcile sediment accumulation and transport problems, alleviate fish protection concerns, and mitigate operation and maintenance requirements:

- Pneumatic Spillway Gates and Weir Modifications
- Compressors, Controls, and Instrumentation
- Regulatory Compliant, Replacement Screen Panels
- Miscellaneous Site Work Improvements

These features can be implemented and operated in accordance with a preformatted logic routine to maintain impoundment stage; discriminate between high- and low-suspended solids entrainment (measured as turbidity) and perform subsequent diversion control measures; perform

total bypass operations for turbid water releases; and monitor site operating conditions. With the concept proposed, SCWD's diversion facilities will be self-cleaning in the sense that they will operate concurrently with high flows to transport sediment through the impoundments. Sediment and debris may continue to settle within the impoundment, however the influence of stream velocities upstream of the spillway gate and along the intake will be sufficient to maintain an incised channel. Since the impoundment is not required from the standpoint of operational storage, the equilibrium attained will enhance both SCWD's diversion capability and the transport of sediment through the creek system.

## Hydraulic Design Methodology

Since stream topography data is not available at the sites of interest, a generic hydraulic analysis has been performed to assess velocity fields within an approximate representation of the impoundments to better understand gate-sizing requirements in relation to sediment transport. The objective of this analysis is to provide a general understanding of the effect from implementing the proposed features relative to sediment transport within the impoundments. The approximate physical representation of the sites, based upon field observations, is sufficient to assess sediment transport at a conceptual level. However, actual stream topography, sediment characteristics, and thresholds of bed mobility should be confirmed before a solution can be rendered with confidence. The basis for evaluating bed mobilization is founded on SCWD's input, Wood Rodgers' characterization of observed particle size distribution, the reference documents entitled, *Loose Boundary Hydraulics* and *Erosion and Sedimentation*, and the Federal Highway Administration's surface water modeling software, FESWMS, Version 2.0.

Sediment delivery in a stream channel is related to the flood hydrograph, channel geometry, and sediment characteristics. Sediment transport consists of bed load (the movement of streambed material) and wash load (erosion of material from the watershed). The latter is not addressed in this analysis simply because it pertains to a finer grain size material and will generally remain in suspension. The process of bed mobilization occurs when fluid flows over a bed composed of material whose grains are set in motion from shear stress generated by flow, otherwise known as



incipient motion. Sediment delivery is a continual process involving erosion, transport, and deposition. It involves three inherent elements: transport of suspended solids; bed load (movement of sediment sliding along the invert), and saltation (movement of entrained sediment colliding with and rebounding from impact with the streambed). In this case, the mobility of bed material is not dependent upon incipient motion, but rather conservation of momentum and hydrodynamic force, since the entrained sediment will already be mobilized when it enters the impoundments.

Grain size and terminal fall velocity are the most critical parameters for use in relating sediment properties with the theories of grain motion. These elements are functions of particle shape, boundary roughness, turbulence, density, drag, lift, and sediment concentration. The sediment properties in this particular case pertain to predominantly non-cohesive, alluvial materials. Although smaller grain-size materials exist, they are of less significance since channel maintenance is dependent on providing sufficient velocities for continued mobility of the more coarse particles.

The bed material mobilized at the Majors Creek diversion under high flow conditions is assumed to be predominantly comprised of medium to coarse sand (Sieve No. 60 to Sieve No. 10, or 0.25 mm to 2.0 mm). The bed material at the Laguna Creek diversion is comprised of a much broader array of grain-size material and is assumed to range from fine gravels to cobbles (1/16" to 6"). Although information on grain-size distribution at each site is not available, the observed characterization of materials is deemed sufficient for purposes of this analysis. Further definition of grain-size distribution is required before a final determination of sediment transport mechanics can be made.

Particle shape affects sediment transport, but there is no direct and quantitative way to assess the particle shape and its effect on fall velocity, due to the infinite nature and uniqueness of particle shape. Therefore, more general assumptions are applied to allow mathematical estimation of sediment transport. The moving grains are subject to the force of gravity which continually drives the material toward the bed of the stream channel, a tangential force attributed to flow



velocity that propels the material downstream, turbulence assisting in lift that keeps sediment in suspension, and frictional resistance at the boundary conditions causing shear stress as water moves along the interface.

The accuracy of sediment routing depends upon the suitability of the sediment transport formula applied and definition of hydrology, hydraulics, and in-situ material characterization. Since these variables are not well defined, an extensive analysis is not appropriate. However, for the purpose of establishing a basic understanding of sediment transport within the localized area of the proposed features, recommended minimum permissible velocities are used to identify incipient motion with respect to particle size (*Erosion and Sedimentation*, Table 7.2). Once mobilized, sediment will not require the same magnitude of velocity to maintain motion in contrast to the values shown for incipient motion, shown on Table 1 below. Therefore, this approach provides a conservative method by which to assign a minimum threshold for maintaining suspension and/or transport of sediment load. The velocities attributed to incipient motion for bed transport are defined in Table 1:

**TABLE 1**  
**MINIMUM TRANSPORT VELOCITIES\***

| Soil Type                   | Manning's Coefficient | Minimum Flow Velocity, fps |
|-----------------------------|-----------------------|----------------------------|
| Fine Sand (Colloidal)       | 0.020                 | 1.50                       |
| Fine Gravel (Non-Colloidal) | 0.020                 | 3.75                       |
| Cobbles and Coarse Gravel   | 0.035                 | 6.50                       |

\*Minimum Velocities for Incipient Motion in Canals with depth < 3 feet.

A mathematical model representing approximate impoundment boundaries and associative structures was modeled after the Laguna Creek diversion. Channel topography was assumed using as-built drawings of the existing diversion facility. Since the hydrology and features of the Majors Creek diversion are nearly identical, it is assumed the model output is representative for both facilities. Hydrologic data was obtained from former USGS gages on both creeks for a period of record from October 1969 to October 1976 (Laguna USGS Gage #11161590 and

Majors USGS Gage #11161570). Each gage was formerly positioned within the vicinity of each diversion to provide the best available data, as shown on Figure 1.

A two-dimensional, finite-element model was constructed in this analysis using the Federal Highway Administration's Finite Element Surface-Water Modeling System (FESWMS) Version 2.0. A graphical interface, SMS Version 7.0, was used to facilitate model development and data processing. The input data used in the analysis reflects the existing intake structure, weir, and proposed spillway structure. FESWMS determines modeling solutions by applying two-dimensional, depth-averaged conservation of mass and momentum equations and incorporating effects from channel bed friction, channel wall friction, and fluid stresses caused by turbulence.

The software applies differential equations to numerically solve for individual subregions or finite elements defined within the physical limits of the area modeled. The software describes surface water flow in the horizontal plane where vertical accelerations are relatively small and, in most engineering applications, can be neglected. Slip boundary conditions were defined for the lateral edges of the channels and impoundments, whereas the upstream and downstream ends of the model are designated as open boundaries where flow is designed to enter and leave the modeled network. A total flow of 280 cfs (the maximum flow of record from 1969-1976) was specified at the upstream model boundary and incremental unit flows were uniformly distributed across the node string. At the downstream end of the model, the water surface elevation was directly specified to allow the flow to pass through critical depth just upstream of the proposed spillway crest. Since channel slope, topography, and normal depth conditions are not known for the respective channels, the critical depth method was selected for analytical purposes. The intake structure was modeled with no flow diverted because it will not be operational when turbidity is high, a condition that is coincident with periods of high runoff.

