Looking downstream to Cascade Drive Bridge Culvert in Old Mill Park (June 15, 2022).

Project Description

Fish Passage Improvement
Old Mill Creek at Cascade Drive Bridge Culvert in Old Mill Park
APN 028-091-09 & 028-102-12
Mill Valley, CA
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geomorph DESIGN

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Fish passage on Old Mill Creek is impeded by the Cascade Drive bridge/culvert in Old Mill Park (Figure 1 – Location map).

Looking downstream from top of concrete-covered fill apron through the culvert barrel (June 15, 2022).

The existing concrete arch culvert opening is an approximately 9.5-ft-diameter circle with a gradual v-shaped concrete-filled invert making the opening height approximately 8.5 ft. The concrete floor slopes approximately 5% downstream, and spills over the sloped apron downstream from the outlet with a short fall directly into a plunge pool with scattered loose boulder rip-rap on the bed. Extending downstream from the culvert, the channel bed and banks are covered with boulder rip-rap. There are at least two buried redwood logs exposed on the bed about 100 feet downstream from the culvert. There is steeply-sloped concrete apron immediately upstream from the culvert inlet. The apron creates a spillway. Summer low flows pond up to the spillway crest elevation.

The concrete-covered apron on the upstream side of the bridge is in failing condition. Old Mill Creek low-flows spill through a narrow approximately 3-ft-wide slot cut through part of the thickness of apron materials: a 3-4"-thick top layer of newer concrete, covering a massive thickness of what appears to be poor quality concrete or asphalt concrete fill placed within a historical timber structure, including tops of vertical timber piling, possibly remnants of a pre-1911 road crossing, and/or a low-head dam associated with the 1830s sawmill 250 ft downstream. Structurally, the apron structure can be likened to a concrete-faced concrete filled timber crib dam, with unknown foundation supported by almost 200-year-old timber piers of unknown depth and spacing. There are also exposed redwood logs near the recreated historical mill structure, which may be remnants of a timber-cribbing reinforced channel.

The material beneath the newer concrete cover is lower strength and in places within the length of the apron flow line that underlying material has eroded to undermine the concrete cover layer laterally by 4-6 or more horizontal feet. The apron crest forming the upstream pool tail-out has down-cut approximately 9 inches – through the entire top layer of newer concrete and several more inches into the older low quality concrete fill.

[Review fish passage suitability of culvert.]
[Add re. field observations of fish attempting to pass the culvert.]
[See Ross Taylor and Associates 2003]
[See Far West Restoration Engineering 2004]

Preliminary Structural Evaluation of Bridge Culvert. Cascade Drive or Cascade Way bridge is an earth-filled solid concrete arch that is possibly more than 100 years old. Several bridges in Marin County were constructed in 1911 following damaging 1910-1911 winter storms. The original concrete quality was poor and the concrete was only lightly steel-reinforced. The bridge is on an unknown, likely shallow foundation and the structure has developed severe cracks. A 2020 Field Observation Report by California Infrastructure Consultancy (now MGE) recommended that the City of Mill Valley replace the bridge (Mill Valley Structure No. 22). The report estimated that the bridge's safe remaining life is less than 10 years.

Because the City does not currently have funding for bridge replacement capital improvement projects, the MGE report also recommended making temporary stop-gap bridge stabilization repairs costing approximately [$237,000], including a measure estimated to cost $140,000 to clad both headwalls and the arch soffit with a 6" layer of high strength rod reinforced concrete (shotcrete method). Cladding within the culvert would reduce the diameter by 12 inches which would increase the estimated 100-year peak flow water surface elevation upstream from the culvert.

