Kimley»Horn

MEMORANDUM

To:	Steve Jesberg, PE Public Works Director City of Capitola
From:	Tammie Moreno, PE Kimley-Horn and Associates, Inc.
Date:	December 15, 2016
Subject:	Due Diligence, Stockton Avenue Bridge, City of Capitola, Ca

Project Background

The City of Capitola is located on the Pacific coast, in western Santa Cruz County, in west-central California. Capitola is situated approximately 4 miles east of the City of Santa Cruz and encompasses an area of approximately 1.9 square miles. The city's largest stream is Soquel Creek which flows southeasterly through the center of the City of Capitola. Stockton Avenue crosses Soquel Creek with a beam bridge that was built in 1934. The City of Capitola is seeking to mitigate flood risk caused by large debris getting caught in the Stockton Avenue Bridge piers over Soquel Creek during a rain event. (Figure 1)

Figure 1. Project Location

Watershed Characteristics

Soquel Creek is a 16+ mile long creek with numerous tributaries (Figure 2). The creek begins in the Santa Cruz Mountains, winds around Soquel Demonstration State Forest and the western portion of the Forest of Nisene Marks state park, and then flows south through the community of Soquel and into Capitola Village where it empties into Monterey Bay. The Soquel Creek basin encompasses 43 square miles and is triangular, having a width of approximately 1 mile near the ocean and widening to approximately 12 miles in the upper portion of the basin. In the upper reaches, the terrain is steep and heavily forested. In the lower reaches the basin changes to terraces and rolling hills near the ocean at Capitola. The watershed basin is mostly underlain by erodible sandy loam. Landslides are common to the watershed because of the material, steep hills, seismic activity, and intense rainfall.

Historically, woody debris from the upper reaches has caused log jams at Soquel Drive Bridge that crosses Soquel Creek upstream of the Highway 1 and Stockton Avenue Bridges. The Soquel Drive Bridge has experienced multiple log jams and the bridge has been replaced multiple times, the latest in 2003 at which time a clear span bridge was constructed to minimize debris blockage.

Floodplain Review

Flood hazard areas identified on the FEMA Flood Insurance Rate Map are defined as a Special Flood Hazard Areas (SFHAs). SFHAs are areas that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood.

The project is located on Map Number 06087C0352E in Zone AE (Figure 3). Zone AE areas are subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations (BFEs) are provided in Zone AE. Mandatory flood insurance purchase requirements and floodplain management standards apply in this zone.