The Manning's roughness coefficients through the impoundments for Majors and Laguna creeks are identified in Table 1 as 0.020 and 0.035, respectively. The roughness coefficients are related to one-dimensional flow to account for the turbulence and deviation from a uniform velocity, and are therefore conservative as the model inherently determines influence from turbulence and

shear stress in two-dimensional flow. An eddy viscosity value of 0.6 ft<sup>2</sup>/sec was assigned for flow conditions and is typically used in natural channels. Eddy viscosity accounts for lateral shear stress caused by turbulence. It is a function of the fluid properties *and* flow geometry.

The spillway was modeled using an empirical, one-dimensional equation to provide greater accuracy, since the weir flow equation has been well proven. The discharge coefficient over the spillway is determined using the following equation:

$$C = C_s \cdot C_w \cdot L_w \cdot \sqrt{g}$$

Where:

$C$  = weir coefficient, 30.1

$C_s$  = submergence factor, 1.0

$C_w$  = dimensionless discharge coefficient, 0.53

$L_w$  = weir segment length, 10.0 ft

$g$  = gravitational constant, 32.2 ft/s

FESWMS 2.0 is limited to a model capacity of 55,000 elements and an allowable front width of 1,200. The model developed in this analysis contained 550 elements with a front width of 90. The model nodes were constructed to define approximate impoundment limits estimated from field observations. As-built drawings were used to define the physical structures. A simplified 3-point geometric mesh was constructed and combined with approximate bathymetry data to produce a three-dimensional, triangulated irregular network. This network was further converted to nine-node quadrangular elements to provide greater model stability.

Results of the model are provided on Figure 2 - "Velocity Distribution," and Figure 3 - "Flow Depth." The model results identify velocity fields in the impoundment for the purpose of relating velocity to bed mobilization. The results graphically illustrate velocity fields and flow depths within the modeled impoundment. Through the use of velocity contours, the model results provide an understanding of horizontal velocity magnitude and distribution within the impoundment. The

FIGURE 2  
VELOCITY DISTRIBUTION

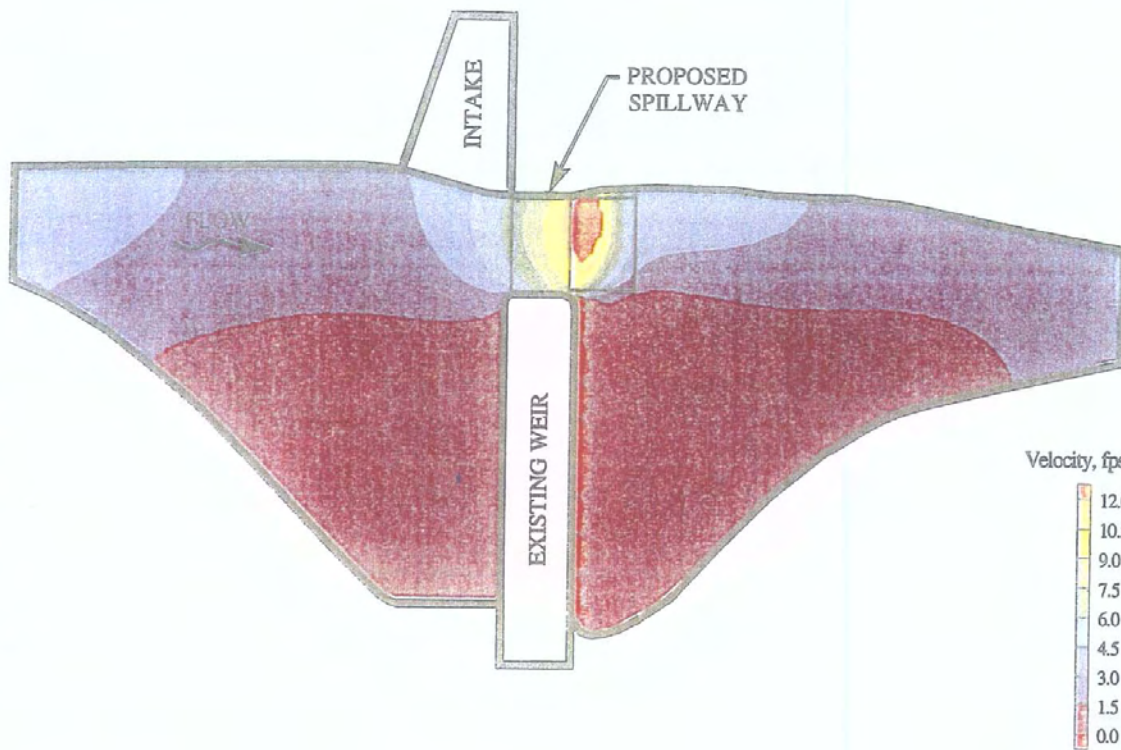
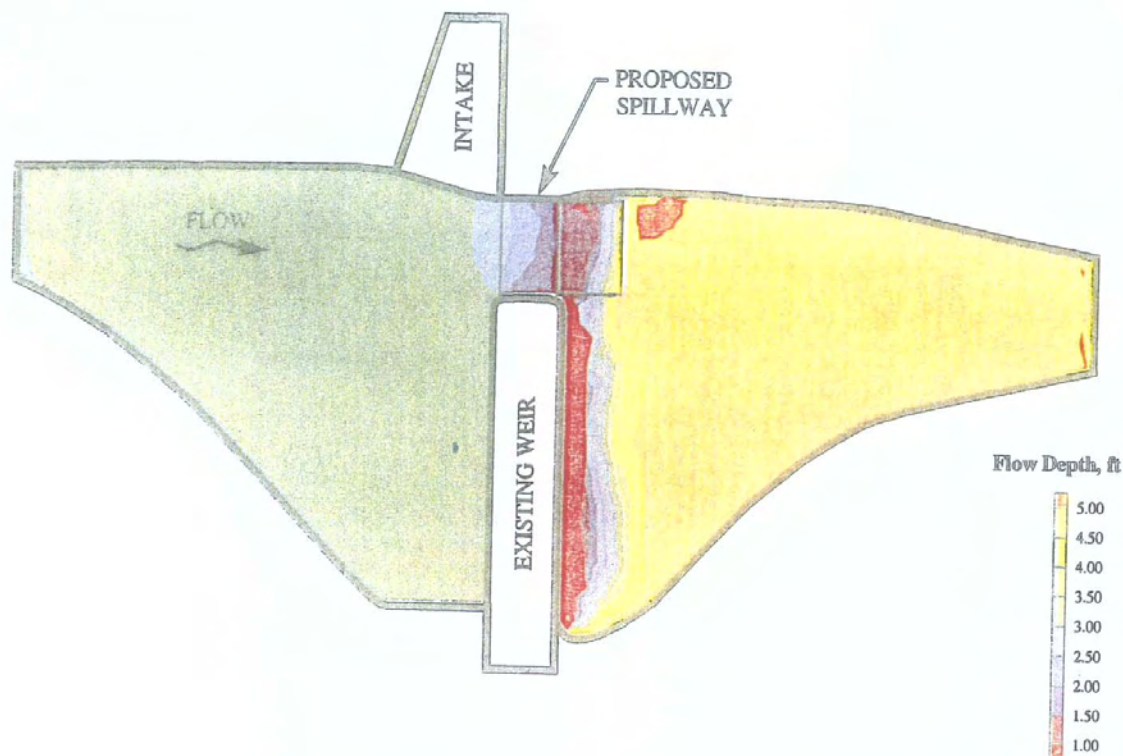


FIGURE 3  
FLOW DEPTH





velocity fields can be correlated with the bed mobility guidelines presented in Table 1, to assess velocity influence and appropriateness of gate sizing.