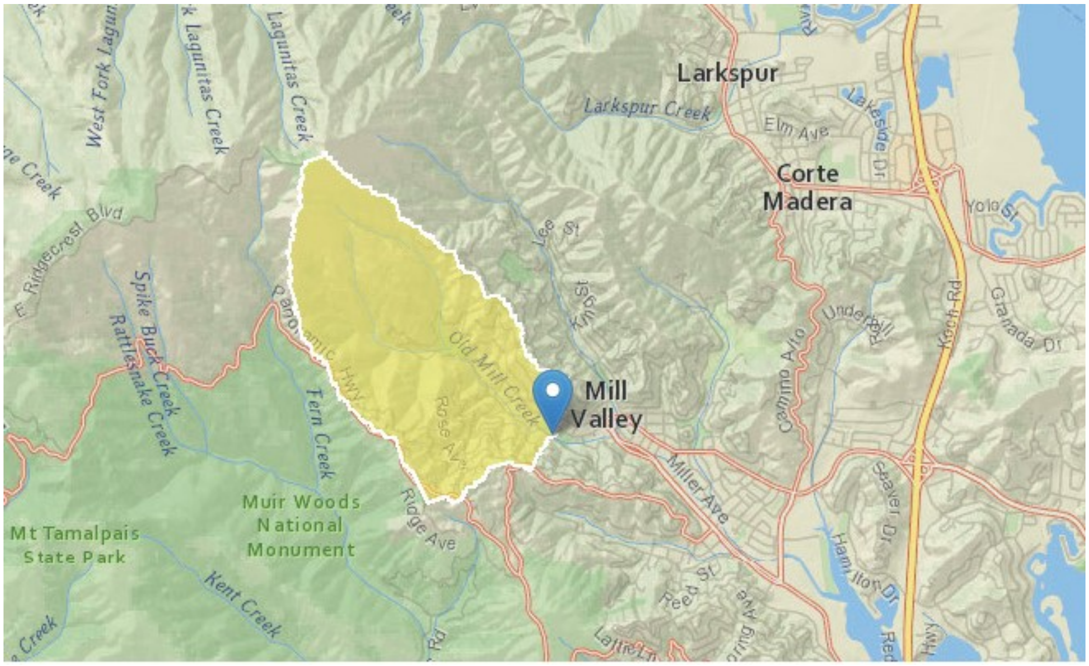

Figure 2*. 1.7-square mile watershed of Old Mill Creek tributary to Cascade Drive Bridge Culvert in Old Mill Park.*

It appears structurally feasible to implement fish passage improvements in combination with bridge replacement or temporarily stabilizing in-place the existing bridge/culvert:

> <u>Alternative 1</u>. Remove and replace the bridge/culvert with a new clear-span bridge over a restored natural channel suitable for fish passage.
>
> <u>Alternative 2</u>. Remove the concrete aprons on the upstream and downstream sides of the existing bridge/culvert and construct restored natural channels smoothly conforming with the existing culvert barrel floor inlet and outlet. Backwater or roughen the existing culvert floor to ensure suitable passage. Stabilize in-place the existing bridge/culvert with new pier foundation supported headwall/tailwalls and steel-reinforced concrete cladding with the culvert barrel. In the future, remove the bridge/culvert, restore the channel bed, and construct a new clear-span bridge crossing over the channel.

Summary Hydrology and Hydraulic Evaluation. Old Mill Creek is a perennial stream draining 1.7 square miles of steep redwood and fir forested canyon walls and higher elevation sage-scrub covered slopes up to a 2,518-ft elevation watershed crest near East Peak Mt. Tamalpais (elevation 2,571 ft) (Figure 2 – Watershed Map). According to StreamStats (USGS utility), the mean annual precipitation within the 1.7-acre watershed is 44.7 inches/year. The watershed is 56.8% forested and 35.9%

urbanized. About 3.8% of the watershed area is covered by impervious surfaces. There are no reservoirs upstream.

Table 1 lists best available information estimated annual peak flows at the site. Estimates according to regional regression equations including urbanization and other adjustments by Gotvald et al. (2012) are expected to be about 30% lower than actual gage measured peak flows.

