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May 31, 2006

SENT VIA EMAIL

Sandra Guldman
Friends of Corte Madera
Creek Watershed
Box 415
Larkspur, CA 94977

Subject: Developed fish ladder alternatives for Pastori Avenue at San Anselmo Creek

Dear Sandra,

We have completed development of three alternative fish ladder designs for the Pastori Avenue road crossing. The following briefly describes each of the design alternatives we have developed. Also attached are schematic drawings of the fish ladder alternatives. These alternatives are meant to be considered along with non-fish ladder type design alternatives developed by Stetson Engineers. Stetson Engineers has also prepared preliminary cost estimates associated with alternatives 1 and 3. We recently sent them drawings for alternative 2, and hope to have a cost estimate for this alternative by June 6th.

Please contact us if you have any questions or comments.

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CC: James Reilly, Matt Smeltzer, Joe DeMaggio, Ross Taylor

Enclosed: Schematic drawings of alternatives
Cost estimates for Alternatives 1 and 3

1.0 BACKGROUND

San Anselmo Creek is a major tributary to Corte Madera Creek, which drains into San Francisco Bay in Marin County. San Anselmo Creek supports populations of anadromous steelhead trout, which are listed as threatened under the Federal Endangered Species Act.

Pastori Avenue crosses San Anselmo Creek within the town of Fairfax. The crossing consists of a concrete bridge on concrete abutments. A large apron spans the abutments and serves as a grade control structure. The apron maintains a drop of approximately 8 feet. In the 1980's an Alaskan Steeppass fish ladder was installed to provide for steelhead passage (Figure 1 and 2). However, the Steeppass is poorly suited for providing adult passage at typical migration flows. At migration flows the hydraulic capacity of the Steeppass is overwhelmed, and there is inadequate attraction flow for fish to find the outlet. For example, in winter of 2006 trout were observed attempting to swim up the sloping face of the apron rather than attempt the Steeppass. Additionally, an Alaskan Steeppass does not provide passage for juvenile salmonids and is highly susceptible to plugging by debris.

A recent fish passage assessment of road-stream crossings within Marin County identified the site as a high priority for treatment (Taylor, 2003). The Friends of Corte Madera Creek Watershed received grant funding to develop design alternatives for improving fish passage at the Pastori Avenue crossing. Michael Love and Associates were tasked with developing up to three fish ladder type alternatives for the project. Nature-like and natural-grade alternatives are to be developed by Stetson Engineers. Stetson Engineers are also to prepare cost estimates for each alternative and be responsible for final engineering and design once a preferred alternative is selected.

2.0 FISH PASSAGE OBJECTIVES AND SITE CONSTRAINTS

Each fish ladder alternative is intended to improve passage conditions for adult steelhead, resident rainbow trout, and juvenile salmonids.

A primary site constraint was the need to maintain the upstream channel grade. Much of the upstream channel bed likely consists of sediment deposition associated with the backwater effects from the concrete bridge apron/dam. However, allowing the channel bed to incise through this deposited sediment was deemed undesirable. While the shopping center adjacent to the channel and support piling within the upstream channel predate the apron there is currently numerous retaining walls that encroach into the active channel. Allowing for and considering upstream channel incision was out of the scope of the fish ladder alternatives.

Another site constraint was to avoid a structure that encroached too close to the existing bridge abutments. For structural reasons, Stetson's engineer, Joe DeMaggio,

Figure 1 – The existing Pastori Ave. Bridge over San Anselmo Creek, with a concrete apron between the bridge abutments that functions as grade control. Poorly functioning Alaskan Steeppass fish ladder in center.

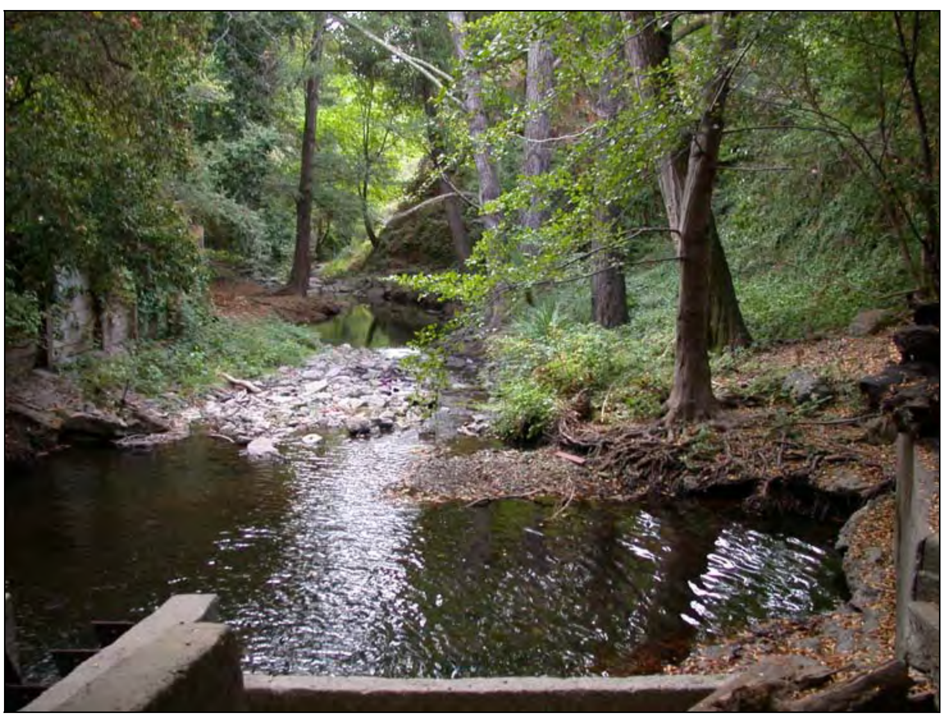


Figure 2 – Channel immediately downstream of the Pastori Ave. bridge.

recommended that fish ladder structures be set back a minimum of 5 feet from both bridge abutments.

3.0 PREFERRED FISH LADDER TYPES

After exploring various types of fish ladders a pool and chute fish ladder was selected as the most appropriate for the site. This type of fish ladder can provide suitable passage conditions at high flows while passing debris and sediment relatively well. They consist of a series of weirs constructed out of concrete or sheet pile. Hydraulically, they produce streaming (chute) flow down the center of the ladder and plunging flow along the edges. The plunging flow is suitable for fish passage while the streaming flow within the chute increases the flow capacity of the ladder. Bates (2001) provides a detailed description of pool and chute ladders along with design procedures.

4.0 FISH PASSAGE DESIGN CRITERIA

Each developed alternative is intended to improve passage conditions for both adult and juvenile salmonids. Both the California Department of Fish and Game (DFG) and the NOAA Fisheries (formerly NMFS) have guidelines for adult and juvenile salmonid passage at road-stream crossings (CDFG, 2002; NMFS, 2001). The guidelines were written jointly and are intended to be functionally equivalent. The guidelines recognize that for retrofit of an existing crossing, meeting the hydraulic design criteria should be "a goal for improvement and not the required design threshold".

2.1 Fish Passage Design Flows

The low and high fish passage design flows define the range of flows that passage should be provided. Both NOAA Fisheries and DFG have recommended fish passage design flow criteria that are based on exceedance flows (Table 1). The low and high fish passage flows for juvenile salmonids, resident trout, and adult steelhead are estimated from exceedance flows for the site. Since San Anselmo Creek is not gaged, exceedance flows from two nearby stream gaging stations were utilized:

USGS Station No.:	11460100	11460000
Station Name:	Arroyo Corte Madera D Pres A Mill Valley	Corte Madera C A Ross
Drainage Area:	4.68 mi^2	18.1 mi^2
Years in Operation:	1965 -1986	1951 - 1993

The two streams have very similar flow characteristics and their drainage areas bracket the 8.5 mi^2 drainage area of San Anselmo Creek at Pastori Ave. Exceedence flows for the two streams were scaled by drainage area to develop a flow duration curve for the project site (Figure 2). From the flow duration curve passage design flows were obtained (Table 1).

Table 1 – Estimated fish passage design flow for San Anselmo Creek at Pastori Ave., based on DFG (2002) and NOAA Fisheries (NMFS, 2001) criteria.

Drainage Area = 8.5mi^2				
	Low Passage Flow		***High Passage Flow***	
Species and Lifestage	**Criteria**	**Flow**	**Criteria**	**Flow**
Juvenile Salmonids	Greater of 95% Exceedance Flow of 1 cfs	1 cfs	10% Exceedance Flow	26 cfs
Adult Rainbow Trout	Greater of 90% Exceedance Flow of 2 cfs	2 cfs	5% Exceedance Flow	61 cfs
Adult Steelhead	Greater of 50% Exceedance Flow of 3 cfs	3 cfs	1% Exceedance Flow	235 cfs

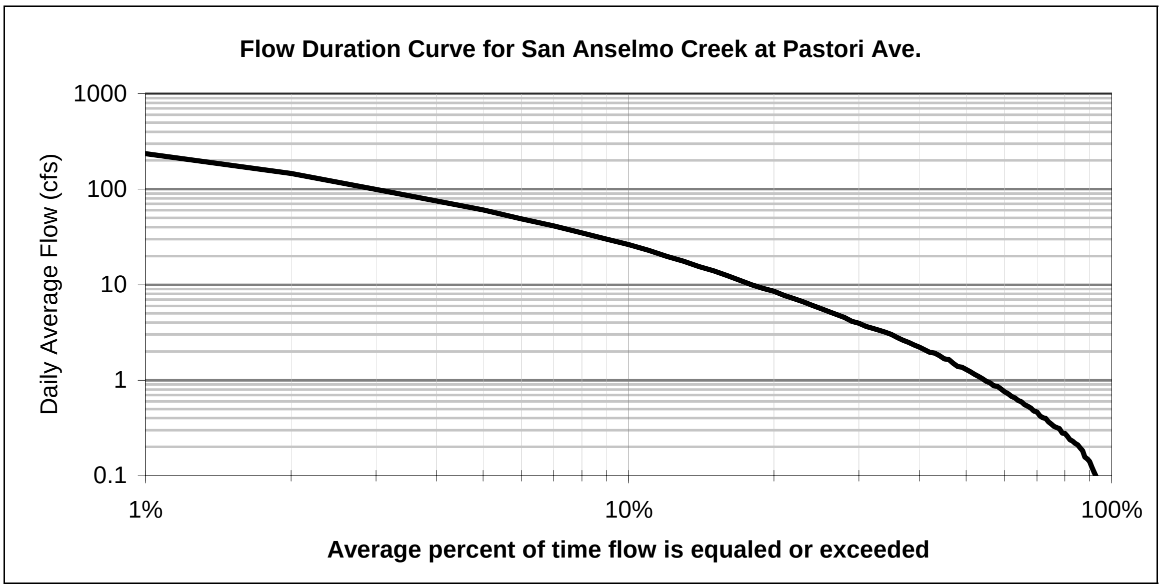


Figure 3 – Constructed annual flow duration curve for project site based on exceedance flows from two nearby gaged streams, scaled by drainage area.