Given the identification of the velocity distribution presented on Figure 2, a state of topographical equilibrium will occur within the impoundment. A self-stabilizing bed regime will occur within the impoundments as a result of the proposed modifications. Low velocities within the impoundments will continue to allow sedimentation, however, higher velocities near the intakes and spillways will keep bed material in suspension and transport it downstream in a desired fashion. Velocities of approximately 2.0 fps and 5.5 fps are assumed sufficient at the Majors Creek and Laguna Creek diversions, respectively, to maintain incised channels adjacent to the intake structures. The resultant channel conditions are illustrated in Figure 4, "Estimated Ultimate Conditions."

As shown on Figure 5, "Velocity Trace Diagram," the disbursement of velocities is revealed through particle tracing that demonstrates a high-velocity flow regime occurring adjacent to the intake structure, whereas dead zones are determined to exist within the right side of the impoundment and tail race pools. These conditions will ultimately allow material to deposit within the right side of the impoundment under the proposed operating conditions as shown in Figure 4, however, a self-sustaining channel will be maintained where needed. Since only the maximum flow within the period of record is used to model hydraulic conditions, it is not representative of lower flow conditions when bed mobilization occurs. It does, however, provide a basis for sizing the gates for the two facilities. It appears a 10-foot-wide gate will suffice for the Majors Creek diversion where approximately 2.0 fps velocities are required to transport sediment through the impoundment. A gate size less than 10-feet-wide may be required to develop sufficient velocities for sediment transport of more coarse materials through the Laguna Creek impoundment.

FIGURE 4  
ESTIMATED ULTIMATE CONDITIONS

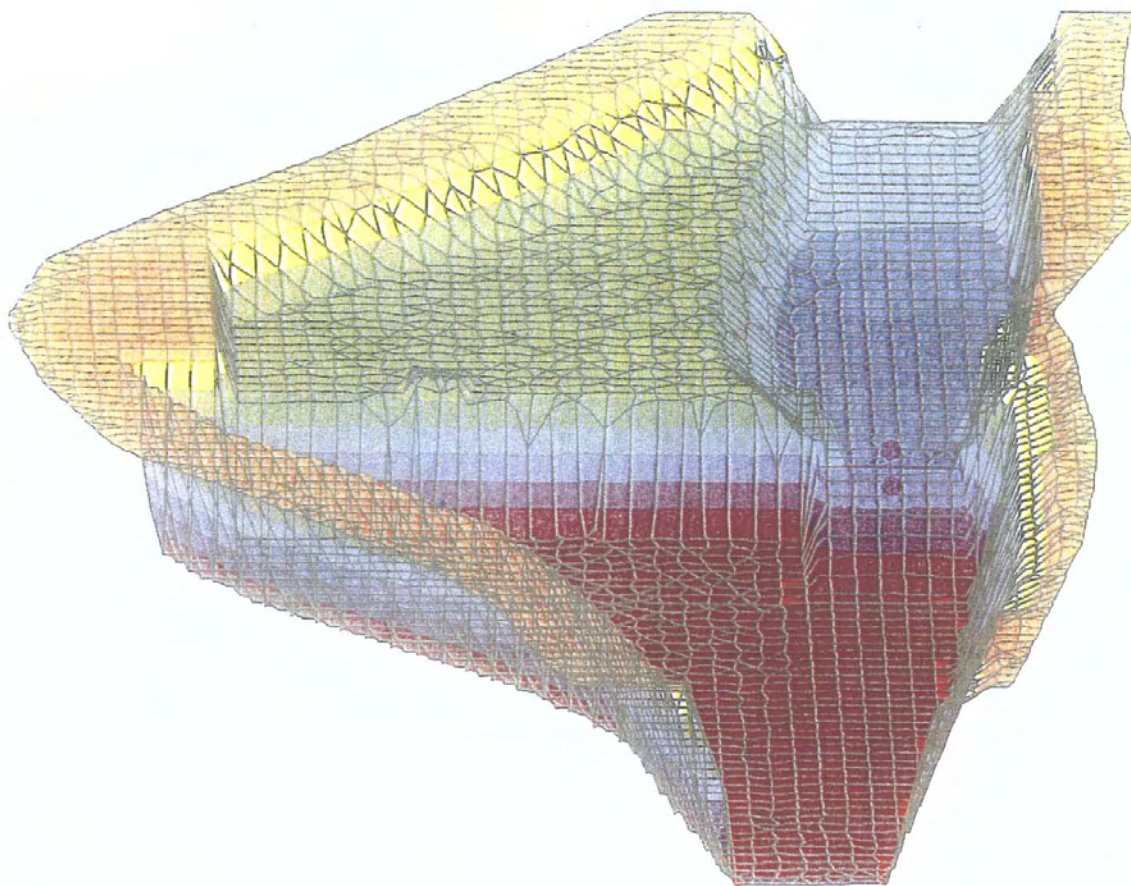
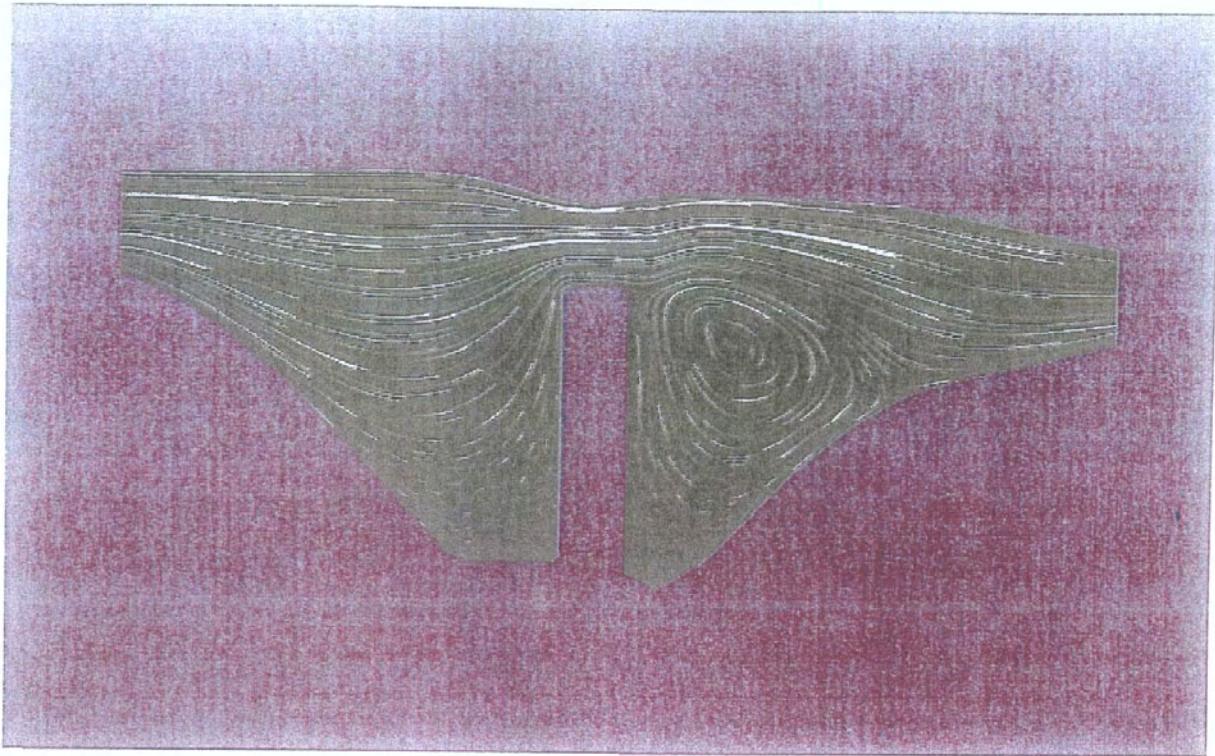


FIGURE 5  
VELOCITY TRACE DIAGRAM



Again, the conclusions at this level are approximate given the lack of definition of foundational design parameters. Final design of the facilities will require sediment characterization, topographic data, and turbidity versus flow relationships to confirm channel sediment transport conditions. Nevertheless, the conclusions rendered herein provide a reasonable order of magnitude for sizing the gates appropriately to accomplish the desired objective.