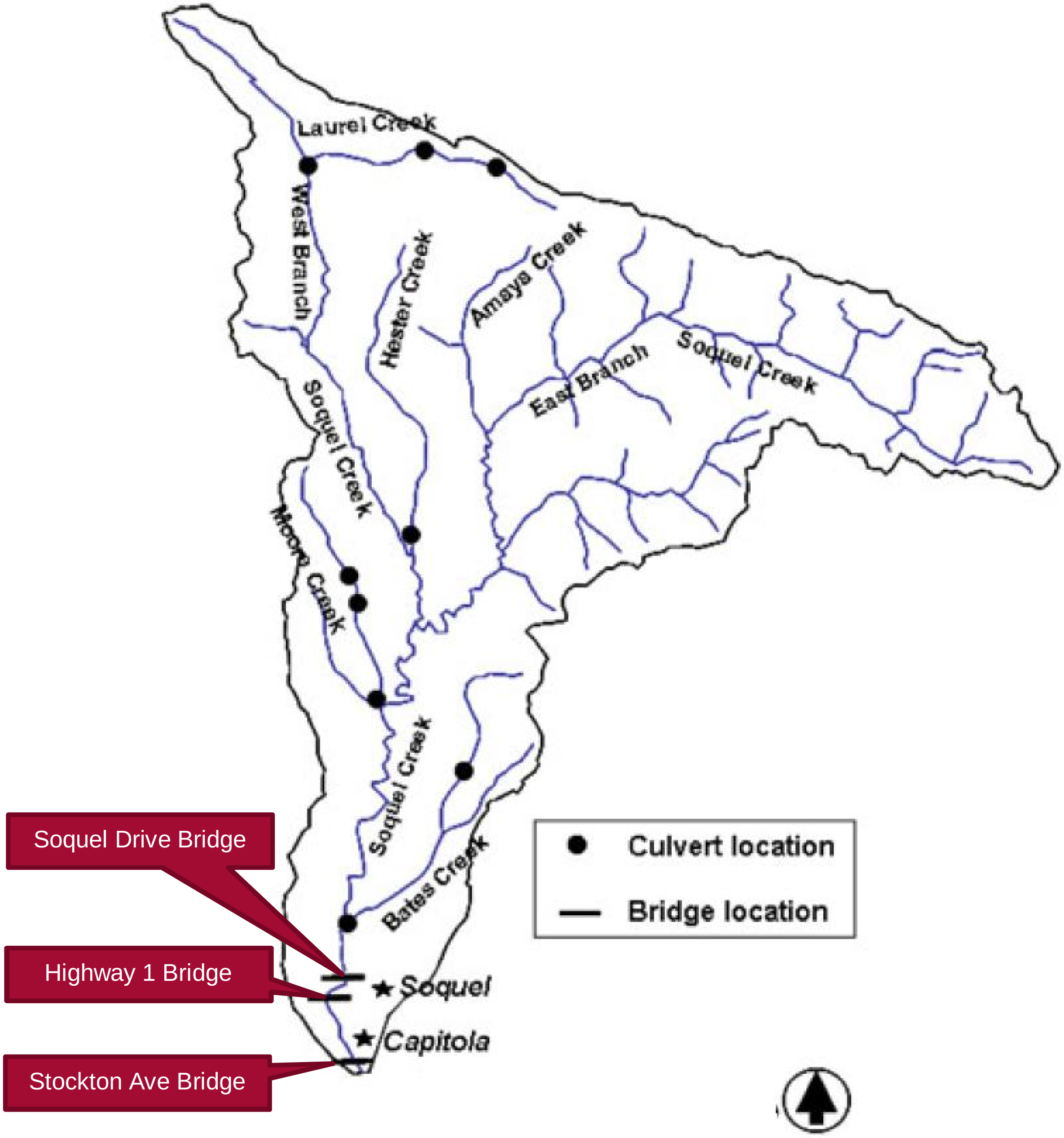

Figure 2. Soquel Creek Watershed

Figure 3. FEMA Flood Insurance Map

Flooding Problems

The rainy season extends from October through May. Flooding usually occurs in December, January and February. The December 1955 and the January 1982 storms are two of the largest flooding events on record for Santa Cruz County. Some of the results of these two flooding events are described below.

Major flooding occurred in December 1955 when a 72-hour period storm fell on the Soquel Creek Basin. The estimated peak flow for this event at the Soquel Creek gage was 15,800 cfs, which corresponds to a 1.43-percent-annual-chance recurrence event. Some damage from bank erosion and deposition of debris was done to commercial and residential property adjacent to Soquel Creek in Capitola. Most damage caused by the overflow of Soquel Creek occurred outside of Capitola. A major logjam occurred at the Soquel Drive Bridge, causing a severe backwater condition and displacing 350 persons.

Another major flood occurred in January 1982. The estimated peak flow for this event at the Soquel Creek gage was 9,700 cfs, which corresponds to a 6.67-percent-annual-chance recurrence event. A massive logjam occurred at the Soquel Drive Bridge (Figure 4). The floodwaters rose rapidly along Soquel Creek and caused major damage flooding one home on the eastern bank just south of State Highway 1 and eroding the banks of some homes along Riverview Drive in Capitola.

Figure 4. Logjam upstream of Soquel Drive Bridge after January 1982 storm.

Debris Concerns at Stockton Avenue Bridge

The Soquel Creek watershed has a history of forming log jams at Soquel Drive Bridge during large rain events, specifically in 1955 and 1982 which are the largest rain events on record. Log jams are formed when large, whole trees are introduced into the channel and are anchored to the bed or banks. The large trees act as a filter by trapping smaller floating debris causing constriction in flow and backwater effects upstream. The backwater effect diverts flood water from the channel onto the adjacent floodplain and causes bridge failure. The Soquel Drive Bridge was replaced in 1890, 1927, 1956 and 2003. To mitigate for log jams, the most recent replacement of Soquel Drive Bridge was built over three feet higher, compared to the previous bridge, and with no support piers in the river in to provide increased flood capacity. Soquel Drive Bridge now has a span of 140' for debris to pass under Soquel Drive Bridge. The concern is that the debris that can now pass freely under Soquel Drive will cause a log jam upstream of the Stockton Avenue Bridge.

The Stockton Avenue Bridge is a beam bridge built in 1934 with three openings and two support piers. The bridge crosses Soquel Creek as it enters the Pacific Ocean. A study in 2011 by University of California Berkeley determined that the average tree length in the watershed is between 15 and 30 feet. The smallest span opening (Figure 5) is approximately 10-feet on the east abutment between the east pier and the concrete headwall, leaving the bridge susceptible to log jams. During field investigations, large tree branches were observed caught within the smaller span openings upstream of the bridge (Figure 6).