2.2 Hydraulic Design Criteria

For hydraulic design of fish ladders, the DFG and NOAA Fisheries guidelines have the following applicable criteria:

Maximum drop between weirs
Juvenile Salmonids: 6 inches
Adult Steelhead: 12 inches

Additional criteria are provided by Bates (2001) for pool and chute fish ladder designs are listed below:

Minimum Pool Depth:	2.0 feet
Maximum EDF[1] Adult Rainbow Trout: Adult Steelhead:	 3.0 ft-lbs/s/ft^3 4.0 ft-lbs/s/ft^3
Acceptable Fish Ladder Slopes:	10% to 16%
Desired Fish Passage Corridor :	2.0 feet per side
Minimum attraction flow:[2]	25%

[1] Energy Dissipation Factor (EDF) is a measure of the amount of turbulence produced in the pool below each weir.
[2] Attraction flow is the percent of total stream flow contained within the fish ladder.

5.0 HYDRAULIC MODELING OF FISH LADDER ALTERNATIVES

A spreadsheet model was developed for analyzing fish passage hydraulics at various flows for different pool-and-chute fish ladder configurations. An empirically derived equation developed by Rajartanam (1988) was used for predicting the flow when streaming begins to occur within the chute.

For portions of the weir that contain plunging flow, the hydraulics were calculated using standard equations and coefficients for sharp crested V-shaped weirs (King, 1939). For portions of the weir that were partially submerged and still sustained plunging flow, the flow was adjusted using a submergence ratio (Villemonte, 1947).

For the streaming flow within the chute the weirs are submerged and act as large scale roughness elements. Streaming flow in the chute was modeled with the Chezy equation, which assumes uniform flow. Estimates of the Chezy roughness coefficients for chutes were obtained from values presented in Bates (2001), which were empirically derived from scale model tests.

Each of the developed alternatives includes bypass weirs, which concentrate allowing a portion of the flow to go around the ladder at high flows. Using bypass weirs will increase the operational flow range of the fish ladder. Flows over the bypass weirs were modeled using standard equations and coefficients for horizontal sharp crested weirs (King, 1939).

6.0 FINAL DEVELOPED FISH LADDER ALTERNATIVES

Three alternative fish ladder designs were developed. Although none of them completely meet all of the design criteria due to site constraints, they each provide varying levels of improvement for fish passage balanced against structure size and cost.

6.1 Alternative 1 – Pool and Chute Fish Ladder with 6 inch Drops

Alternative 1 consists of a 65.5 feet long by 13 feet wide (inside width) pool and chute fish ladder consisting of 6 inch drops between each weir (see attached schematic drawings). There are a total of 14 weirs, each spaced 5 feet apart to producing an overall fish ladder slope of 10%. The entrance of the ladder extends 9.5 feet into the existing scour pool below the apron and the ladder exit is placed 35 feet upstream of the apron.

Bypass weirs are placed at the top of the existing apron on both sides of the ladder. They are designed to concentrate low-flows into the ladder. At higher streamflows the flow is split, with a portion of it going over the spillway and the remaining proportion flowing directly into the ladder. To allow for adjustment and to fine-tune fish passage conditions the ladder is equipped with adjustable "flashboards" placed in slots along the spillway and within the chute of each weir. If vandalism is a concern, the flashboards can be constructed of rigid material, such as square steel tubing, and locked in place with tamper proof fasteners.

<u>6.1.1 Hydraulic Performance</u>

The design meets juvenile fish passage criteria by maintaining maximum drops of 6 inches between weirs. The Alternative 1 fish ladder is designed to function as a traditional pool and weir ladder with plunging flow at low flows, and then transition to streaming flow down the center and plunging flow along the edges once the chute becomes full (Figure 4). Table 2 provides a summary of fish passage conditions for this alternative based on the spillway flashboards set at a height of 6 inches (as shown on schematic drawings). This is considered the optimal setting based on modeling results and the desire to provide suitable passage conditions at both adult and juvenile migration flows. Flashboards could be lowered to increase bypass flow and improve adult passage at higher flows or raised to increase the attraction flow and improve ladder entrance conditions.

Flow within the chute transitions from the plunging to streaming regimes at approximately 4 cfs. This is roughly the average winter baseflow. The recommended minimum fish passage corridor of two feet per side is reached at the 6% exceedance flow of 53 cfs. Above this flow juvenile salmonids are likely to be unable to ascend the ladder, and conditions will be less than optimal for adult salmonids. The maximum recommended turbulence level for adult steelhead occurs at the 2% exceedance flow of 154 cfs, which is less than the recommended 1% exceedance flow, but is a dramatic improvement in fish passage compared to existing conditions.

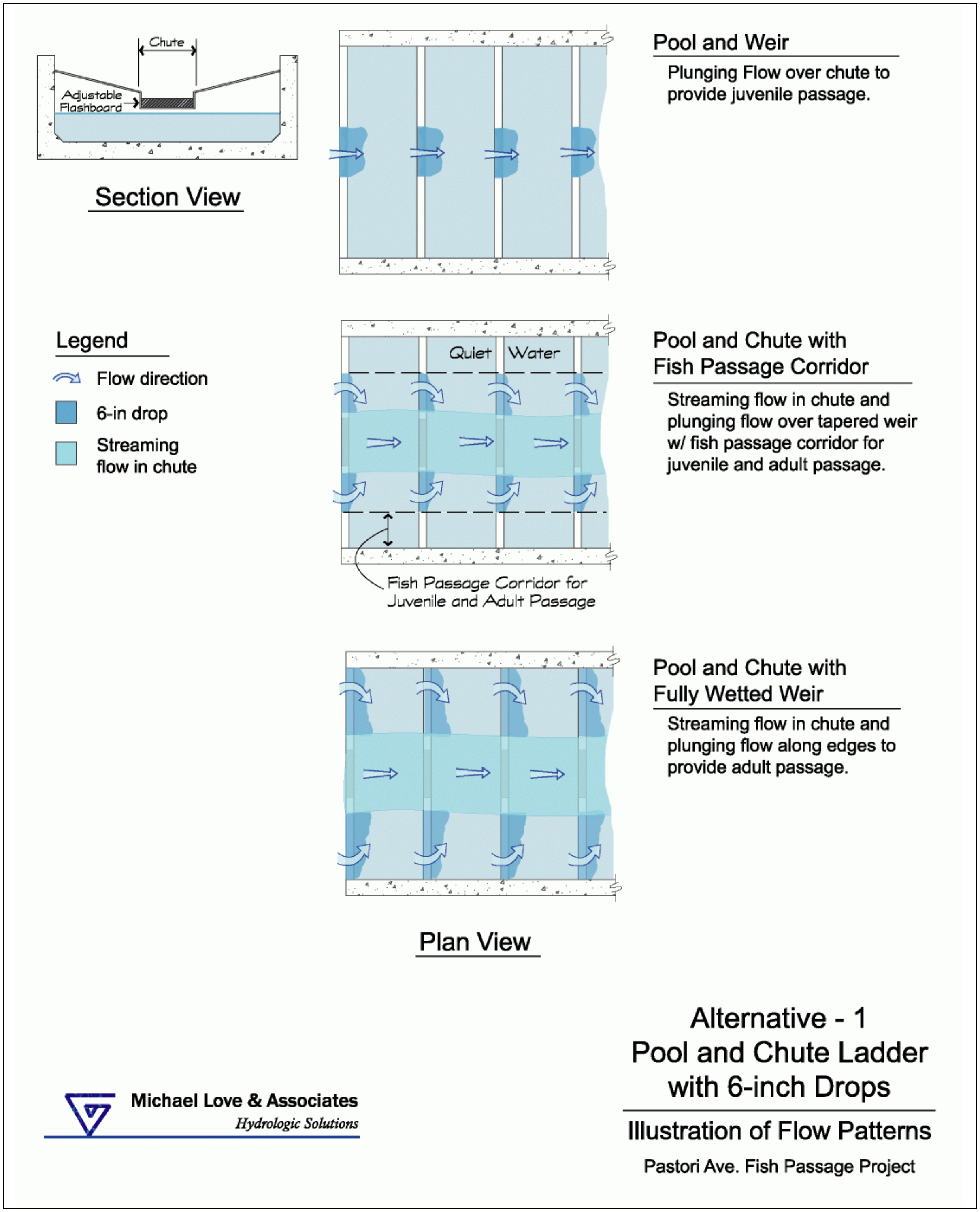


FIGURE 4 - Illustration of fish passage flow characteristics associated with Alternative 1.

Table 2 - Predicted hydraulic conditions for Pastori Ave. Alternative 1 – Pool and Chute Fish Ladder with 6 inch Drops. Flashboards in spillway are positioned at presumed optimal setting.

Weir Parameter	Transition to Streaming Flow[1]	Fish Passage Corridor of 2 feet	Maximum Turbulence (EDF) Resident Rainbow Trout	Maximum Turbulence (EDF) Adult Steelhead
Streamflow (Exceedance Flow)	4.1 cfs (29%)	53 cfs (6%)	111 cfs (3%)	154 cfs (2%)
Proportion of Flow in Ladder	100%	56%	52%	51%
Depth over Weirs	0.55 ft	1.16 ft	1.77 ft	1.97 ft
Length of Dry Weir per Side[2]	4.4 ft	2.0 ft	0	0
Energy Dissipation Factor (EDF)	0.7 ft-lb/s/ft^3	0.7-lb/s/ft^3	3.0 ft-lb/s/ft^3	4.0 ft-lb/s/ft^3

[1] Flow fills the chute and transitions from plunging to streaming.
[2] Weir becomes fully wetted (no dry weir) at a depth over weir of 1.65 ft.

6.2 Alternative 2 – Pool and Chute Fish Ladder with 9 inch Drops

Alternative 2 consists of a 48.5 feet long by 13 feet wide (inside width) pool and chute fish ladder consisting of 9 inch drops between each weir (see attached schematic drawings). There are a total of 9 weirs, each spaced 6 feet apart producing an overall fish ladder slope of 12.5%. The entrance of the ladder extends 9.5 feet into the existing scour pool below the apron and the ladder exit is placed 18 feet upstream of the apron.

The shape of the weirs is identical to Alternative 1, with the exception of the depth of the chute. Increasing the drops to 9 inches will reduce the length of the structure by 17 feet as compared to Alternative 1. However, increasing the drop heights will reduce the juvenile fish passage efficiency. Although juvenile salmonids are often observed leaping 9 inches or more in height (Lang et. al, 2004), they typically make numerous attempts before they are successful and often get washed back downstream.

Identical to Alternative 1, the bypass weirs are placed at the top of the existing apron on both sides of the ladder. They include flashboards to allow adjustment and to fine-tune fish passage conditions.