The other aspect of hydraulic engineering pertains to the existing debris/fish screens. The existing diversions are screened to prevent diverting bed material and debris into the pipeline and to protect rainbow trout against entrainment. Screening criteria for rainbow trout is similar to that established for anadromous salmonid species according to the report entitled, "Small Hydroelectric Development in California: The Role of The Department of Fish and Game," Gary Smith, Environmental Services Branch, October 1982. Based upon the 2002 criteria of the California Department of Fish and Game, the surface area of the existing screens, when submerged, is adequate to comply with fish protection criteria for non-continuously cleaned screens. Accordingly, the overall size of the intake structure will not require modification. However, the screen material will need to be changed to comply with the maximum perforation size criteria, and baffles may be required to achieve uniform velocity distribution.

## **Physical Modifications**

The drawings provided in Appendix A, represent the extent of the modifications being proposed for the Majors Creek and Laguna Creek diversion facility improvements. SCWD provided miscellaneous as-built drawings for both facilities that were used to develop as accurate a representation of existing facilities as possible. The drawings in Appendix A provide conceptual illustrations of the proposed modifications. Descriptions of proposed modifications are provided as follows:

## 1. Pneumatic Spillway Gates and Weir Modifications

Control of sediment transport is an issue of paramount importance to SCWD. The existing control weirs are critical to SCWD's water supply operations, however they currently serve as sediment traps. The accumulation of material eventually leads to complete blockage of the intake structures and requires maintenance efforts on an annual basis. To remedy the situation and return sediment transport to a more natural condition, it is recommended a portion of each weir be modified to include an adjustable spillway gate. Spillway gates will maintain the required stage for diversion operations when water quality is acceptable and will be laid back to pass bed load when a predetermined turbidity level is reached.

The weir modifications consist of saw cutting and demolishing a portion of the weir adjacent to each intake structure, as illustrated on the drawings. The proposed invert of the foundation slab at each new spillway section is assigned an elevation that assures no obstruction in the water column above the intake invert when the spillway gate is lowered to its full down position. The object is to maintain an incised channel adjacent to the intake screens to allow the entire surface area to utilize the maximum benefit of fisheries protection. In addition, the operation of the proposed spillway gates will maintain self-sustaining channels adjacent to the intake structures that will mitigate on-going operation and maintenance practices and habitat disturbance.

The new reinforced concrete spillway structures consist of an anchorage slab, training walls, and an apron. The structures are structurally independent of the existing weirs to prevent transfer of static hydraulic loads into the unknown structural capacity of the existing weirs. The new structures, however, will rely on the remnants of the weir for stability and foundation support and will be doweled and bonded at the interfaces accordingly to render the finished product as monolithic as possible.

The pneumatically-controlled spillway gates are designed to mechanically attach to the new reinforced concrete spillway structures. The spillway gates consist of arched gate panels that are anchored to the spillway decks and rest on top or upstream of nylon-reinforced rubber membrane bodies. Although the rubber bodies are inherently resilient, the steel gate panels also serve to protect the bodies from puncture. In contrast to earlier rubber dam systems, the spillway gate concept also provides enhanced repeatability in terms of maintaining desired impoundment stage set points. The proposed spillway gate systems are comprised of anchorage assemblies, cast-in-place drain and air piping, rubber bodies, galvanized steel gate panels, end seals, air compressors, and self-contained, automated pressure control systems.

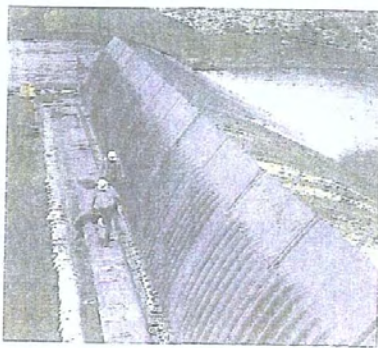


Photo 1.1 - Upstream View



Photo 1.2 - Downstream View



Photo 1.3 - In Service

The spillway gates will continue to impound water to the same levels as the existing weirs. The gates will function as sluiceways when predetermined sediment loads are detected entering into the impoundments.

## 2. Compressors, Controls, and Instrumentation

The proposed modifications will require associative electro-mechanical equipment and instrumentation to fulfill the desired Supervisory Control and Data Acquisition (SCADA) operating objectives. For the diversion systems to operate in accordance with a predetermined logic routine, on-site power, Programmable Logic Controllers (PLCs)

controls, and monitoring instrumentation must be provided. The existing control buildings at each site have sufficient space to accommodate PLCs and compressed air control panels, as well as power supply and compressed air equipment.



Photo 2.1 - Control Building

The Majors Creek control building is partitioned and can accommodate a generator, charger, and battery bank in one compartment and a compressor and control panel in the other. Since the Majors Creek facility is roughly two miles from the nearest electrical utility source, economics do not warrant providing utility power. Therefore, a low-pressure (LP) gas-fire generator and tank are required with a battery bank and charger to power the PLC, controls, and air compressor. The existing compressed air circuits for the control valves may be integrated as necessary.

The Laguna Creek control building currently has an on-site PLC with spare input/output slots that may be used for site control. The facility has utility power provisions and an air compressor within the existing control building. However, the compressor must be upgraded to accommodate the additional demand of the spillway gate.

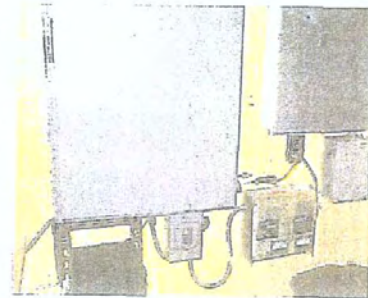


Photo 2.2 - Control Panels

Each intake structure will be fitted with a turbidity meter and level transducer located immediately behind the screens for optimum protection while maintaining an ideal position for monitoring representative turbidity and stage conditions.

### 3. Replacement Debris/Fish Screen Panels

The debris/fish screen assemblies currently employed by SCWD are rudimentary in nature and consist of vertical plate screen panels installed within channel embeds at the entrances

of the intake structures. Although the existing screens are functional and have offered a satisfactory performance record, it is recommended replacing the screen panels to conform to regulatory agency fish screening criteria for non-anadromous salmonid species. Since the diversion facility locations are inaccessible to anadromous salmonid species due to downstream obstacles, the topic of screening is less critical.

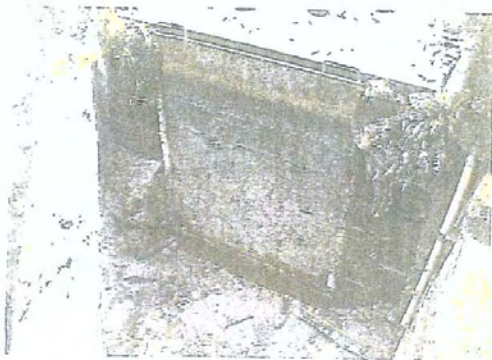


Photo 3.1 - Majors Creek Intake Screen



Photo 3.2 - Laguna Creek Intake Screens

Since the existing screen panels provide sufficient surface area to accommodate allowable approach velocities and fish protection under a noncontinuously cleaned operation, the recommendation of replacing the screen panels is made specifically from the standpoints of opening size, corrosion resistance, and mitigation of biological fouling. The existing screen panels should be replaced with anti-fouling coated, Type 304 stainless steel wedge-wire screen panels of the same physical dimensions.

