ALTERNATIVES ANALYSIS

PASTORI STORM DRAIN OUTFALL

TOWN OF FAIRFAX, CALIFORNIA

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Hydrology and Hydraulic Analysis

INTRODUCTION

During the disaster event, street runoff from the December 31, 2005 flood caused the suspended terminal section of an 24-inch CMP to fail and discharge stormwater directly onto the bank beneath the failed culvert, on the left bank of San Anselmo Creek (looking downstream) immediately downstream from Pastori Avenue Bridge. During the disaster event, the Town placed emergency rock rip rap on the eroded bank to protect the bridge and the adjacent residence from further bank erosion. The culvert outlet needs to be replaced and the bank stabilized to prevent against another minor bank failure immediately downstream.

There is a related condition that must be taken into consideration when replacing the culvert outlet. The Town of Fairfax has experienced localized flooding in the area of Kent Avenue and Belle Avenue in the vicinity of Pastori Avenue. The storm drain system upstream of the Pastori Avenue culvert outlet was unable to effectively convey storm water from the north side of Sir Frances Drake Boulevard (SFDB), causing the storm water to flow across SFDB into the residential area of Kent Avenue and Belle Avenue. It is suspected that the existing storm drain line in SFDB is dilapidated and in need of replacement. The line was video inspected and found to be in disrepair. This Alternatives Analysis focuses on the impacts of alternatives related to the size of the outfall pipe and improvements/rehabilitation of pipes upstream.

The Pastori Avenue Bridge crossing immediately upstream is a concrete-bottom reinforced box culvert that was modified to contain a steel-fabricated denil-type fish ladder in approximately the 1970s. Ross Taylor and Associates (2006) identified the Pastori Avenue Bridge fish ladder as a priority for replacement to improve fish passage in the watershed. Detailed conceptual fish ladder replacement designs (not part of this project) have been prepared by Michael Love and Associates that would preserve the existing abutments and footings for the bridge. The RSP (rock slope protection) Energy Dissipation Structure with Large Woody Debris Channel Margin proposed for the Pastori Storm Drain Outfall will not impact any of the fish ladder replacement alternatives.

EXISTING CONDITIONS

The existing conditions affecting the size of the outfall pipe replacement and improvements/rehabilitation of pipes upstream are described below.

1. Flooding

   Severe flooding in the residential neighborhood around Kent Avenue, Belle Avenue, and Hill Avenue, in the Town of Fairfax, has been observed during moderately sized storm events. Flooding occurs due to the undersized and deteriorated Pastori Avenue outfall watershed storm drain system. Over taxing of the storm drain system results in flooding at low points surrounding inlets. Significant flooding is occurring during small recurrence interval storm events.

   Flooding around Kent Avenue, Belle Avenue, and Hill Avenue is also due to storm water crossing Sir Francis Drake Boulevard (SFDB), due to undersized and deteriorated pipes in SFDB. The additional runoff, in conjunction with an undersized system, produces considerable flooding.

   Historically, an undersized 24-inch storm drain main in Pastori Avenue contributed to flooding in the Kent Avenue, Belle Avenue, and Hill Avenue area. As a part of the Pastori Avenue Pavement Overlay project a 48-inch storm drain main was installed. The upsized main provides additional capacity in the storm drain system during storm events.

2. Deteriorated Pipes

   The existing storm drain system is largely comprised of vitrified clay pipe (VCP). The existing VCP pipes have cracked or broken over their lifespan and no longer convey storm water flows effectively. In particular, the VCP pipes in SFDB were video inspected and found to be dilapidated. At one point the inspection device was unable to continue through the pipe.

3. Undersized Pipes

   The existing storm drain pipes in SFDB and the outfall at Pastori Avenue are insufficiently sized to convey the 10- and 100- year storm recurrence interval flows. The existing storm drain system consists of a 24-inch VCP outfall, a 48-inch High Density Polyethylene (HDPE) main in Pastori Avenue, an 18-inch VCP main in SFDB, and several smaller feeder pipes.