6.2.1 Hydraulic Performance

The Alternative 2 fish ladder is designed to function as a traditional pool and weir ladder at low flows, and then transition to having streaming flow down the center once the chute becomes full, similar to the Alternative 1 ladder (Figure 5). Table 3 provides a summary of hydraulic and fish passage conditions for this alternative based on having the spillway flashboards set at a height of 4 inches.

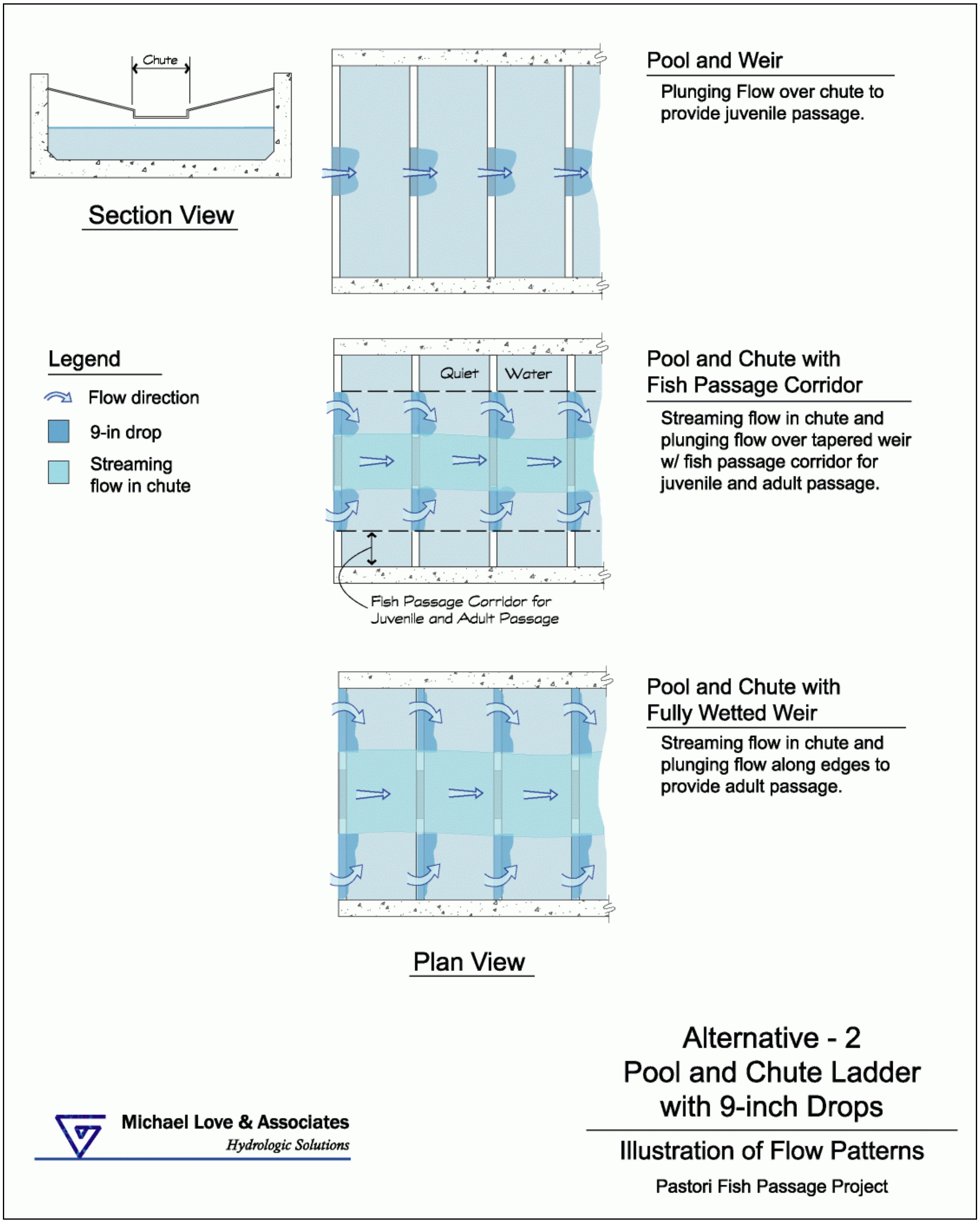


FIGURE 5 - Illustration of fish passage flow characteristics associated with Alternative 2.

Table 3 - Predicted hydraulic conditions for Pastori Ave. Alternative 2 – Pool and Chute Fish Ladder with 9 inch Drops. Flashboards in spillway are positioned at presumed optimal setting.

Weir Parameter	Transition to Streaming Flow[1]	Fish Passage Corridor of 2 feet	Maximum Turbulence (EDF) Resident Rainbow Trout	Maximum Turbulence (EDF) Adult Steelhead
Streamflow (Exceedance Flow)	6.9 cfs (23%)	62 cfs (5%)	131 cfs (3%)	153 cfs (2%)
Proportion of Flow in Ladder	82%	58%	54%	53%
Depth over Weirs	0.78 ft	1.36 ft	1.88 ft	2.05 ft
Length of Dry Weir per Side[2]	4.3 ft	2.0 ft	0	0
Energy Dissipation Factor (EDF)	1.4 ft-lb/s/ft^3	0.7 ft-lb/s/ft^3	3.0 ft-lb/s/ft^3	4.0 ft-lb/s/ft^3

[1] Flow fills the chute and transitions from plunging to streaming.
[2] Weir becomes fully wetted (no dry weir) at a depth over weir of 1.85 ft.

Flow within the chute transitions from the plunging to streaming regimes at approximately 7 cfs, which is higher then the average winter baseflow. The recommended minimum fish passage corridor of two feet per side is reached at the 5% exceedance flow of 62 cfs. Above this flow juvenile salmonids are likely unable to ascend the ladder, and conditions will be less than optimal for adult salmonids. The maximum recommended turbulence level for adult steelhead occurs during the 2% exceedance flow of 153 cfs, which is less than the recommended 1% exceedance flow, but is a dramatic improvement in fish passage compared to existing conditions.

6.3 Alternative 3 – Two-Stage Pool and Chute Fish Ladder

Alternative 3 is a Two-Stage Pool and Chute Fish Ladder. This design minimizes the overall length of the structure while improving fish passage conditions. It consists of a 42.5 feet long by 16 feet wide (inside width) hybrid pool and chute fish ladder. This relatively unique fish ladder design functions in two very distinct flow regimes. At lower flows the water plunges over a series of switchbacks weirs, creating a meandering flow pattern (Figure 6). These switchback weirs produce 6 inch drops, suitable for juvenile salmonid passage. As flow increases, water begins to stream down the chute in the center of the ladder, functioning as a pool and chute ladder. The pool and chute weirs are spaced 7 feet apart and produce 1 foot drops, suitable for adult steelhead passage. The overall slope of the fish ladder is 14%. The entrance of the ladder extends 7 feet into the existing scour pool below the apron and the ladder exit is placed 14 feet upstream of the apron.

Similar to Alternatives 1 and 2, the bypass weirs are placed at the top of the existing apron on both sides of the ladder. Each spillway includes flashboards to allow for some adjustment to fine-tune fish passage conditions. However, given that this ladder is wider than in the other alternatives, the spillway widths are reduced.

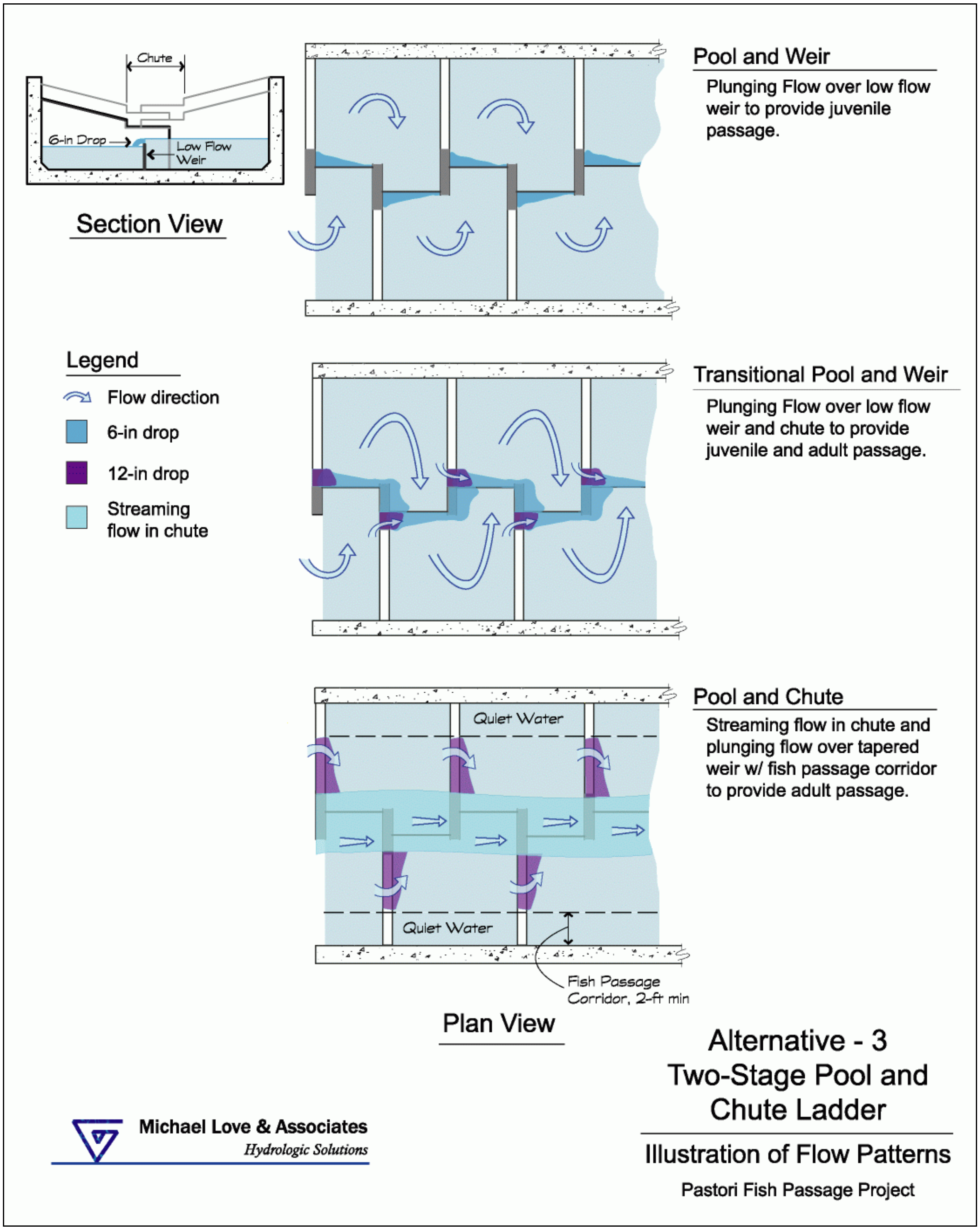


FIGURE 6 - Illustration of fish passage flow characteristics associated with Alternative 3.