The wedge-wire material is generally preferred from a maintenance standpoint due to greater structural integrity and better cleaning performance. The wires are constructed in a wedge configuration that allow the slot widths to increase in the downstream direction, thus allowing debris impinged in the slots to work through if not brushed from the upstream face. This equates to screen that is subject to less occlusion. The wedge-wire material is typically aligned with the wires oriented in the vertical direction. Backing support rods are

resistance-welded perpendicular to the wires and structural framework. A wedge-wire fabric with 1.75 mm slot widths and 50% open area is recommended.

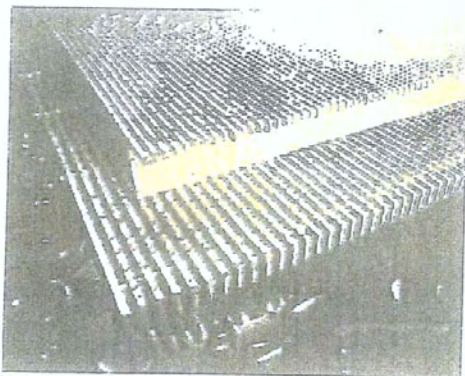


Photo 3.3 - Screen Panels

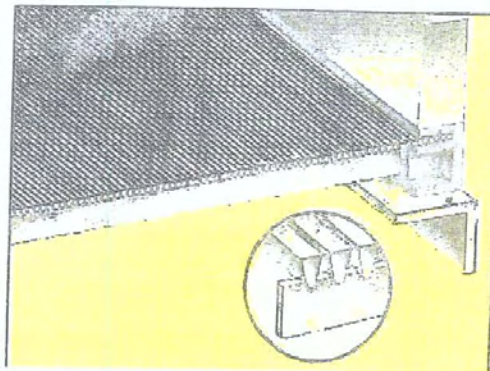


Photo 3.4 - Wedge-wire Fabric

Screen design is typically oriented around several key features or principles consisting of the following design elements: maximum approach velocity and distribution; sweeping velocity; porosity; screen cleaning; exposure time; and system design capacity. The overall surface area of the proposed screens is directly dependent upon the maximum design diversion rate for each facility.

By maintaining the maximum practiced diversion rates, and assuming approach velocities are uniformly distributed throughout the screen surface areas, approach velocities can be expected to be less than 0.1 fps. During operating periods when debris load is minimal and manual cleaning is applied on a weekly basis, hydraulic conditions should be sufficient for fish protection.

The proposed screen arrangements will not support a sweeping velocity component during normal operations. However, since the approach velocities rendered will be relatively low, it is reasonable to assume fish protection will not be jeopardized.

#### 4. Miscellaneous Site Improvements

Implementing additional improvements is recommended at both facilities to protect the proposed structures from subsequent erosion following installation. Each spillway structure will be supplemented with stone protection at the upstream and downstream faces to prevent scour and destabilization. In addition, stone protection should be placed at the right end of the weir at the Majors Creek diversion due to the observed embankment degradation from runoff, erosion, and slope instability. Furthermore, the right weir abutment of the Majors diversion should be extended approximately two feet in elevation and tied into existing grade to force flow containment within the span of the weir crest. Integration of the proposed spillway gates and operations will help to reduce maximum creek stage by accommodating a major portion of the flow. The existing crib wall upstream of the Laguna Creek diversion intake structure should be removed and the embankment reshaped and rocked consistent with the upstream face of the structure as shown on the drawings in Appendix A.

#### Operational Changes

Assuming all proposed physical modifications are implemented, changes in operation and maintenance activities will be relatively minor. The greatest advantage of the proposed arrangement is the automatic operation of the intake and spillway gates relative to inflow and turbidity of streamflow. When turbidity exceeds the desired limit, the spillway gate will lower and the intake gate will close and vice-versa. This operating sequence provides an ideal routine for ensuring bed load is conveyed through the impoundment so as not to affect diversion operations when they are reinstated. Operation and maintenance of the new facilities will include the following:

1. Weekly cleaning of debris/fish screens.
2. Annual inspection of turbidity meters and level transducers.



3. Annual inspection and maintenance of spillway gates.
4. Periodic inspection and maintenance of generator and compressors.
5. Replacing the battery bank at the Majors Creek diversion every four to five years.

## SCHEDULE AND BUDGET

### Design and Construction Schedule

Design and preparation of final construction plans and specifications will require approximately one to two months once the design and operational criteria are finalized and topographic data is available. Procuring the spillway gate components, screen panels, and electronic controls will likely require a three-month lead-time upon receipt of order. The remaining equipment and materials are readily available and should not impact the construction schedule. Total construction time of the two facilities will require approximately one month, assuming construction is performed concurrently. The total time of implementing the proposed modifications will require approximately six to twelve months upon issuing a notice to proceed and depending upon the time of year. Implementing the proposed modifications will require a Streambed Alteration Agreement (1601 Permit) from CDFG. This permit will require completed environmental documentation prior to beginning construction.

The majority of the work will occur within the stream channels, and the construction window will directly coincide with SCWD's diversion season. Special attention will be required with respect to construction timing and environmental mitigation measures. Since streambed alteration agreements stipulate a construction window from July 1 to October 15, SCWD will need to coordinate construction methods that accommodate concurrent diversion operations.

Construction of the aforementioned modifications will involve a cofferdam and temporary bypass system, dewatering, earthwork, reinforced concrete demolition and construction, metalwork fabrication and installation, stone protection, and miscellaneous electrical and mechanical services. The construction methods are straightforward. Increased traffic into and out of the project area will be nominal. The total concrete placement is expected to be no more than fifty yards per site and can be completed in two individual placements per site. Earthwork involving borrow or spoil operations will be confined to the localized area, and habitat disturbance will be no greater than that which is typically administered during annual maintenance activities.

## Budget

Provided below on Table 2 is a summary of Wood-Rodgers' opinion of probable costs for implementing the proposed modifications for both diversion structures.