   The previous 24-inch VCP storm drain main in Pastori Avenue was replaced with the 48-inch HDPE main. The upgrade was installed ahead of other storm drain

improvements due to the Pastori Avenue repaving project, which presented an ideal time to replace the main line. The new 48-inch storm drain main in Pastori Avenue is appropriately sized to convey the design storm flows. However, the system upstream of Pastori Avenue and the outfall are undersized. The undersized outfall to San Anselmo Creek produces creek eroding velocities.

4. Pollutants

Pollutants of concern, during small rain events, are oil, grease, and heavy metals due to vehicle break pads. During flood conditions additional pollutants such as landscape fertilizer and other household pollutants may also be introduced to the storm water runoff.

ALTERNATIVES

The intent of the Hydrology and Hydraulic Analysis that was prepared for the Pastori Storm Drain Outfall was to evaluate the storm drain system in four scenarios (described below), determine the flow rate and velocity of storm water entering San Anselmo Creek at the Pastori Avenue outfall for the four scenarios, and determine if localized flooding is expected to occur.

1. Historic Condition (Scenario 1): The storm drain system prior to the installation of the 48-inch pipe within Pastori Avenue. See Figure 1, "Storm Drain System," in the Figures section of the Hydrology and Hydraulic Analysis in the Appendix of this Alternatives Analysis.

2. Current Condition (Scenario 2): The existing storm drain system (see Figure 1, "Storm Drain System") with the 48-inch pipe within Pastori Avenue and the 24-inch outfall to San Anselmo Creek.

3. Proposed Condition (Scenario 3): The proposed storm drain system (see Figure 1, "Storm Drain System") with the 48-inch pipe within Pastori Avenue and the 48-inch outfall to San Anselmo Creek.

4. Future Condition (Scenario 4): The probable future storm drain system (see Figure 1, "Storm Drain System") with the 48-inch pipe within Pastori Avenue, the 48-inch outfall to San Anselmo Creek, and improvement/rehabilitation of the upstream pipes.

The analysis methodology, assumptions and results of the analysis are provided on pages 1-6 in the Hydrology and Hydraulic Analysis located in the Appendix to this report. The conclusions from the Analysis are below. Any references to appendices are referring to the appendices in the Hydrology and Hydraulic Analysis.

- There is a large reduction in velocities from Scenarios 1 and 2 to Scenarios 3 and 4 that is due to the increase in the outfall pipe diameter from 24-inches to 48-inches.The outfall velocities calculated for Scenario 1, Historic Condition, vary from 43.89 fps to 61.33 fps, depending on the storm recurrence interval being analyzed. Velocities calculated for Scenario 2, Current Condition, range from 43.18 fps to 60.64 fps. Scenario 2 outfall velocities are slightly reduced from Scenario 1 due to the installation of the 48-inch storm drain main in Pastori Avenue. The outfall velocities calculated for Scenario 3, Proposed Condition, vary from 11.11 fps to 15.28 fps. Velocities calculated for Scenario 4, Future Condition, range from 10.92 fps to 15.03 fps.

- The large reduction in velocities and the small reduction in flow rates is due to the changes in the storm drain system which cause the system to go from pressure flow to gravity flow. Scenario 1, Historic Condition, and Scenario 2, Current Condition, both with a 24-inch outfall pipe, are under pressure flow. This is likely the result of an

under capacity outfall pipe and water ponding/ flooding upstream of the system, creating hydraulic head which forces the storm water into the storm drain system and to exit the outfall at a high velocity. As such, the peak discharges seen in Scenario 1 and Scenario 2 are largely due to the storm water being forced through the storm drain system rapidly. The peak discharge for Scenario 2 is less than that of Scenario 1 due to the 48-inch storm drain main in Pastori Avenue. The 48-inch main in Scenario 2 is adequately sized to convey the design storm. As such the storm water in the 48-inch main does not experience pressure force until it reaches the 24-inch outfall, which slightly reduces the peak discharge over that experienced in Scenario 1. Peak discharge is calculated based on the time it takes for storm water to travel from the furthest point in the watershed to the outfall. When a storm drain system is under pressure flow, the travel time is reduced and the peak discharge is increased (see Appendix D through Appendix G for Tc).