6.2.1 Hydraulic Performance

The Alternative 3 fish ladder is designed to function as a pool and weir ladder with a meandering flow pattern and 6 inch drops at low flows. At higher flow the hydraulics transition to streaming flow down the chute and plunging flow over the weirs with 12 inch drops. Table 4 provides a summary of hydraulic and fish passage conditions for this alternative based on having the spillway flashboards set at a height of 5 inches.

Table 4 - Predicted hydraulic conditions for Pastori Ave. Alternative 3 – Two Stage Pool and Chute Fish Ladder. Flashboards in spillway are positioned at presumed optimal setting.

Weir Parameter	Low Flow Weir Full[1]	Fish Passage Corridor of 2 feet	Maximum Turbulence (EDF) Resident Rainbow Trout	Maximum Turbulence (EDF) Adult Steelhead
Streamflow (Exceedance Flow)	2.5 cfs (38%)	80 cfs (4%)	122 cfs (3%)	146 cfs (2%)
Proportion of Flow in Ladder	100%	72%	69%	68%
Depth over Weirs	0.7 ft	1.5 ft	1.9 ft	2.0 ft
Length of Dry Weir per Side[2]	0	2.0 ft	0.6 ft	0
Energy Dissipation Factor (EDF)	0.7 ft-lb/s/ft^3	1.4 ft-lb/s/ft^3	3.0 ft-lb/s/ft^3	4.0 ft-lb/s/ft^3

[1] Flow fills switchback low-flow weirs. At higher flow the drop transitions from 6 inches to 12 inches.

[2] Low-flow switchback weir becomes fully wetted at a depth of 0.7 feet and the high flow weir becomes fully wetted at a depth over weir of 2.0 ft.

Flow fills the switchback weir at 2.5 cfs, which is roughly the winter base flow. Up to this flow the ladder will have 6 inch drops to allow for juvenile passage. As flow increases water will begin flowing over the high flow weirs producing 12 inch drops. At about 6 cfs (25% exceedance flow) flow is expected to begin to stream down the chute, with 12 inch drop over the high-flow weirs. The recommended minimum fish passage corridor of two feet is reached at the 4% exceedance flow of 80 cfs. Above this turbulence within the pool could become excessive due to the shape and placement of the weirs associated with this alternative. The maximum recommended turbulence level for adult steelhead occurs near 2% exceedance flow, at 146 cfs.

This type of fish ladder is somewhat experimental. The concept is derived from a similar fish ladder constructed on Kenny Creek in Washington State (Bates, per. com.). It was designed to function for fish passage only in the switchback flow regime. However, at higher flows it appears to continue to provide fish passage over the high-flow weirs (Figure 7). This ladder type was developed as an attempt to minimize its overall length.

If Alternative 3 appears to be the preferred alternative, it will require further hydraulic analysis to finalize the design.

FIGURE 7 – Photos of Kenny Creek "two stage" pool and chute fish ladder at fish passage flows (left) with 0.8 ft drops and at higher flows (right) with 1.6 ft drops (photos by K. Bates)

7.0 COMPARISON OF ALTERNATIVES

Alternative 1 meets all juvenile salmonid passage criteria. It also will also provide preferred adult steelhead passage conditions (2 ft fish passage corridor per side) up to the 5% exceedance flow and likely provide adults with suitable passage conditions up to the 2% exceedance flow. However, this alternative has the largest footprint and the highest associated cost.

Alternative 2 provides less than ideal conditions for juvenile passage since it contains 9 inch drops between weirs. However, leap heights of 9 inches is well within many juvenile salmonids' leaping abilities, and this ladder is expected to provide passage to a large proportion of the upstream moving juvenile salmonid population. For adult steelhead, Alternative 2 performs approximately same as Alternative 1. However, this alternative has a smaller footprint and lower associated cost.

Alternative 3 is the most innovative design and has the smallest footprint and similar cost to Alternative 2. However, it likely only provides passage to juveniles at flows up to moderate winter baseflow conditions. Additionally, adult steelhead passage will likely be less effective as flows increase above the 4% exceedance flow (80 cfs) due to turbulence and the lack of an adequate fish passage corridor

8.0 REFERENCES

Bates, K. 2001. *Fishway Design Guidelines for Pacific Salmon*. Working paper 1.6 9/2001 Washington Department of Fish and Wildlife.

California Department of Fish and Game (CDFG). 2002. *Culvert criteria for fish passage*. 17 pages.

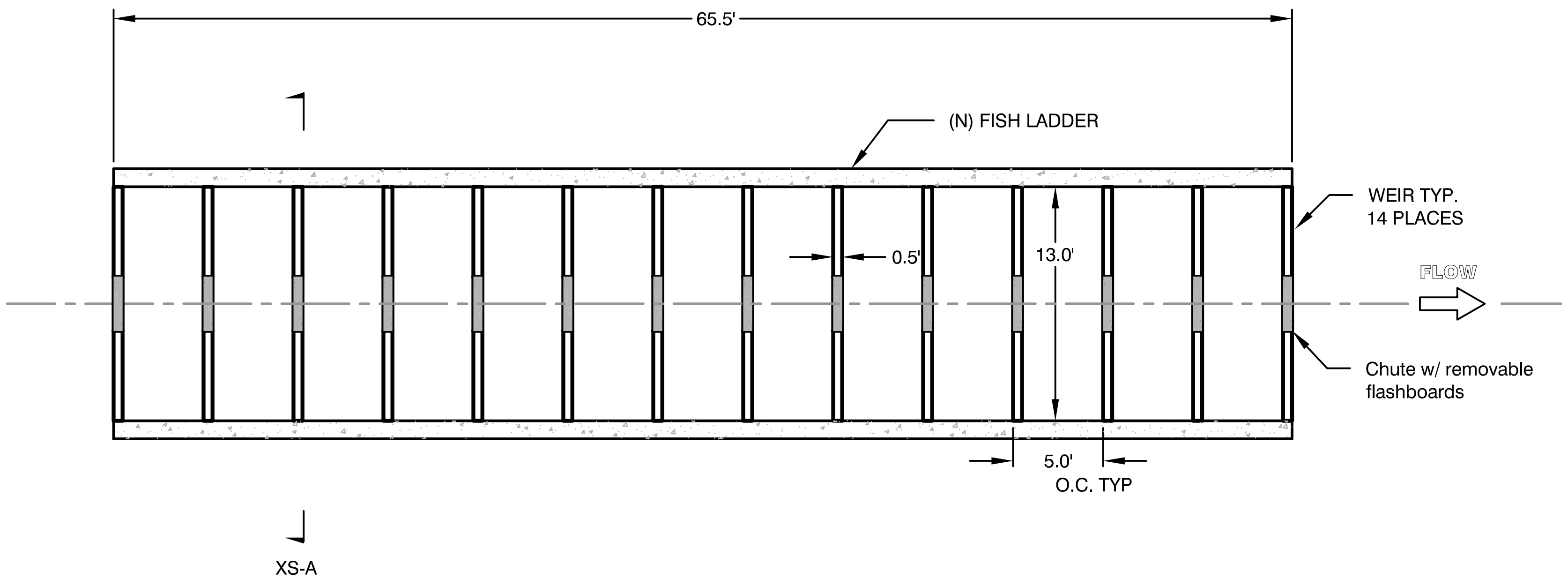
King, H.W. 1939. *Handbook of Hydraulics*, Third Edition, McGraw Hill Book Company

Lang, M., Love, M., and Trush, W., 2004. "Improving Stream Crossings for Fish Passage." *Rep. No. 50ABNF800082,* National Marine Fisheries Service.

National Marine Fisheries Service (NMFS). 2001. *Guidelines for salmonid passage at stream crossings*. NMFS SW Region. 14 pages.

Rajaratnam, N. 1988. *Plunging and Streaming Flows in Pool and Weir Fishways.* Journal of Hydraulic Engineering ASCE. Vol. 114 No.8 Paper No. 22697-2

Taylor, Ross. 2003. Marin County Stream Crossing Inventory and Fish Passage Evaluation: Final Report. Prepared for the County of Marin, Dept. of Public Works.



PLAN
Scale: 1"=10'

ABBREVIATIONS:

APPROX – APPROXIMATE
CONC – CONCRETE
EL – ELEVATION
O.C. – ON CENTER
TYP – TYPICAL
XS – CROSS SECTION

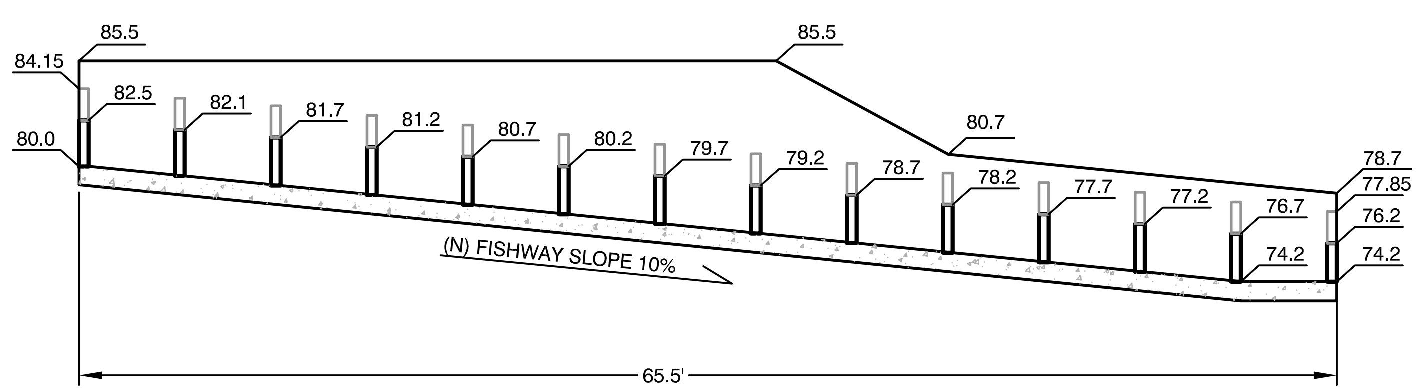
(N) – NEW
(E) – EXISTING

0 5 10
SCALE IN FEET
1" = 10'

NOTES:

1. DROP HEIGHTS FOR WEIR CRESTS IS 0.50' EXCEPT FOR THE UPSTREAM TWO WEIRS WHICH HAVE A DROP OF 0.40'.
2. ALL CONCRETE TO BE CUT AND BLENDED TO NEW WORK AS DIRECTED BY A STRUCTURAL ENGINEER.
3. NEW CONCRETE TO BE REINFORCED AS DIRECTED BY STRUCTURAL ENGINEER.
4. 2" STAINLESS STEEL ANGLE IRON TO BE PLACED FLUSH WITH TOP AND UPSTREAM EDGE OF ALL WEIRS
5. BASIS OF ELEVATIONS, SITE SURVEY DATA PROVIDED BY STETSON ENGINEERING DATE __/__/__.