Table 1.
Estimated Annual Peak Flows
Old Mill Creek at Cascade Drive Culvert
(1.7 square miles)

Recurrence Interval (years)	Gotvald et al (2012) Regional Regression Analysis Annual Peak Flow (cfs)	Stetson Engineers (2013) Model Simulated Annual Peak Flow (cfs)	FEMA Flood Insurance Study(**) Published Annual Peak Flow (cfs)
2	123	(*)	ND
5	244	(*)	ND
10	332	(*)	470
25	450	(*)	ND
50	540	750	750
100	635	870	870
500	ND	ND	1,140

ND – Not Determined
(*) Peak flows for 25-year and smaller recurrence intervals may be obtained from Stetson Engineers or by obtaining and reviewing data appendices from reports.
(**) FEMA Flood Insurance Study (revised August 2017) uses regional regression equations of Rantz (1971). Estimates shown for 1.85-sq mi watershed area at confluence with Arroyo Corte Madera del Presidio downstream from site.

Looking upstream from Cascade Way roadway to creek and failing concrete-covered apron (June 15, 2022).

The only gage in the Arroyo Corte Madera del Presidio watershed (USGS Gage No. 11460100) was established by the USGS in 1965. USGS discontinued operating the gage in 1993. County of Marin has operated the gage since 1993. The drainage area at the gage location is 4.69 square miles.

Stetson (2013) developed a HEC-HMS hydrologic model of the Arroyo Corte Madera del Presidio watershed including Old Mill Creek and Cascade Creek subwatersheds. The model was developed and calibrated in conjunction with the HEC-RAS hydraulic model and quasi-calibrated to produce the 1,810-cfs peak flow discharge measured at the gage during the December 31, 2005 flood.

Stetson published estimated 50-year and 100-year peak flows at the upstream hydraulic model domain on Old Mill Creek about 150 ft upstream from (near the downstream end of Old Mill Park where the drainage area is 1.8 sq mi. These estimated peak flows are suitable for preliminary design peak flows.

[Fish passage design flows would be determined using a combination of regression equation determined flows and drainage area apportioned percentile exceedance flows for daily flow data measured by the gage downstream.]

Figure 3 shows the anticipated flood water surfacre elevations at the Cascade Way bridge/culvert according to free-flowing normal depth open channel flow calculations.

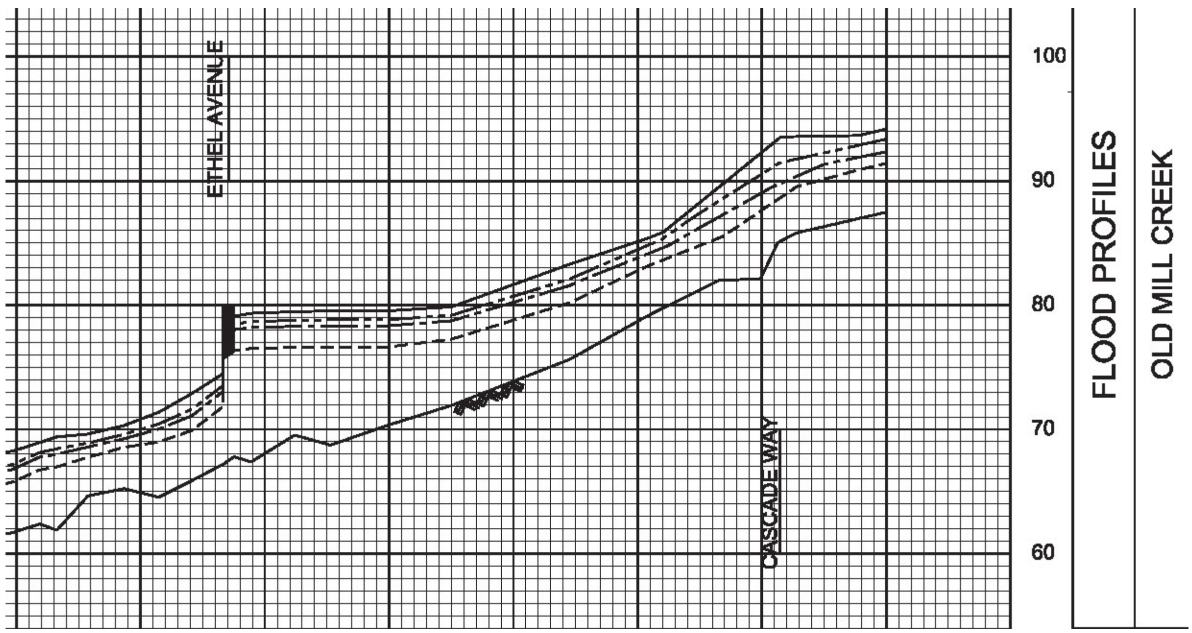

***Figure 3**. FEMA Flood Insurance Study published flood flow water surface elevation profiles at the Cascade Way Bridge/Culvert Crossing. The 100-year peak water surface elevation is about 91.5 feet at the culvert inlet – about 6" below the top of the arch culvert rise (ceiling).*