- Scenario 3, Proposed Condition, and Scenario 4, Future Condition, both with a 48-inch outfall pipe, are under gravity flow. This is due to the larger pipes and inlets allowing storm water to be more efficiently conveyed through the storm drain system. Scenario 3 has an adequately sized outfall. As such the pipe velocity through Pastori Avenue to the outfall is slower than that modeled under Scenario 2. As such, the peak discharge is slightly smaller. However, the storm drain pipes in SFDB are still undersized and force storm water through at a faster rate then Scenario 4. Scenario 4, one possible storm drain upgrade, includes improvements to SFDB. These improvements create a more effectively sized storm drain system over Scenario 3 and produce a longer travel time in the watershed creating a slightly reduced peak discharge.

- The changes in flow rates or discharge at the Pastori Avenue outfall, through each scenario, are minor. The same volume of storm water is entering San Anselmo Creek through each scenario analyzed, however, the time at which the flow peaks and the rate of the peak flow vary. There is only an approximate 3% reduction in peak discharge to San Anselmo Creek from Scenario 1, Historic Condition, to Scenario 4, Future Condition. Given the peak flow rates discussed in this analysis, the change in flow rate between each scenario is statistically negligible.

- The ponding/ flooding is reduced from Scenario 1, Historic Condition, to Scenario 4, Future Condition. There are two reasons why ponding occurs: First, localized flooding is expected to occur where the HGL exceeds the ground surface elevation. With each improvement to the storm drain pipe system, in each consecutive scenario, the expected level of flooding or ponding is decreased (see Appendix D through Appendix G, for predicted HGL elevations of the pipe systems). Second, localized flooding is expected to occur due to incapacity of the grate and/or curb opening of the inlets. With each improvement to the storm drain pipe system, in each consecutive scenario, while HGLs decrease due to increased pipe capacity, inlet depth and spread

remain constant (see Table 4: Inlet Depth and Spread and Appendix H through Appendix K for inlet calculation results).

As seen in Table 3, the hydraulic model predicts that during a 10-year recurrence interval storm event, under Scenario 4, Future Condition, there will be no flooding or ponding. However, flooding or ponding may occur during the 25-, 50-, and 100-year recurrence interval storm event.

The storm drain system analyzed in Scenario 4, Future Condition, is one possible solution to the storm water issues in the Kent Avenue and Belle Avenue area. Other solutions include, but are not limited to, routing the storm water from the intersection of Kent Avenue and SFDB through the residential neighborhood and connecting to the Pastori Avenue 48-inch line at a deeper point in the system. Another option is to direct the storm water from the City of San Anselmo side of the Pastori Avenue outfall watershed to another outfall discharging to the San Anselmo Creek.

IMPACTS OF EACH ALTERNATIVE

The impacts of each alternative as related to creek flows - local effects, fish passage suitability, aquatic habitat, creek flows - downstream flooding effects, Pastori Bridge and pollutants are presented below.

1. Creek Flows - local effects

   a. Peak flows - local effects on flooding. San Anselmo Creek peak flow discharges at the Pastori Avenue Bridge crossing can be estimated using drainage area ratio extrapolation from estimated in the 1977 Flood Insurance Study for the Town of Fairfax prepared by the U.S. Department of Housing and Urban Development (HUD). Using this method, the estimated San Anselmo Creek 10-year peak discharge at the Pastori Bridge crossing is about 1,900-2,000 cfs, and the 100-year discharge is about 3,600-4,000 cfs. The estimated 500-year peak discharge is about 4,700-5,100 cfs, or about 1,100 cfs greater than the estimated 100-year discharge.

      According to HUD (1977) and recently updated FEMA floodplain mapping, this section of San Anselmo Creek upstream and downstream from Pastori Avenue Bridge contains both the entire estimated 100-year and 500-year flood discharges without overtopping the banks. In other words, in this local area, the existing San Anselmo Creek channel can accommodate approximately 1,100 cfs more than the estimated 100-year peak discharge without initiating overbank flooding.