DRAFT
NOT FOR CONSTRUCTION



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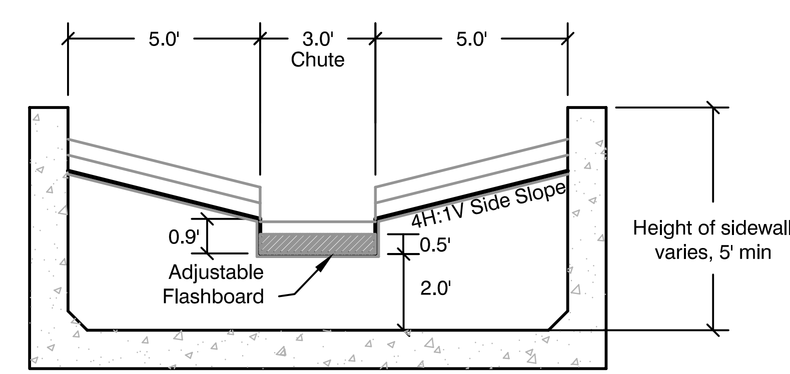

Section A
Scale: 1"=5'
Looking Upstream

San Anselmo Ck at Pastori Ave. Fish Passage Project
FRIENDS OF CORTE MADERA CREEK WATERSHED
DESIGN: ML/AL DRAWN: AL
JOB: Pastori Saunders 5/31/06 Sheet 1of 3

Alternative 1 - Pool and Chute Ladder with 6 inch Drops

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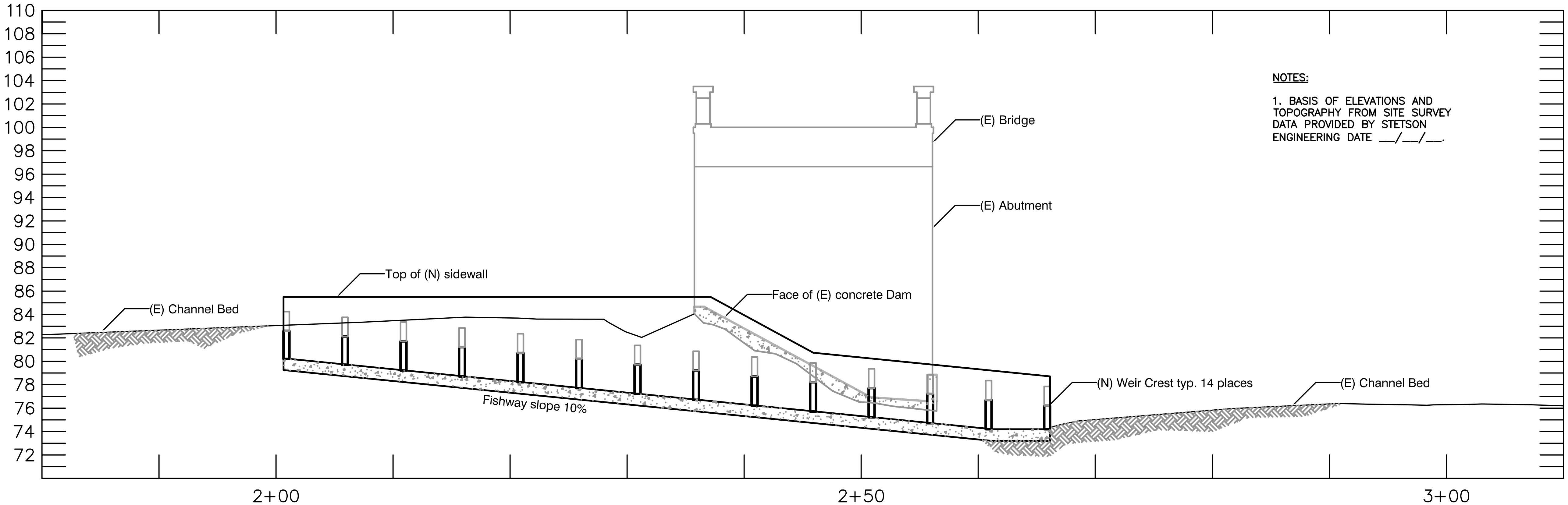

NOTES:

1. BASIS OF ELEVATIONS AND TOPOGRAPHY FROM SITE SURVEY DATA PROVIDED BY STETSON ENGINEERING DATE __/__/__.

PROFILE

Scale: 1"=10'

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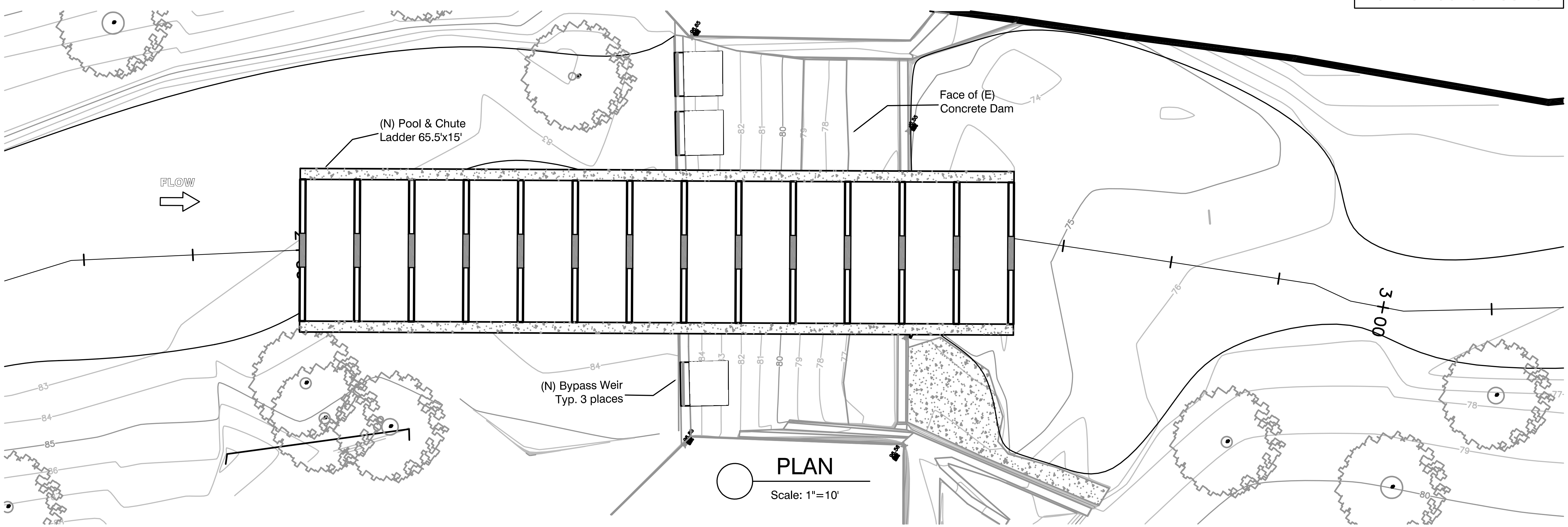

PLAN

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San Anselmo Ck at Pastori Ave. Fish Passage Project

FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL

JOB: Pastori Saunders 5/31/06

Sheet 2 of 3

Alternative 1 - Pool and Chute Ladder with 6 inch Drops

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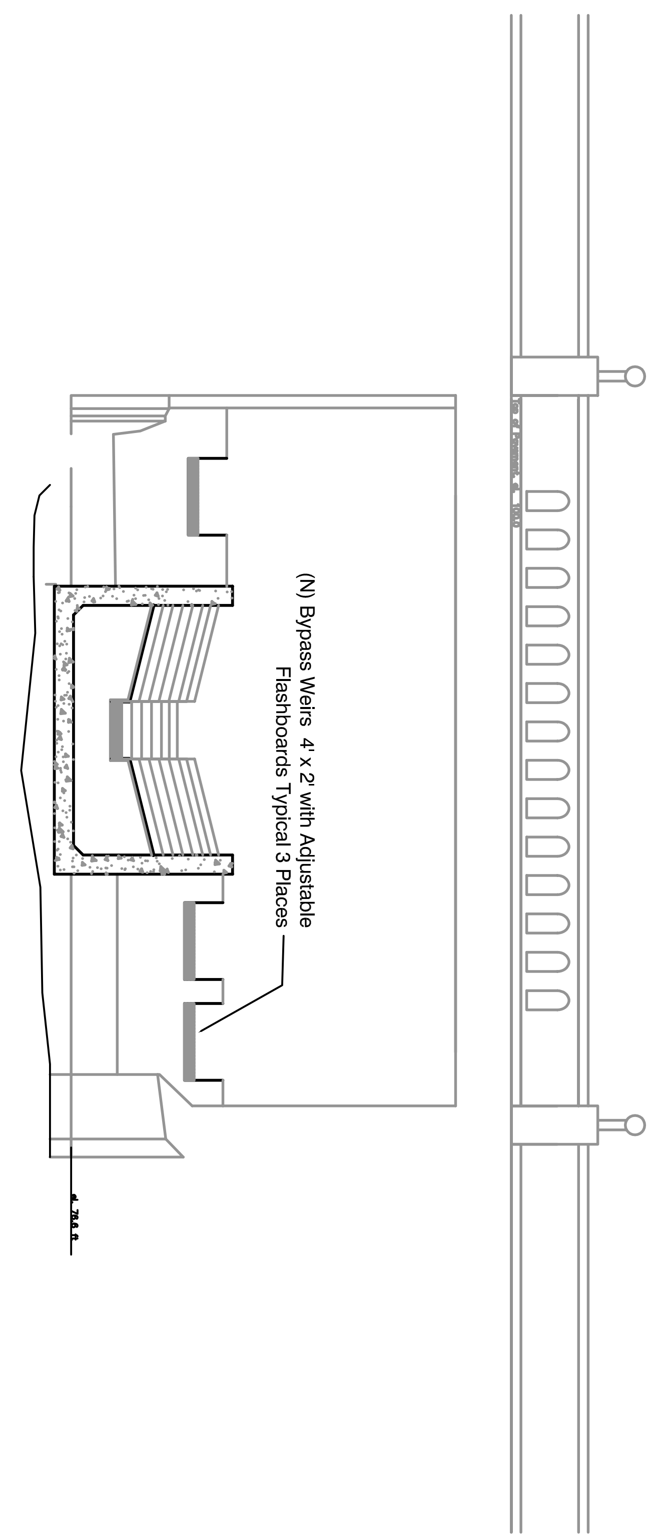

Section at Crest of (E) Dam

Scale: 1"=10'