TABLE 2  
OPINION OF PROBABLE COSTS

| Modification                                     | Cost, \$ |
|--------------------------------------------------|----------|
| Spillway Gates and Weir Modifications            | 150,000  |
| Compressors, Controls, and Instrumentation       | 100,000  |
| Replacement Debris/Fish Screen Panels            | 20,000   |
| Miscellaneous Site Work Improvements             | 20,000   |
| Subtotal                                         | 290,000  |
| Contingencies                                    | 40,000   |
| Engineering, Design, and Contract Administration | 50,000   |
| Environmental Documentation and Permitting       | 15,000   |
| Performance Testing                              | 5,000    |
| TOTAL                                            | 400,000  |

## REFERENCES

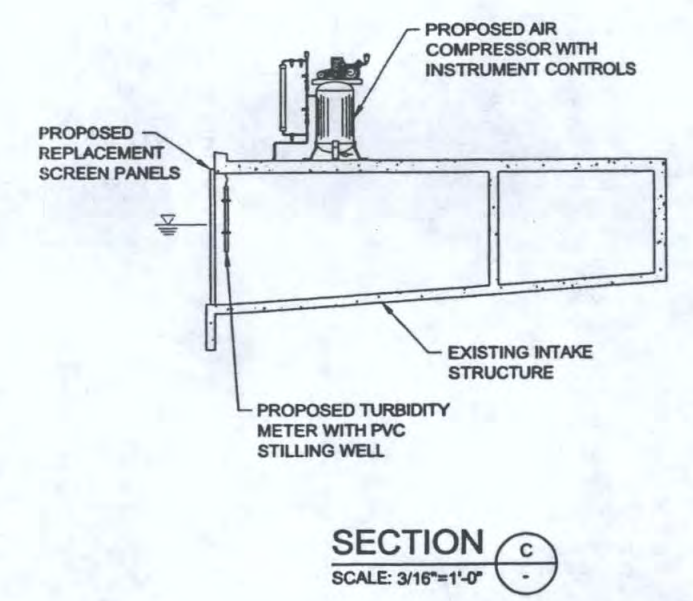
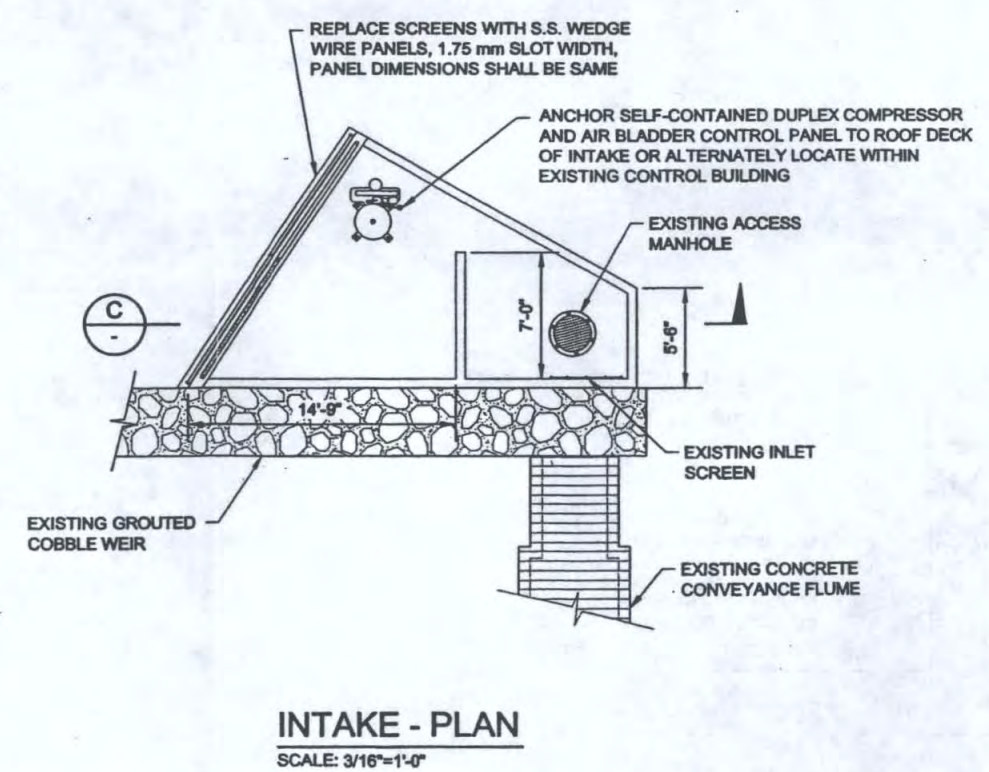
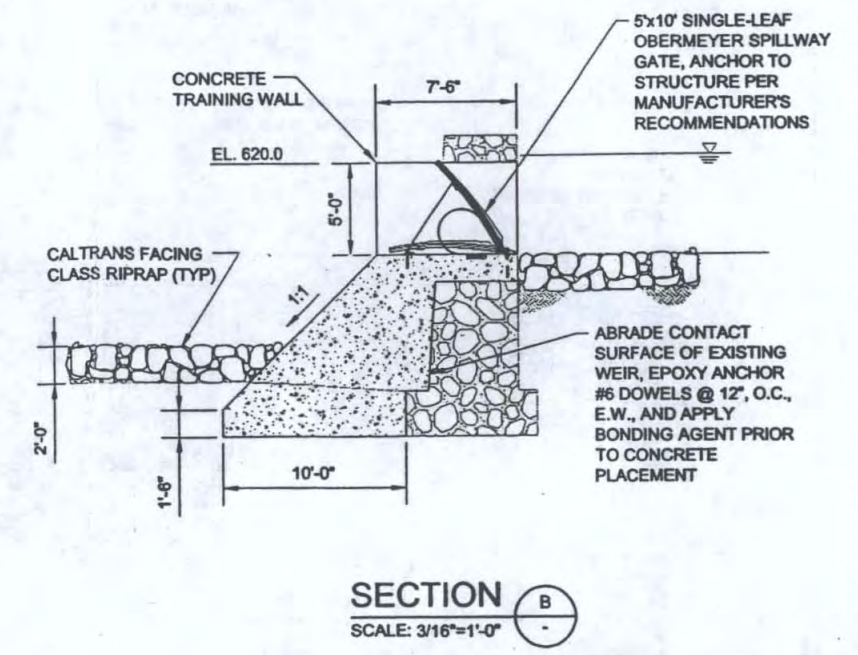
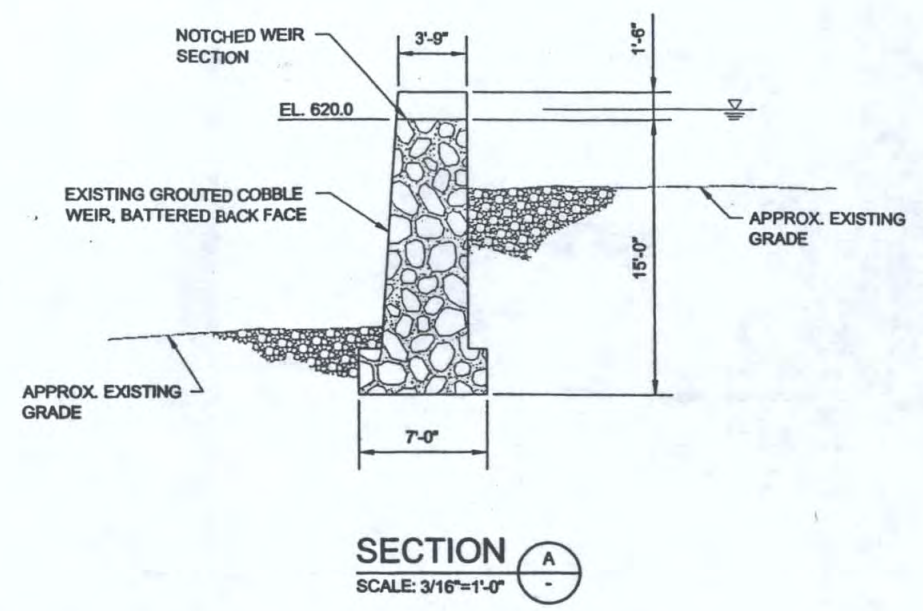
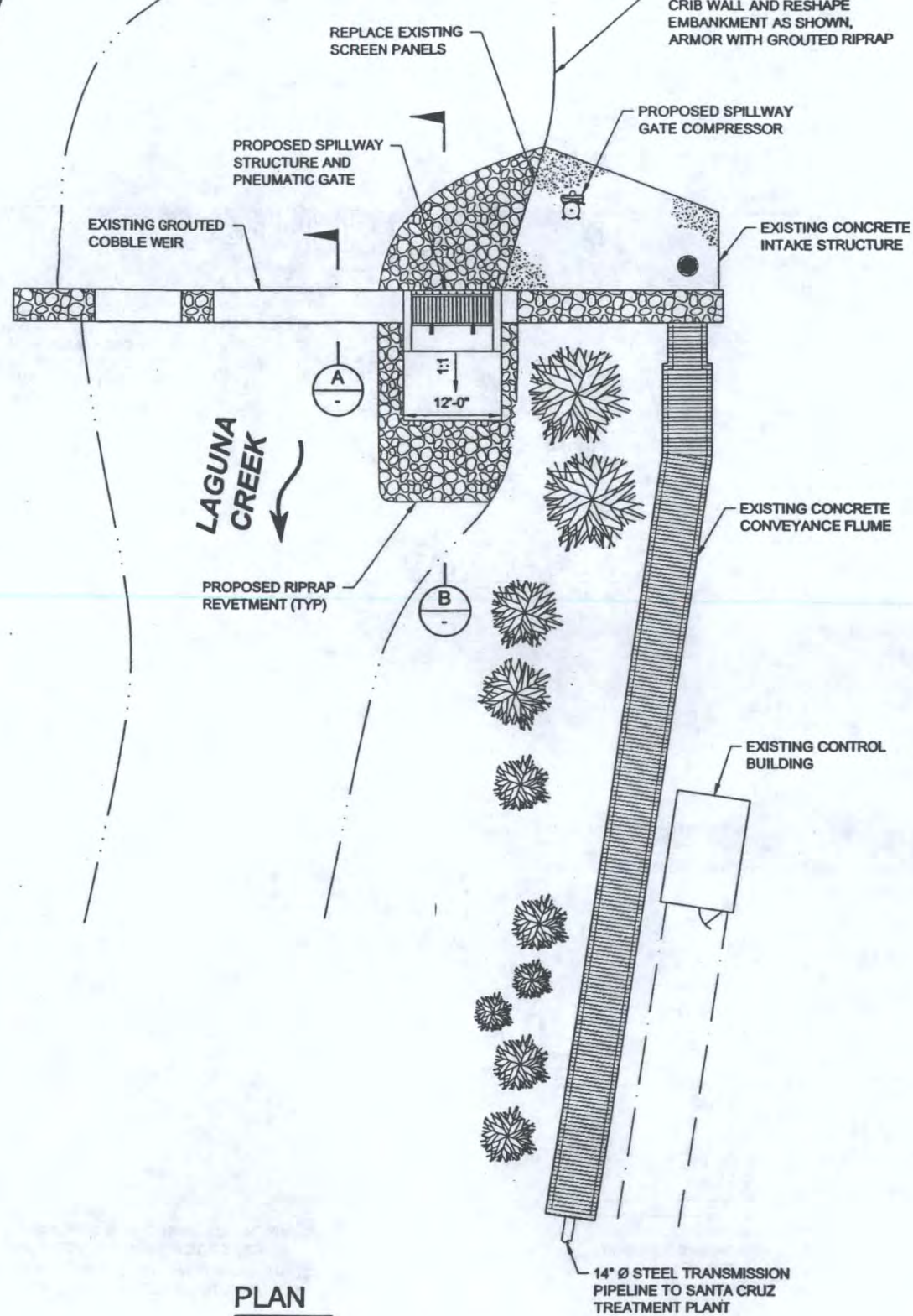
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## APPENDIX A