      For the various alternatives (scenarios) evaluated by the Hydrology & Hydraulics Study, the estimated 10-year and 100-year peak flow discharges from the Pastori Avenue stormwater drain outfall would range from 133.7 to 137.9 cfs, and from 187.3 to 192.6 cfs, respectively. Note that the differences in peak outflow discharge between alternatives are approx. 4-5 cfs. Therefore, none of the alternatives would cause the local peak flow to approach or exceed the estimated 500-year flood discharge, and none of the alternatives would cause local flooding.

   b. In-channel flow velocities - local effects on bed and bank erosion and habitat suitability. The original pre-failure outfall (Scenario 1) was a 24-inch-diameter extension of the 24-inch-diameter stormwater pipe which turned down the creek bank with what appeared to have been a 45-degree elbow fitting on the downstream face of the bridge abutment. Failure of the original outfall facility was likely due to the excessively high pressure flow passing through the undersized 24-inch-diameter culvert putting excessive forces on the 45-degree elbow.

In Scenario 1, the original, or historic, 24-inch outfall directed approximately 43.9 feet per second (fps) (10-yr) to 61.3 fps (100-yr) exit velocity discharges directly into the low-flow water surface of the existing plunge pool, probably contributing to the unusual deepness of the plunge pool along its left bank margin. In the current condition (Scenario 2), with the outfall pipe blow off, the existing 24-inch outfall spills approximately 43.2 fps (10-yr) to 60.6 fps (100-yr) exit velocity discharges onto the temporarily protected bank. Scenarios including a 48-inch diameter outfall reduce the exit velocity by about 75% because of the enlarged outlet opening size and reduced pressure flow in the downstream section of the stormwater system. Exit velocities for both Scenario 3 & 4 range from about 11 fps (10-yr) to about 15 fps (100-yr).

All of the alternatives would produce lesser effects of plunge pool bed scour than did the original outfall, because none of the alternatives would turn down the stormwater flows directly into the pool with a 45-degree elbow. Instead, stormwater discharges would fall onto a rip-rap slope protection energy dissipation structure with incorporated large woody debris at the channel margin. This way, the stormwater discharges from the alternative replacement outfalls, even if they were substantially greater than the original 24-inch-diameter outfall issued, would produce less focused, more broadly distributed and lower velocity flows entering the existing plunge pool.

Downstream from the plunge pool, there would not be appreciable differences in the San Anselmo Creek velocities resulting from the various alternatives or as compared to the original outfall configuration. This is because extremely turbulent flows occurring in the plunge pool dominate any such hydraulic effects.

Theoretically, if the Project were to cause greater peak flow discharges entering San Anselmo Creek from the Pastori Avenue storm drain system, it may then marginally increase the magnitude of near-bed and near-bank high velocity currents, and this way increase the instantaneous maximum peak shear stresses and average shear stresses felt on the bed and banks near and downstream from the outfall. Instantaneous peak shear stresses cannot be reliably computed, but channel-averaged shear stresses generally go with depth. Some of the differences in peak flow discharge are made up by increased velocity, not depth, especially in this relatively steep section of the creek. According to hydraulic principles, it is reasonable to estimate that a five percent increase in local peak flow resulting from the range of alternatives evaluated in this study would produce a 0.25 percent increase in instantaneous channel-averaged shear stress. However, the Hydrology & Hydraulics Analysis estimates that Scenarios 2, 3, and 4 would produce less peak flow discharge to San Anselmo Creek than did Scenario 1 (Historic Condition). Therefore, no impacts from

local bed scour differences are expected to result from any Project alternatives.

San Anselmo Creek downstream from Pastori Avenue Bridge is geomorphically unique from other sections within the urbanized mainstem valley floor. Beginning about 700 ft downstream from the bridge, the right bank is formed by a tectonically-influenced rapidly (in geologic-geomorphic) terms mass wasting or downslope creeping landslide complex (e.g., Smith et al. 2006). The steep stream bed in that reach is notable for its seemingly chaotic bedforms comprised of large boulders leftover as "lag deposits" from frequent past landslides onto the bed. So, within the first approx. 700 ft downstream from the bridge, there is potential for increased bank erosion at the right bank. However, there are no structures located nearer than several hundred feet from the top of bank within the single property parcel forming that bank. Again, the theoretical marginal increase in right bank erosion potential is on the order of 0.25 percent. This is the instantaneous maximum difference (i.e., lasting several minutes). The actual, annual average or long-term average difference is negligible. Moreover, hydraulic model calculations suggest that peak flow discharges will be reduced from Historic Condition, or increased by about 0.2 cfs from the Current Condition - these peak flow discharges would produce negligible impacts on high velocity currents and bed and bank scour and erosion potential.