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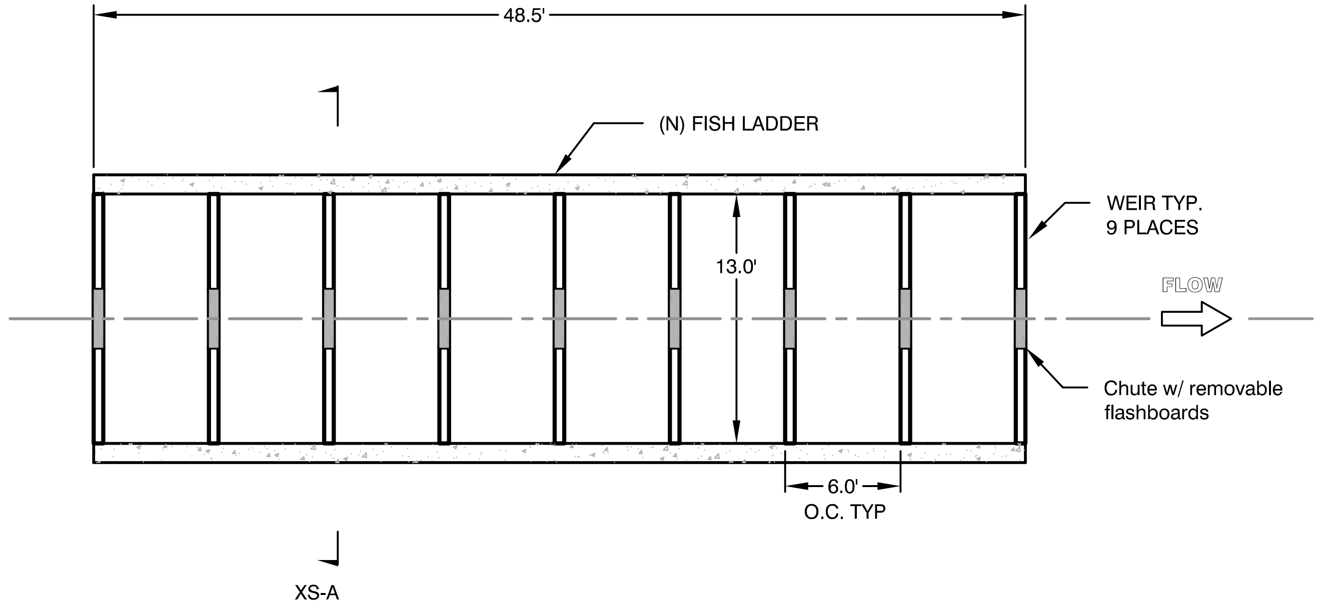
Alternative 1 - Pool and Chute Ladder with 6 inch Drops

San Anselmo Ck at Pastori Ave. Fish Passage Project

FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL

JOB: Pastori Saunders 5/31/06



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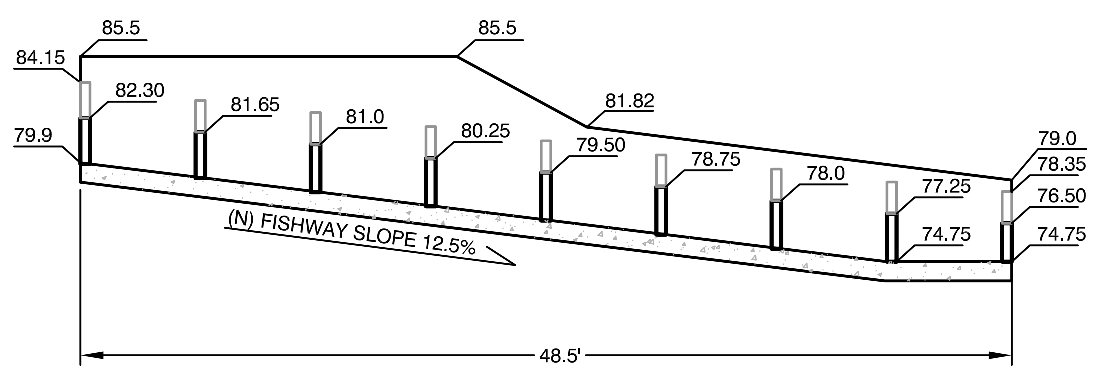
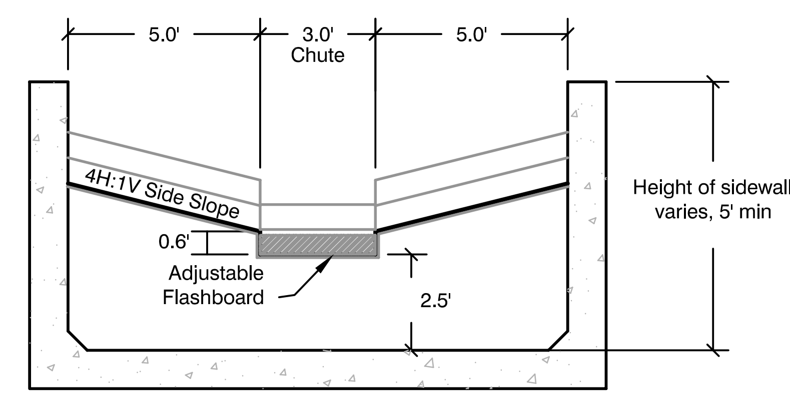


ELEVATION
Scale: 1"=10'

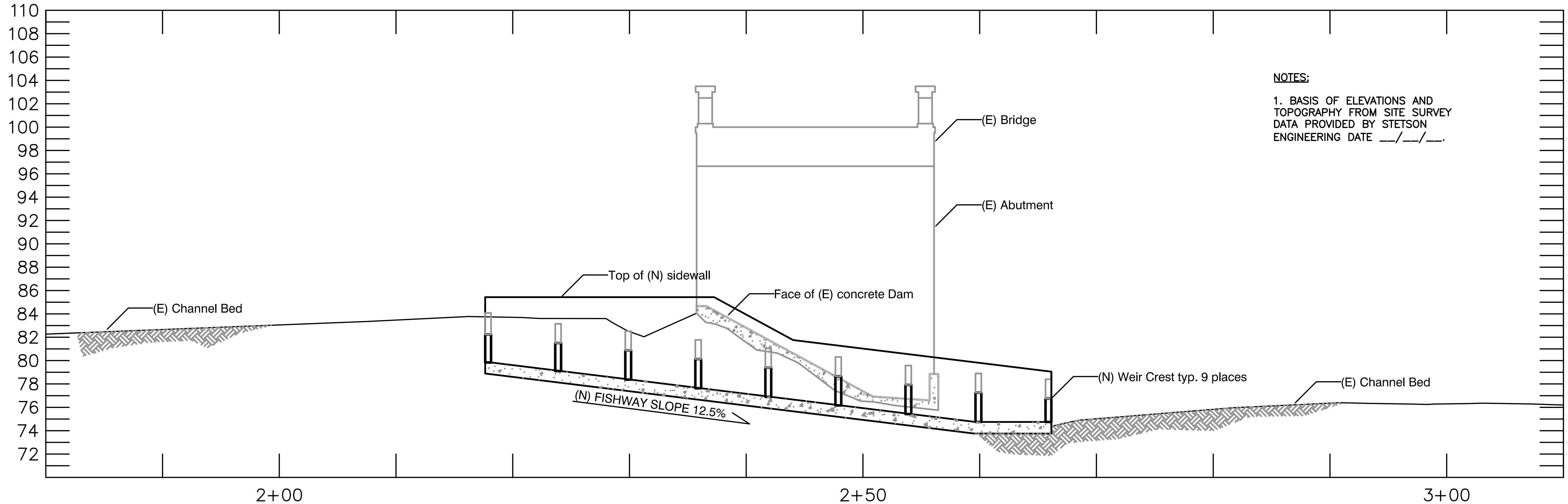


Section A
Looking Upstream
Scale: 1"=5'

San Anselmo Ck at Pastori Ave. Fish Passage Project FRIENDS OF CORTE MADERA CREEK WATERSHED	DESIGN: ML/AL DRAWN: AL JOB: Pastori Saunders 5/31/06 Sheet 1 of 3

Alternative 2 - Pool and Chute Ladder with 9 inch Drops

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 ● Arcata, CA 95518 ● (707) 476-8938

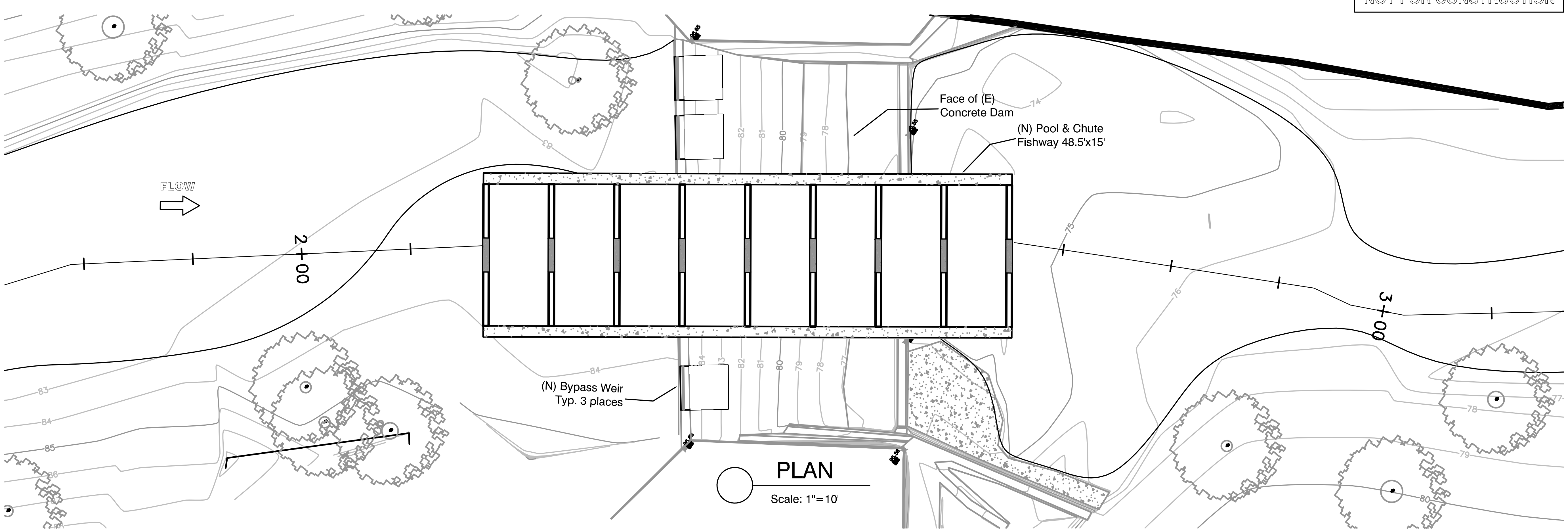


PROFILE

Scale: 1"=10'

DRAFT

NOT FOR CONSTRUCTION



PLAN

Scale: 1"=10'