According to preliminary hydrology and hydraulic evaluation, the existing culvert is adequately sized for passing the 100-year peak flows but would not provide adequate freeboard for passing debris. Under temporary stabilized conditions (with the barrel diameter and ceiling elevation reduced by 6" thick steel-reinforced concrete cladding, the 100-year peak flow upstream water surface elevation would be expected to rise as much as 1 vertical foot upstream, but it does not appear that this would cause overbank flooding or damage to property. There is not a FEMA regulatory floodway on Old Mill Creek.

Looking upstream to culvert outfall with sloped concrete apron and plunge pool (June 15, 2022).

Looking downstream to the plunge pool and rip-rap dominated pool tail-out (June 15, 2022).

Looking to left bank at saw mill structure close to the channel (June 15, 2022).

Looking upstream to the concrete flash-board dam. Mill structure in background (June 15, 2022).

Preliminary Channel Geomorphology Evaluation. 2019 LiDAR topographic mapping of the Old Mill Park site shows that Old Mill Creek has flat channel bed slope running 200 ft upstream from the approximately 88-ft elevation crest of the failing concrete spillway apron upstream from the bridge-culvert. The bed elevation drops about 5 feet through the apron and culvert barrel. Downstream from the culvert, the channel bed and banks are covered by boulder rock rip-rap, and there are a number of log weirs visible on the channel bed. The bed elevation drops about 5 feet over 200 feet downstream from the culvert (average channel bed slope 2.5%).

About 110 feet downstream from the culvert apron outfall there is a recreated historical saw mill structure on the left bank very close to the channel. The narrowest channel cross-section occurs at the upstream end of the saw mill structure. The right bank is a very steep invasive vegetation covered rip-rap slope below the Molina Avenue roadway. Another 80 feet downstream there is a historical concrete flash-board dam that has a minor or negligible effect on channel bed elevations.

Table 3.
Theoretical Bankfull Channel Width and Depth
Old Mill Creek at Cascade Drive Culvert
(1.7 square miles)
(Beiger at al. 2015)

	Old Mill Creek
Bankfull width (ft)	13.9 - 16.4
Bankfull depth (ft)	1.2 - 1.4

Preliminary Design Alternatives Analysis. The Old Mill Creek fish passage improvement project requires coordinated design of two components:

(1) design of bridge/culvert replacement or stabilization/modification; and

(2) design of restored channel and/or fishway design through the bridge/culvert section conforming with existing channel bed and bank grades upstream and downstream.

Typically, for fish passage improvement projects at vehicle crossings, there are physical constraints for either the vehicle crossing or the channel improvement component. For example, replacement bridge opening width limitations may reduce he suitability of natural channel restoration for fish passage improvement. Or grading limitations upstream or downstream from the crossing require a steeper than natural channel, or a fishway/hybrid design.

However, it appears that the Old Mill Creek fish passage improvement project may have a single clear optimal design alternative:

> (1) A new replacement clear-span bridge spanning between new replacement concrete abutment walls set more than 16 feet apart for providing sufficient width for an unconstrained natural restored bankfull channel (estimated bankfull channel width 14-16 ft). Greater widths may be feasible at similar bridge replacement cost depending on bridge type selection and design development for bridge deck thickness and spans;
>
> (2) A restored natural channel extending upstream from the bridge/culvert section to meet grade with the natural channel upstream (eliminating the backwatered stream segment) and conforming well with the existing channel bed elevations and dimensions downstream near the recreated saw mill structure. Additional channel modifications downstream from the saw mill structure can be implemented by the project for removing the existing concrete flash-board dam, completing natural channel bed and bank restoration with relatively small cut-and-fill quantities over an approximately 390-foot-long reach.