In the Spring of 2006, after the December 31, 2005 flood, the Town of Fairfax contracted with Fluvial Geomorphology Consulting (FGC) to prepare a detailed geomorphology study of San Anselmo and Fairfax Creeks within the Town limits, including several public property sites damaged by the floods. As part of this effort, Fluvial Geomorphology Consulting and Stetson Engineers Inc. (2006) field delineated and mapped individual sections of the streambanks downstream from Pastori Avenue Bridge. That study identified three separate chronically erosion-prone sections of right bank within the 970-ft-long reach downstream from the bridge within town limits: (1) an approx. 70-ft-long section of approx. 1(H):2.5(V)-sloped, 18-20-ft-high bank beginning approximately 230 ft downstream from the bridge (Site RB_B*-3); (2) an approx. 100-ft-long section of approx. 1(H):2.5(V)-sloped, 18-20-ft-high bank beginning about 600 ft downstream from the bridge (Site RB_B*-2); and (3) an approx. 250-ft-long section of steeply-sloped 35-40-ft-high and higher aforementioned landslide body complex (Site RB_B*-1). The study recommended that limited grading and erosion control measures be taken to reduce mid- and upper bank erosion at the upstream 66-ft-long site where there is a riparian canopy gap, but recognized that feasibility was limited by dense riparian tree coverage. The study concluded that the other right bank sites could not be feasibly stabilized. Indeed, the extent of bank erosion in the 1,000-ft long reach downstream from the bridge is a natural artifact of the

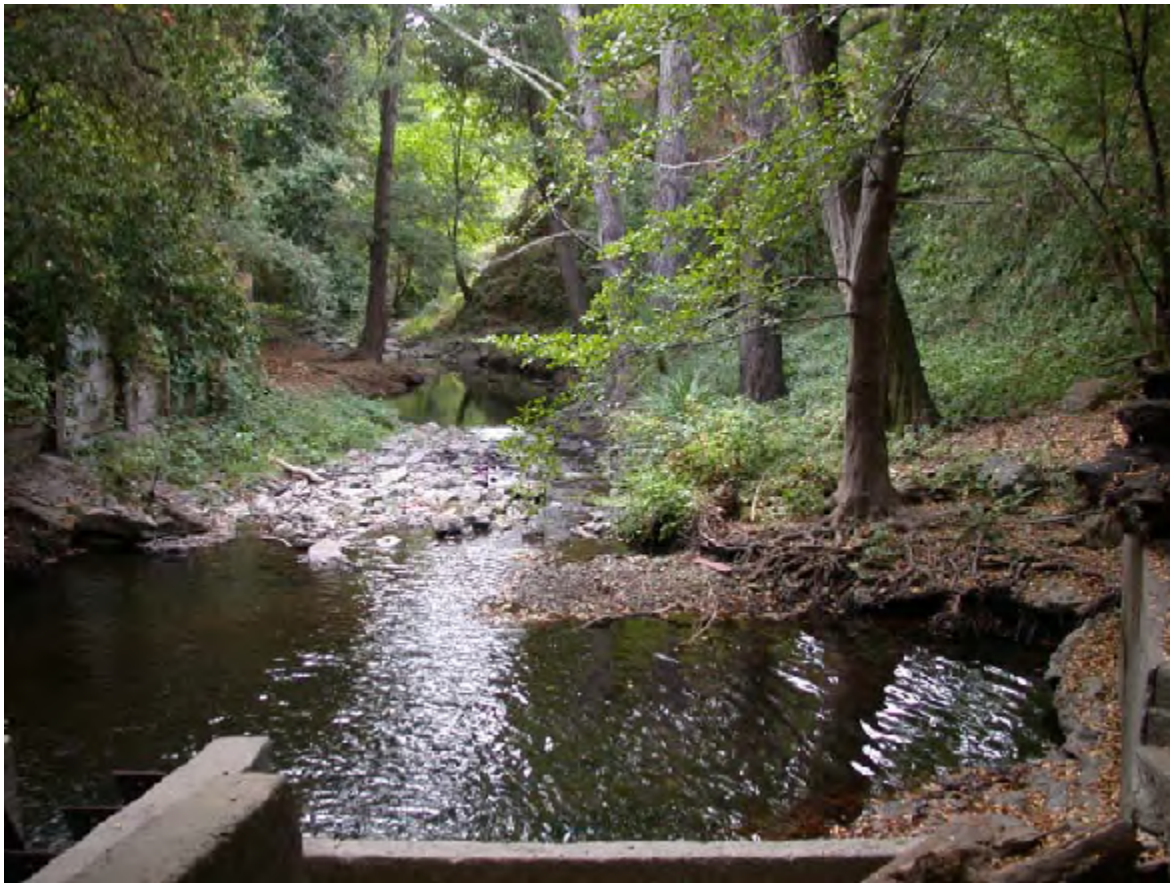
tectonically-influenced geomorphic processes there. Dense clay exposed in the toe of the bank at the two upstream most sites indicates that the toe of the bank is eroding laterally relatively slowly.