San Anselmo Ck at Pastori Ave. Fish Passage Project

FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL

JOB: Pastori Saunders 5/31/06

Sheet 2 of 3

Alternative 2 - Pool and Chute Ladder with 9 inch Drops

Michael Love & Associates
Hydrologic Solutions
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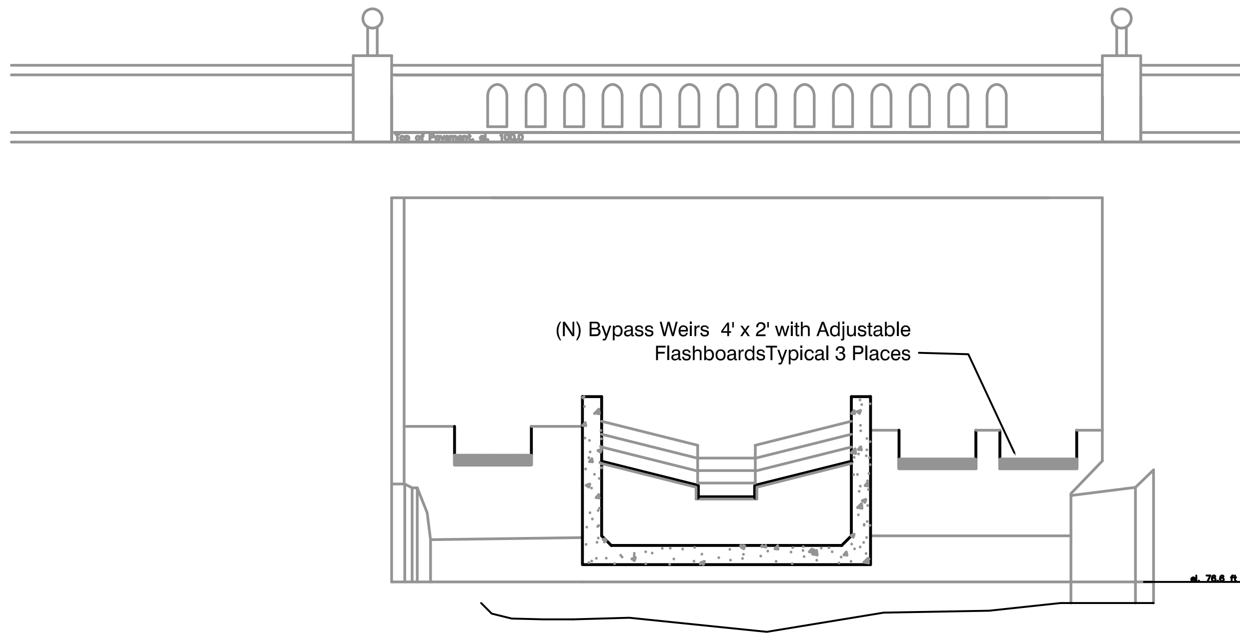

SECTION AT
CREST OF (E) DAM

Scale: 1"=10'

DRAFT
NOT FOR CONSTRUCTION

San Anselmo Ck at Pastori Ave. Fish Passage Project
FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL
JOB: Pastori Saunders 5/31/06

Sheet 3 of 3

Alternative 2 - Pool and Chute Ladder with 9 inch Drops

Michael Love & Associates
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PO Box 4477 • Arcata, CA 95518 • (707) 476-8938

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ABBREVIATIONS:

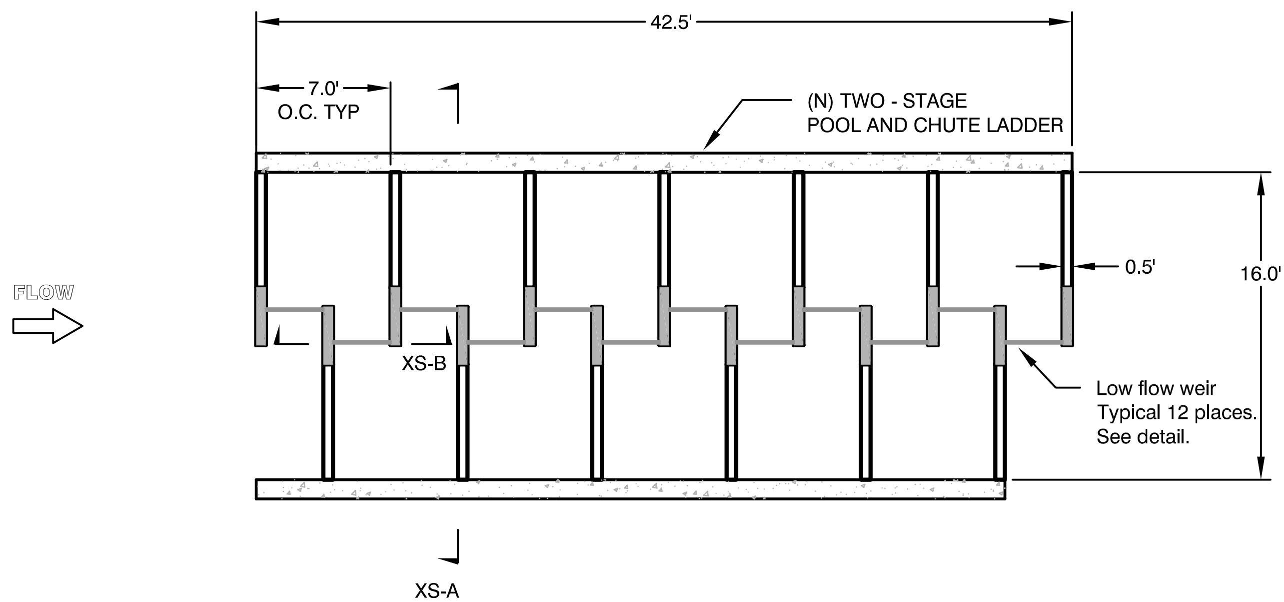
APPROX – APPROXIMATE
CONC – CONCRETE
EL – ELEVATION
O.C. – ON CENTER
TYP – TYPICAL
XS – CROSS SECTION

(N) – NEW
(E) – EXISTING

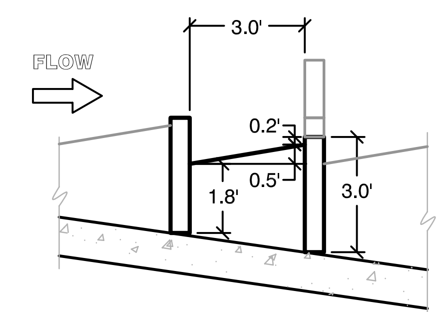
0 5 10
SCALE IN FEET
1" = 10'

NOTES:

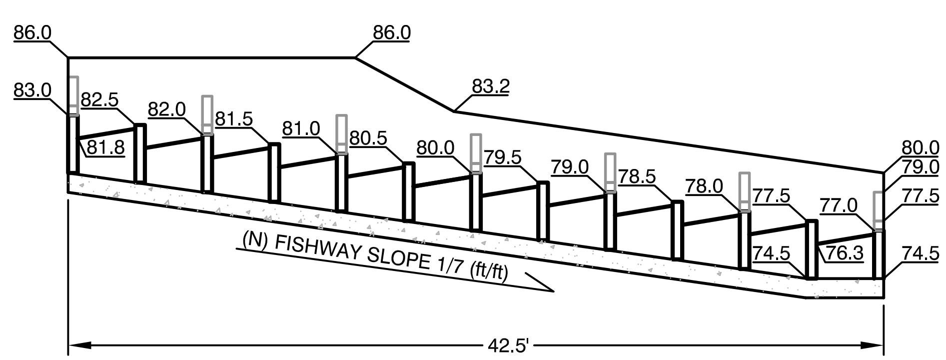
1. BASIS OF ELEVATIONS, SITE SURVEY DATA PROVIDED BY STETSON ENGINEERING DATE __/__/__.
2. ALL CONCRETE TO BE CUT AND BLENDED TO NEW WORK AS DIRECTED BY A STRUCTURAL ENGINEER.
3. NEW CONCRETE TO BE REINFORCED AS DIRECTED BY STRUCTURAL ENGINEER.
4. 2" STAINLESS STEEL ANGLE IRON TO BE PLACED FLUSH WITH TOP AND UPSTREAM EDGE OF ALL WEIRS



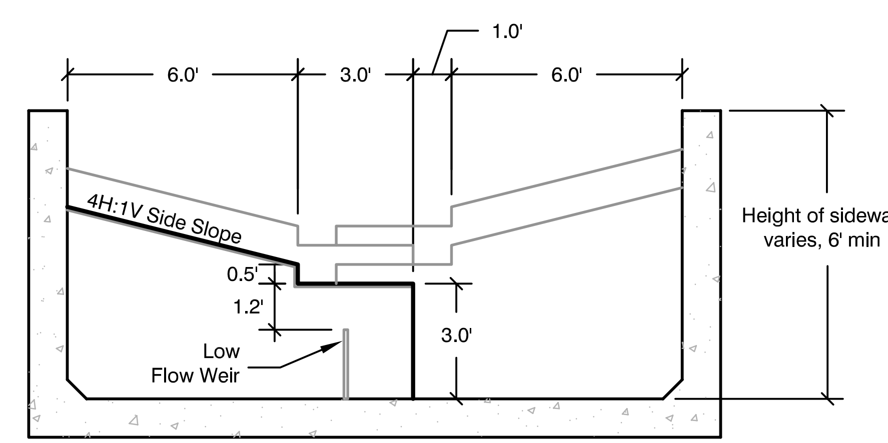
PLAN
Scale: 1"=10'



Section B
Low Flow Weir Detail
Scale: 1"=5'



ELEVATION
Scale: 1"=10'



Section A
Looking Upstream
Scale: 1"=5'

San Anselmo Ck at Pastori Ave. Fish Passage Project
FRIENDS OF CORTE MADERA CREEK WATERSHED
DESIGN: ML/AL DRAWN: AL
JOB: Pastori Saunders 5/31/06
Sheet 1of 3