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## DRAWINGS



- NOTES:**
1. INSTALL EQUIPMENT IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
  2. ALL DIMENSIONS SHALL BE FIELD-VERIFIED BY CONTRACTOR PRIOR TO COMMENCEMENT OF WORK.

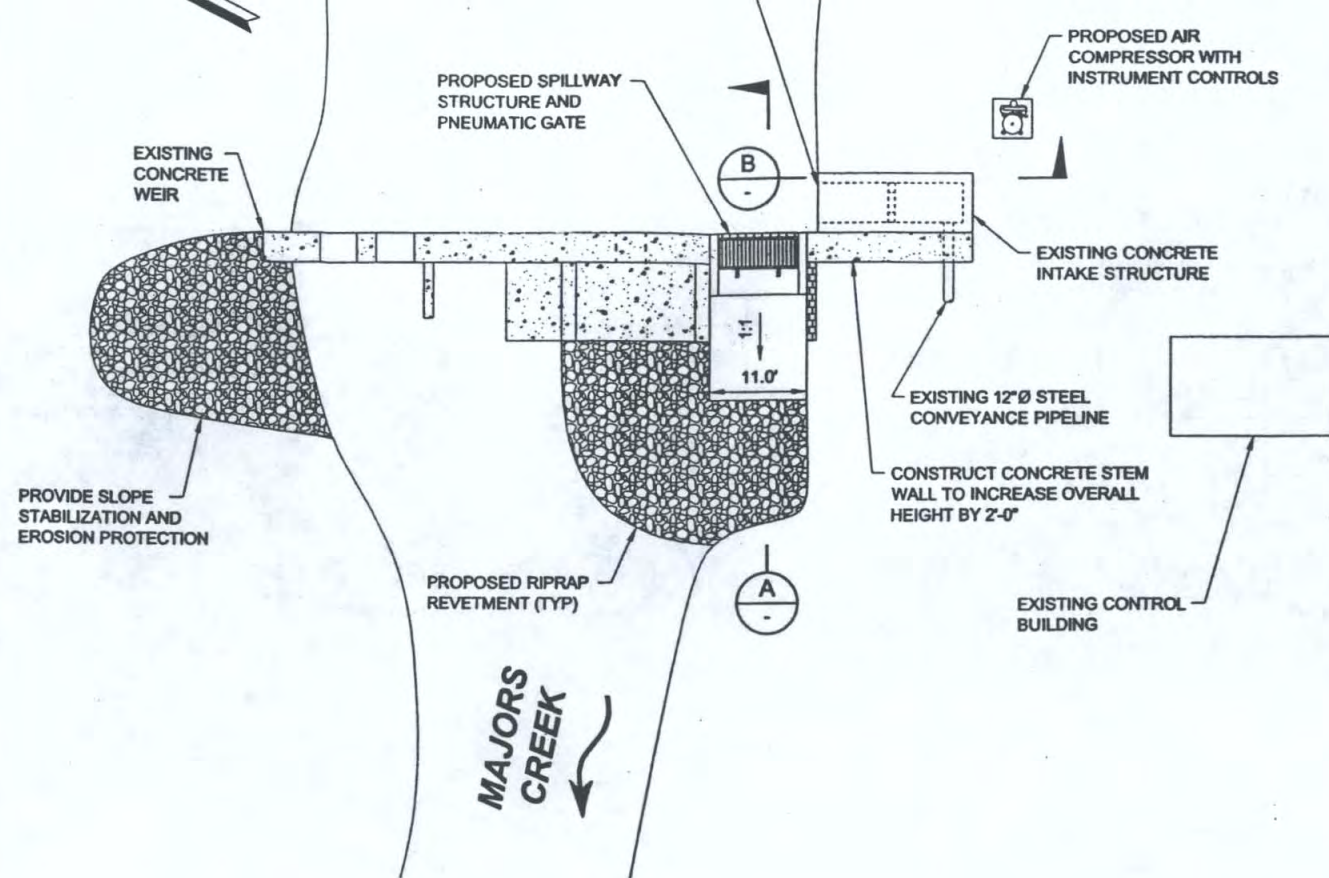
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**HALF-SIZE PRINT**