The study identified only one erosion prone section of the left bank, an approx. 30-ft-long section of the left bank beginning about 35 ft downstream from the bridge where there is an existing residential retaining wall in poor/failing condition (Site LB_B*-1). Erosion potential at that site appears to be a function of the failing condition of the wall exacerbated by erosion pressure caused by San Anselmo Creek at high stages, not related to discharges from the Pastori Avenue stormwater outfall. It has not been confirmed, but it may also be that stormwater exceeding the capacity of the Pastori Avenue stormwater drainage network pools on Pastori Avenue and contributes to bank erosion at LB_B*-1 by spilling onto that residential property and over the bank where the wall is failing.

None of the alternatives for Pastori Avenue outfall replacement affect the recommendations made for the erosion-prone bank sections identified by the geomorphology study within 1,000 ft downstream from the bridge because the erosion problems identified were mid- and upper bank erosion in the non-cohesive oversteepened upper bank materials, where the theoretical maximum marginal 0.25 percent increase in bed and bank shear stress would not be felt.

Overall, velocity effects on local bed and bank erosion appear to be clearly less than significant, and, incidentally, nonetheless potentially entirely mitigated by the three proposed mitigation measures, discussed below (Energy Dissipation Structure with Large Woody Debris Channel Margin, Town of Fairfax Stormwater Management Ordinance, Ross Valley Flood Reduction Feasibility Study).

Notably, the 2006 geomorphology study also recommended that the left bank beneath the then-failed Pastori Avenue outfall be reinforced with rip-rap slope protection, similar to the proposed alternatives evaluated herein.



*San Anselmo Creek downstream from the Pastori Avenue Bridge. Site RB_B*3 is in the background of view.*

2. Fish Passage Suitability

The Pastori Avenue Bridge is a barrier to fish passage by salmonids (Ross Taylor and Associates 2006). In approximately 1975, the bridge structure was fitted with a concrete and steel "Alaskan steeppass-type" fish ladder to improve fish passage, but the structure functions poorly. The Friends of Corte Madera Creek sponsored a study by Michael Love and Associates to develop and compare alternatives for removing and replacing the fish ladder to improve fish passage as far as feasible. Michael Love and Associates (2006) first recognized that natural stream restoration or "natural grade" alternatives for fish passage improvement were not generally feasible because they would require massive filling downstream from the bridge and massive cutting upstream from the bridge. The Fair-Anselm Plaza shopping center upstream

from the bridge has several pier footings in the channel bed which may be compromised by bed elevation changes. Moreover, "natural grade" alternatives would require reconstructing the abutments and abutment footings for the Pastori Avenue Bridge, the existing footings being of unknown construction. Both natural channel restoration or "natural grade" type and grade-controlled roughened-rock ramp type passage structures were determined, in general, to be prohibitively expensive or otherwise infeasible.

Downstream face of the Pastori Avenue Bridge, existing Alaskan steeppass-type fish ladder, and plunge pool. The original 24-inch-diameter stormwater outfall is shown at right (2005 photo).

The feasibility study prepared three different fish ladder replacement alternatives none of which would not entail significant upstream and downstream channel changes or disturbance of the existing bridge abutments and footings. All of the alternative replacement structures were designed to minimize the width of the footprint they would displace within the existing

concrete structure beneath the bridge to avoid disturbing the abutments and footings as far as feasible. All of them would situate the replacement structure on the same centerline axis as the existing structure. Alternative 1 and 2 are 13-ft-wide (inside dimension) and extend 9.5 ft downstream into the existing plunge pool. Alternative 3 is 16-ft-wide and extends 7 ft downstream into the existing plunge pool.