Alternative 3 - Two Stage Pool and Chute Ladder

Michael Love & Associates
Hydrologic Solutions
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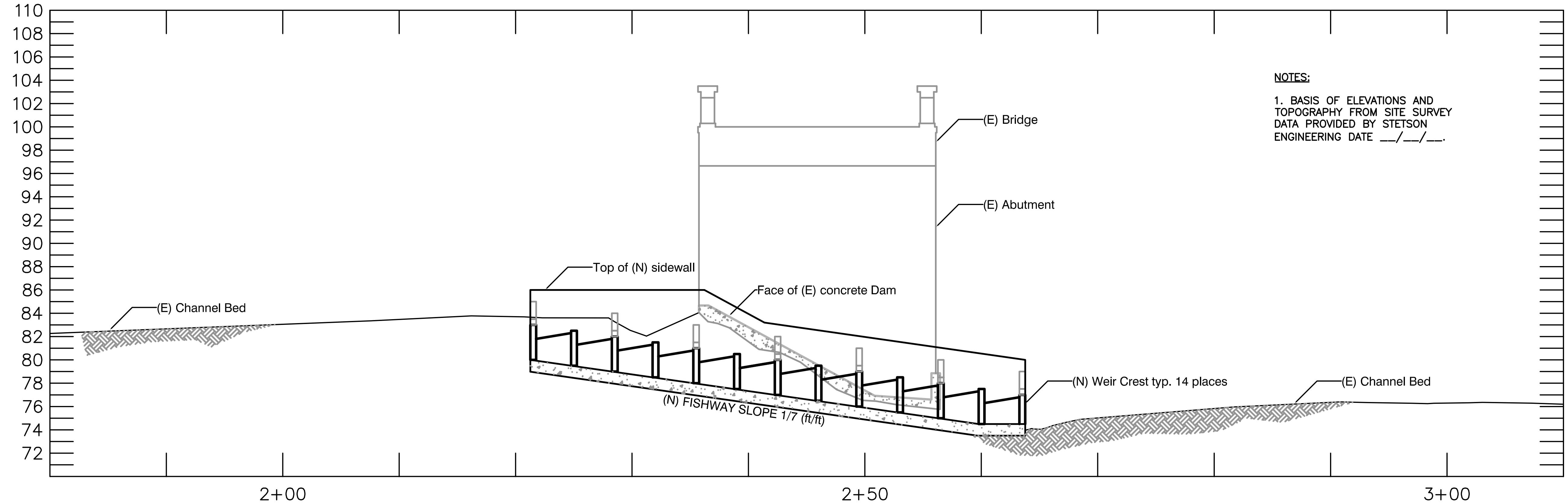

NOTES:

1. BASIS OF ELEVATIONS AND TOPOGRAPHY FROM SITE SURVEY DATA PROVIDED BY STETSON ENGINEERING DATE __/__/__.

PROFILE

Scale: 1"=10'

DRAFT

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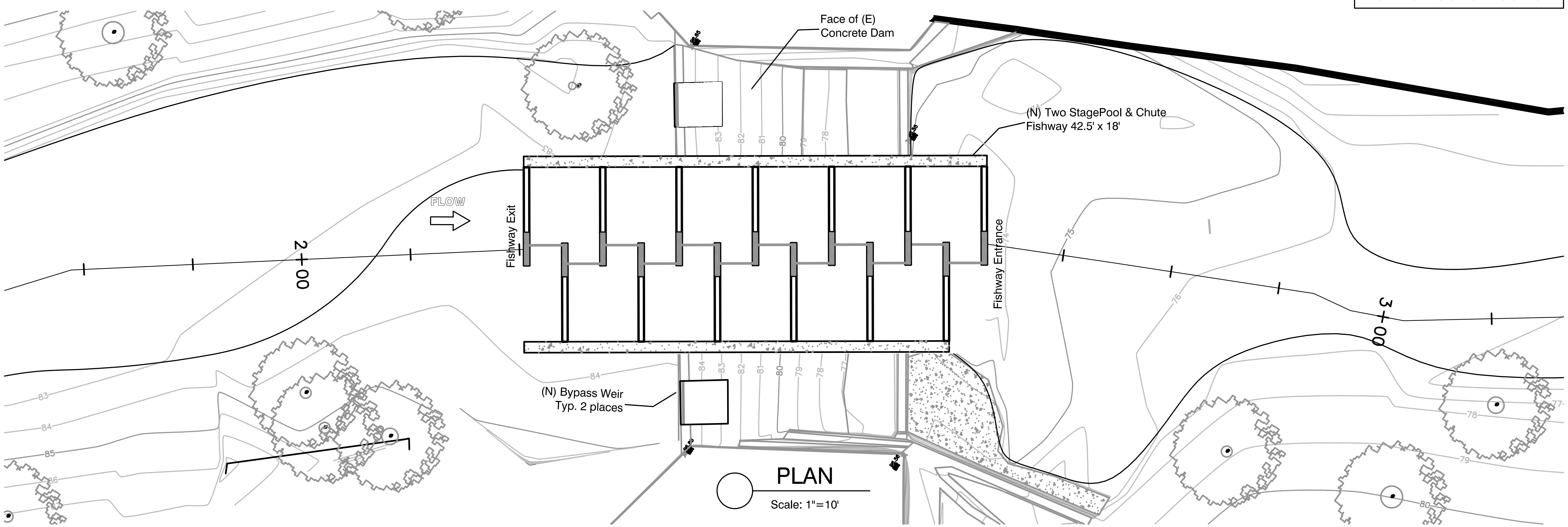

PLAN

Scale: 1"=10'

San Anselmo Ck at Pastori Ave. Fish Passage Project

FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL

JOB: Pastori Saunders 5/31/06

Sheet 2 of 3

Alternative 3 - Two Stage Pool and Chute Ladder

Michael Love & Associates
Hydrologic Solutions
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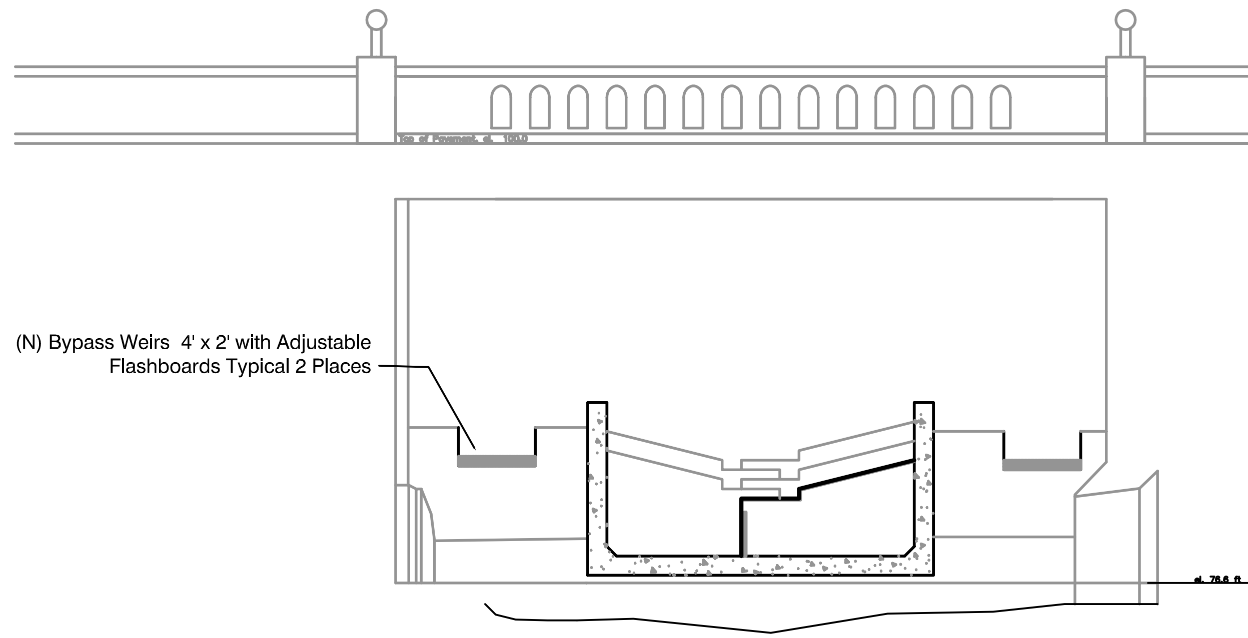

Section at Crest of (E) Dam

Scale: 1"=10'

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San Anselmo Ck at Pastori Ave. Fish Passage Project
FRIENDS OF CORTE MADERA CREEK WATERSHED

DESIGN: ML/AL DRAWN: AL
JOB: Pastori Saunders 5/31/06

Alternative 3 - Two Stage Pool and Chute Ladder

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 476-8938

Preliminary Cost Estimation
Pastori Crossing Fish Passage Project
Alternative 1 - Pool and Chute Fishway with 6-inch Drops

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Cost	Remarks
1	Mobilization and demobilization	1	LS	9,000	9,000	
2	Demolish & remove existing concrete	20	cy	500	10,000	13' + 4' = 17' wide cut by 30' long
3	Care of creek during construction	1	LS	2,000	2,000	
4	Earthwork excavation	310	cy	80	24,800	17' x 70' x 7'
5	Place and compact base material	40	cy	140	5,600	assume 12-inch thick
6	Structural concrete footing	40	cy	800	32,000	assume 12-inch thick
7	Structural concrete side walls	42	cy	800	33,600	assume 12-inch thick
8	Structural concrete baffles	20	cy	800	16,000	14 required, assume 6" thick
9	Adjustable flash boards	14	each	200	2,800	
10	Bypass weirs	3	each	500	1,500	
11	Rock riprap	20	ton	150	3,000	
12	Backfill, earth at side walls	38	cy	100	3,800	
13	Backfill, concrete at side walls	7	cy	800	5,600	
14	**Subtotal Construction**				**149,700**	
15	Contingencies and unlisted items @25%				37,400	
16	**Subtotal Construction and Cont.**				**187,100**	
17	Engineering and Permitting @20%				37,400	
18	Construction Inspection @10%				18,700	
19	**Subtotal Eng., Permit., Insp.**				**56,100**	
20	**Total**				**243,200**	

Notes:

1 Cost estimate based on Alternative 1- Pool and Chute Fishway with 6" Drops prepared by Michael Love & Associates Dated 11/01/05

November 8, 2005
f:\data\2128\Analysis\Pastori Alternative 1Cost Estimate.xls

Preliminary Cost Estimation
Pastori Crossing Fish Passage Project
Alternative 3 - Two Stage Pool and Chute Ladder

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Cost	Remarks
1	Mobilization and demobilization	1	LS	9,000	9,000	
2	Demolish & remove existing concrete	22	cy	500	11,000	16' + 4' = 20' wide cut by 30' long
3	Care of creek during construction	1	LS	2,000	2,000	
4	Earthwork excavation	240	cy	80	19,200	20' x 45' x 7'
5	Place and compact base material	30	cy	140	4,200	assume 12-inch thick
6	Structural concrete footing	30	cy	800	24,000	assume 12-inch thick
7	Structural concrete side walls	23	cy	800	18,400	assume 12-inch thick
8	Structural concrete weirs	15	cy	800	12,000	13 required, assume 10" thick
9	Bypass weirs	2	each	500	1,000	
10	Rock riprap	20	ton	150	3,000	
11	Backfill, earth at side walls	16	cy	100	1,600	
12	Backfill, concrete at side walls	7	cy	800	5,600	
13	**Subtotal Construction**				**111,000**	
14	Contingencies and unlisted items @25%				27,800	
15	**Subtotal Construction and Cont.**				**138,800**	
16	Engineering and Permitting @20%				27,800	
17	Construction Inspection @10%				13,900	
18	**Subtotal Eng., Permit., Insp.**				**41,700**	
19	**Total**				**180,500**	

Notes:

1 Cost estimate based on Alternative 2- Two Stage Pool and Chute Ladder prepared by Michael Love & Associates Dated 11/01/05

November 8, 2005

f:\data\2128\Analysis\Pastori Alternative 2 Cost Estimate.xls