This preliminary concept design is partially shown on the attached Site Plan and Thalweg Profile exhibit. An average 2.3%-sloped natural channel can fit into the site extending from the 88-ft stable bed elevation 140 ft upstream from apron spillway crest to the 79-ft bed elevation about 5 ft downstream from concrete flash-board dam 180 ft downstream from the downstream apron outfall.

A restored natural 2.3%-sloped channel would have a “step-pool” bed forms, with channel-spanning bands of boulders forming “steps” and shallow pools between steps. The band spacing, boulder size, boulder protrusion above the channel bed elevation and engineered streambed material dominating the bed material between bands would be determined according to methods in the fish passage improvement design literature and standard practice. The design details would be optimized for fish passage suitability using 2D/3D hydraulic modeling. Rock sizes would be selected so key pieces do not move during potential 100-year or larger design flood peak flows. Step-pool channel design theory would be applied to produce a naturalistic channel similar to what would have existed at the site prior to human disturbance, is self-sustaining and maintenance free, and supports nearshore native riparian vegetation.

However, because funding for bridge replacement is limited at this time, Design Alternative 2 is preferred. In Design Alternative 2, the existing bridge/culvert would be stabilized in-place until a future date when the bridge may be replaced. In Design Alternative 2, the channel would be restored leading into and leading out of the existing culvert inlet and outlet, and the floor of the culvert would be backwatered or roughened to ensure suitable passage.

Other Design Alternatives may be developed and analyzed for substantiating that the project prepares the optimal design. Discovery of physical constraints related to tree protection, utility protection, or right-of-way limitations could constrain restored channel limits in places. There may be alternatives related to pedestrian access to the channel bed and circulation of access through the replacement bridge opening. The public process may require consideration of a design alternative that retains the grade control function of the existing concrete apron spillway crest and the resulting shallow enlarged pool habitat that results. This alternative may require a steep-sloped fishway for matching with the steep apron slope.

Work Plan and Key Personnel. Design development This preliminary cost estimate is for providing civil and structural engineering design services combined with specialized fish passage design and associated hydraulic modeling as needed to develop conceptual design alternatives for improving fish passage suitability through Old Mill Creek within the Cascade Drive crossing.

Task	Design & Permitting Phase Work Plan	Design Team Member
1	Topographic, Structural, and Utilities Survey	Civil Engineer Licensed Surveyor Structural-Bridge Engineer Utilities Locator
2	Geotechnical Investigation	Geotechnical Engineer
3	Hydrology and Hydraulic Modeling Baseline Study	Civil Engineer Hydrologist
4	Bridge Replacement Type Selection Alternatives Analysis	Structural-Bridge Engineer
5	Fish Passage Suitability Alternatives Analysis	Civil Engineer Fish Passage Specialist Restoration Designer

6	Conceptual Design Plans and Cost Estimation (30%) – Channel Restoration and Bridge Replacement. Possibly more than one design alternative for 30% design.	Civil Engineer Fish Passage Specialist Channel Design Advisor Geotechnical Engineer Structural-Bridge Engineer Landscape Architect
7	Public Meetings and Environmental Process	Environmental Planner
8	Preferred Alternative – Design Plans and Specs, Design Basis Report, Cost Estimation (60%, 90%, 100%) – Channel Restoration and Bridge Replacement	Civil Engineer Fish Passage Specialist Restoration Designer Geotechnical Engineer Structural-Bridge Engineer Landscape Architect
9	Environmental Permitting	Environmental Planner

Design Team Member	**Key Personnel**
Civil Engineer	Matt Smeltzer, Geomorph Design
Licensed Surveyor	Shane Rauch, Capstone
Structural-Bridge Engineer	Nader Tamannaie, MGE
Utilities Locator	[TBD]
Geotechnical Engineer	Scott Stephens, Miller-Pacific (?)
Hydrology & Hydraulics	James Reilly, Stetson Engineers (?)
Fish Passage Specialist	Mike Love, MLA (?)
Channel Design Advisor	Anne Chin, UC Denver
Landscape Architect	[TBD]
Environmental Planner	[TBD]

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