The footprints of all of the three alternatives were overlain on the design plans for design context during design development, and are shown on the final plans to demonstrate that none of the stormwater outfall and dissipation structure alternatives would impact the design performance of the fish passage alternatives. Specifically, the drawings demonstrate that the Energy Dissipation Structure with Large Woody Debris Channel Margin would not extend laterally into the downstream extended hydraulic field of any of the alternative fish passage structures.

3. Aquatic Habitat

There is an unnaturally wide and deep plunge pool immediately downstream from the Pastori Avenue Bridge. The pool is perennial. The original 24-inch-diameter outfall discharged immediately above an existing concrete wood retaining wall extension of the existing still intact concrete retaining wall. The trajectory and velocity of the discharge from the original outfall probably helped to maintain the depth of the plunge pool near the base of the retaining wall, as did spill flows dropping 8 vertical feet through the Pastori Bridge concrete apron. Practically no cover for fish exists along the existing margins of the plunge pool.

Installing a stable engineered RSP energy dissipation structure necessarily requires filling a portion of the existing plunge pool to achieve the minimum necessary face slope and keyway depths for structural stability. The proposed Energy Dissipation Structure with Large Woody Debris Channel Margin would fill with rip-rap approx. 19 CY of the existing pool at summer low-flow stage (controlled by the downstream riffle crest elevation).

As discussed below, the proposed Energy Dissipation Structure with Large Woody Debris Channel Margin is designed to be self-mitigating by offsetting the volumetric reduction in pool habitat with enhanced summer rearing habitat and transient winter refugia habitat.

4. Creek Flows - downstream flooding effects

According to the Hydrology & Hydraulics Analysis, the Project (Scenario 3)

would increase the 10-year peak flow discharged from the Pastori Avenue storm drain system to San Anselmo Creek compared to the current condition by 0.3 cfs. The Project would not change the 100-year peak flow discharge. The Project would reduce both the 10-year and 100-year peak discharges by about 2 cfs compared to the original, pre-failure (historic) condition (Scenario 1).

As discussed above, the Project would not affect local flooding out of San Anselmo Creek banks in the vicinity of the project (i.e., within Town of Fairfax limits) because it would cause very small differences in peak flow in San Anselmo Creek and the creek has significant excess flood flow capacity there. San Anselmo Creek is flood-prone downstream from Fairfax town limits, beginning in San Anselmo near Nokomis Avenue.

The December 31, 2005 flood has been estimated to have been an approx. 100-year flood. It produced an approximately 5,150-cfs peak flow at Nokomis Avenue. The Project would theoretically not increase that flow and would therefore have no affect on flooding downstream from Fairfax town limits.

The January 25, 2008 flood has been estimated to have been an approx. 5-10-year flood. It produced an approximately 2,600-cfs peak flow at Nokomis Avenue. The flood nearly overtopped or began to overtop both the Nokomis Avenue Bridge and the Madrone Avenue Bridge. According to the Hydrology & Hydraulics Analysis, the Project would have increased the amount of the peak flow at Nokomis Avenue by as much as approx. 0.3 cfs, or about 0.01 percent. This amount of peak flow increase is less than significant, and nonetheless potentially entirely mitigated by two of the proposed mitigation measures discussed below (Town of Fairfax Stormwater Management Ordinance, Ross Valley Flood Reduction Feasibility Study).

5. Pastori Bridge

There is no effect on the bridge under Scenario 1, historic conditions, and Scenario 2, existing conditions.

For Scenarios 3 & 4, removal of the 24" outfall and installation of the 48" outfall will require work on both sides of the bridge abutment.

The work on the street side of the abutment constitutes the majority of the effort to install the new 48" pipe, and will include the following:

- Excavation of AC paving and soils to expose the full length of the existing 24" pipe.