DESIGNED BY:  
T. BULLER  
DRAWN BY:

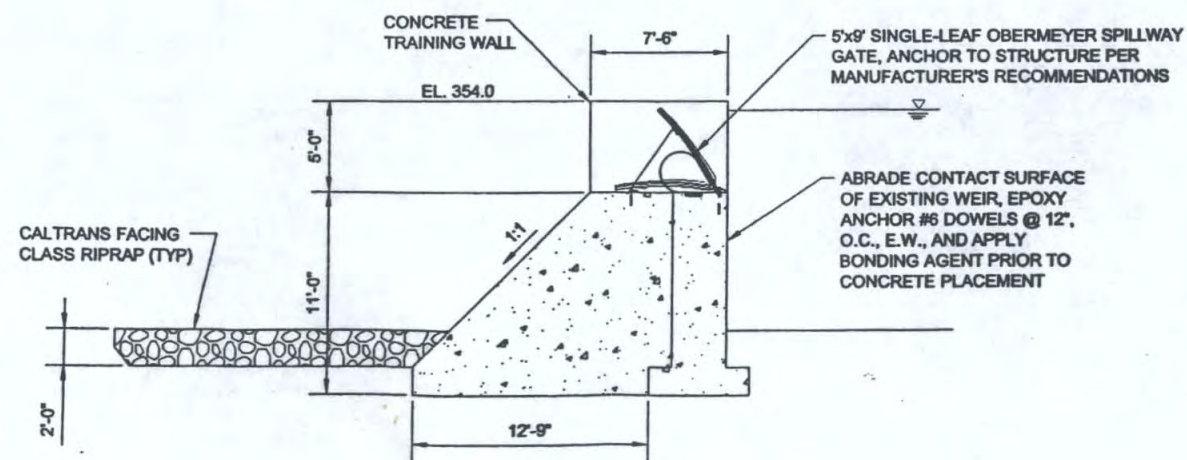


SANTA CRUZ WATER DEPARTMENT  
NORTH COAST SYSTEM REHABILITATION PROJECT

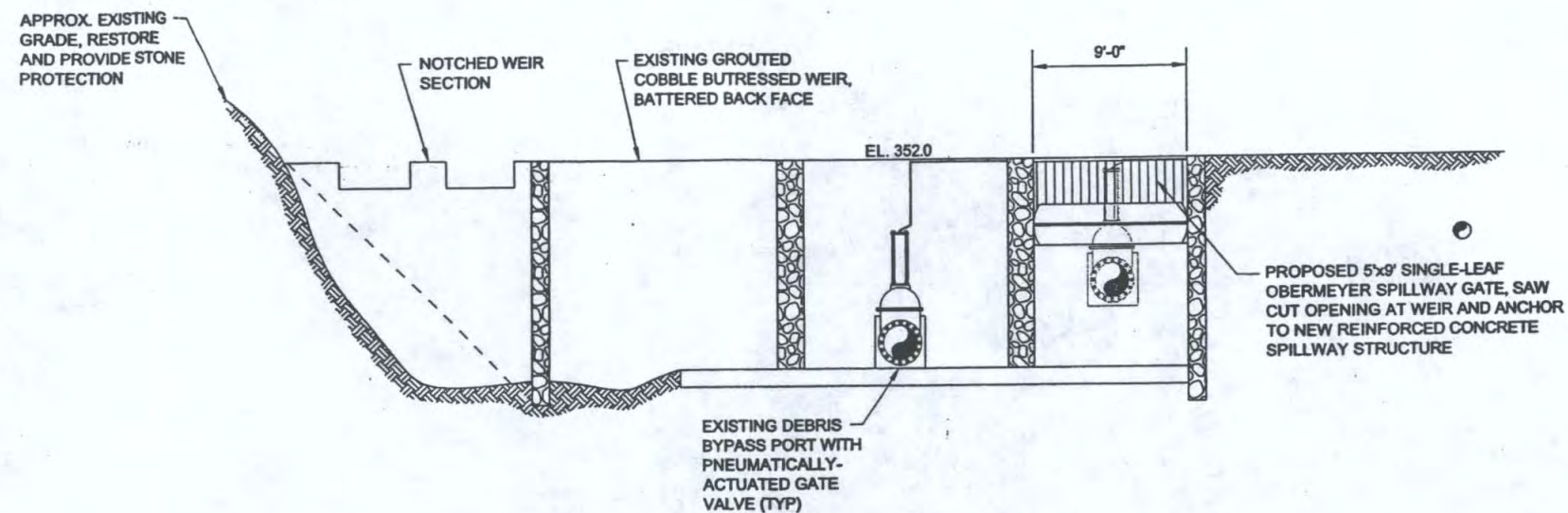
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AS SHOWN



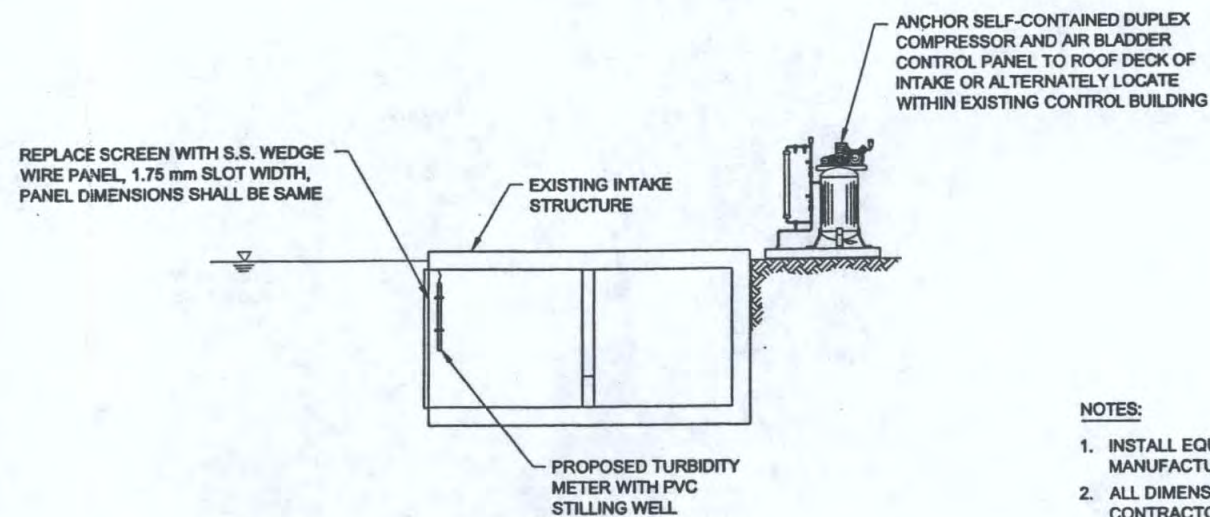
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**SECTION A**  
SCALE: 3/16"=1'-0"



**WEIR - ELEVATION**  
SCALE: 3/16"=1'-0"



**SECTION B**  
SCALE: 3/16"=1'-0"

**NOTES:**

1. INSTALL EQUIPMENT IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
2. ALL DIMENSIONS SHALL BE FIELD-VERIFIED BY CONTRACTOR PRIOR TO COMMENCEMENT OF WORK.

**PRELIMINARY**  
**HALF-SIZE PRINT**

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T. BULLER  
DRAWN BY:  
T. BULLER

**WOOD RODGERS**

SANTA CRUZ WATER DEPARTMENT  
NORTH COAST SYSTEM REHABILITATION PROJECT

SCALE OF ORIGINAL

AS SHOWN