- Removal of the 24" pipe
- Enlarging of opening through abutment to accept the 48" pipe. This will require some very minor demolition work on the creek side of the abutment.
- Install any strengthening of the abutment required to accept the 48" pipe. This work would be done on the back side (street side) of the abutment.
- Install 48" pipe. Some minor work (hand grouting around the pipe) would be required on creek side of the abutment.
- Backfill trench for 48" pipe, and re-pave street.

The work on the creek side of the abutment should be of a minor nature and will consist of minor demolition for the new 48" pipe, and some finish work for grouting around the pipe. No heavy construction or equipment is anticipated on the creek side of the abutment.

6. Pollutants

During small rainfall events, each alternative has similar pollutants of concern, related largely to vehicular traffic in roadways. The pollutants of concern are typically oil, grease, and heavy metals due to vehicle break pads.

During larger rainfall events, the pollutants of concern differ for each alternative. Under Alternative 1 - Historic Condition and Alternative 2 - Existing Condition, the hydraulic model predicted flooding/ponding due to the 24-inch outfall and undersized storm drain system. Due to the flooding additional pollutants of concern may be introduced to the storm water runoff from storm water ponding into private yards and structures. Such pollutants are, but not limited to, landscape fertilizer and other household pollutants.

Under Alternative 3 - Proposed Condition and Alternative 4 - Future Condition, the extent of flooding/ ponding is unknown; however, it is reduced from that seen in Alternatives 1 and 2 due to improvements to the storm drain system. The potential flooding/ponding on private land is reduced and thus the presence of landscape and household pollutants is also reduced.

AVOIDANCE/MITIGATION MEASURES

1. Energy Dissipation Structure with Large Woody Debris Channel Margin

   As mitigation for placing rock rip-rap fill within the existing plunge pool, the proposed Energy Dissipation Structure with Large Woody Debris Channel Margin includes a large log-rootwad extending from the margin of the RSP into the plunge pool's summer low-flow water column to create cover for enhanced summer rearing habitat in the pool. The rootwad might also create some high flow refugia for holding during high flows.

2. Town of Fairfax Stormwater Management Ordinance.

   The Town of Fairfax is in the process of developing for adoption an ordinance requiring new development and redevelopment projects to meet certain to-be-determined minimum standards in stormwater management. It is expected that the ordinance will require development/redevelopment projects requiring a building permit and exceeding to-be-determined minimum project size limits to submit a stormwater control or drainage plan and supporting hydrology & hydraulics study results demonstrating that the project will cause no net increase in peak stormwater runoff discharged from the project site. Typically, implementation of Low Impact Development and stormwater management Best Management Practices are designed to cause no net increase in 25-year or longer recurrence interval rainfall-runoff events. As such they typically cause a reduction in the 10-year peak stormwater discharge compared to pre-project conditions. When the proposed ordinance is in place, future development/redevelopment in the Pastori Avenue storm drain system watershed should then, at a minimum, over time, cause a net decrease in the 10-year peak flow discharge from the storm drain outlet. It is not generally feasible to reliably calculate how much reduction is reasonable to expect, and how long it will take for the reduction to occur. Nonetheless, implementation of a stormwater management ordinance should be expected, over time, to entirely or nearly entirely mitigate the Project effects on peak flows discharged from the Pastori Avenue storm drain system.

3. Ross Valley Flood Damage Reduction Feasibility Study.

   In 2009, Marin County contracted with a team of engineers and architects led by Stetson Engineers Inc. to develop alternatives for reducing the frequency and severity of damaging flooding in the Ross Valley. The study is looking at opportunities to construct off-stream detention basins on public lands to reduce peak flows in the streams. The study is also developing hydraulic models and using them to develop alternatives consisting of suites of structural measures to increase channel capacity and reduce overbank flooding. Typical measures being evaluated include floodwalls, bridge crossing reconstruction, channel dredging, channel enlargement, removal of

encroached and failed bank stabilization structures, etc.

The study is taking a watershed-scale approach to reducing peak flows and increasing channel capacity, including potential detention basins upstream from the Pastori Avenue bridge crossing that would reduce peak flows there by hundreds of cfs. Preliminary results will be presented at public meetings beginning in Summer 2010.

More information about the study can be obtained about the feasibility study at: www.rossvalleywatershed.org

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APPENDIX

Hydrology and Hydraulic Analysis, Pastori Storm Drain Outfall