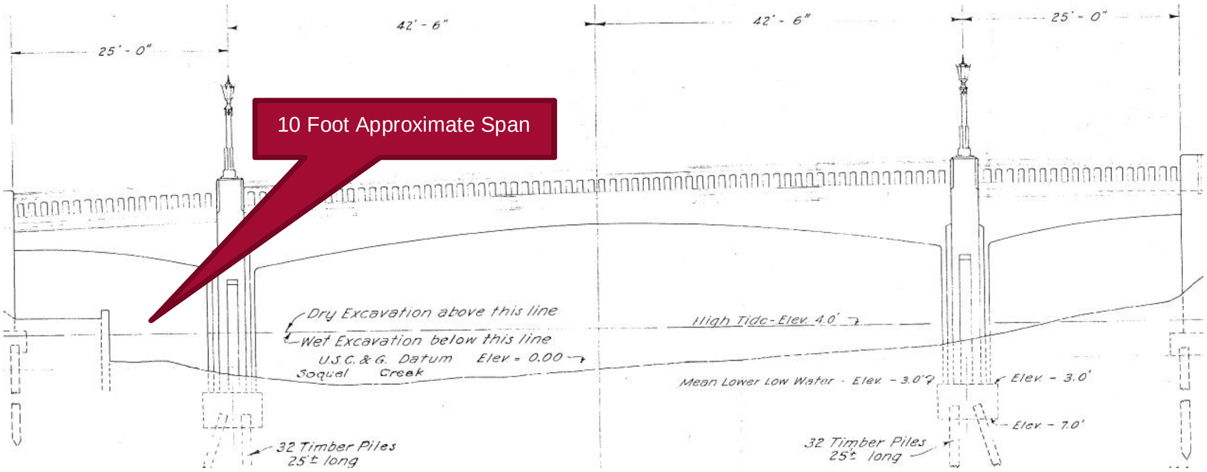

Figure 5. Stockton Avenue Bridge Record Drawing

Figure 6. Photo, Looking Downstream, Stockton Avenue Bridge

Potential Debris Control Countermeasures

The Stockton Avenue Bridge is furthest downstream bridge in the watershed. The watershed is known to have large woody debris that has historically caused flooding by damming up bridges. Upstream bridges at Soquel Drive and Highway 1 have larger spans than the Stockton Avenue Bridge. This creates the potential for debris to accumulate upstream of Stockton Avenue Bridge.

Characterization of the debris supply is important for proper drainage structure design and the selection of debris countermeasures depends on the type of debris transported to the site. From historical flooding summaries and photos and the 2011 University of California Berkley study, debris in Soquel Creek is mainly medium and large floating debris consisting of logs or trees and tree limbs and large sticks. Sources of this material comes from trees introduced into the stream by bank erosion and mass wasting. Floating debris accumulations initially form at the water surface, and without maintenance or removal, will grow toward and eventually become part of the streambed.

Debris control countermeasures, both structural and non-structural, have been used effectively to prevent or reduce the size of debris accumulations at bridges and culverts. Non-structural measures include management of the upstream watershed and maintenance. Structural measures include features that can either intercept debris, deflect debris, or orient debris to facilitate passage through the structure. Deflection and orientation measures are needed to redirect or reorient debris flows in Soquel Creek to prevent accumulation of the material upstream of the Stockton Avenue Bridge. A review of structural debris control countermeasures was conducted. A discussion of potential countermeasures to redirect and/or reorient debris in Soquel Creek is provided below with recommendations for the Stockton Avenue Bridge.

Debris Sweeper

A debris sweeper can be installed on the upstream side of the bridge pier to deflect debris. A debris sweeper is a polyethylene device that is rotated by the channel flow, causing the debris to be deflected away from the pier and through the bridge opening. The deflectors are intended to buffer the structure itself from impact and steer debris around the structure. Because sweepers rotate freely, they shed debris, greatly reducing the likelihood of accumulation. The device is attached to a vertical stainless steel cable so that it can travel vertically as the water surface rises and falls (Figures 7 and 8). The device is suitable for medium to large floating debris and requires low maintenance. Debris sweepers have been installed on bridges in Oklahoma, Virginia, Tennessee, Washington, and Oregon.

Since installation of this system does not require disturbance of the stream channel, installation causes little environmental impact. For the Stockton Avenue Bridge, a minimum of two debris sweepers would be needed, one on each pier to deflect debris into the wider, center span. Four sweepers, one on the water surface and one submerged on each pier, may result in better deflection Installation of debris sweepers does not guarantee that all logs will be deflected. There will still be a chance that tree logs that do not get deflected would jam within the shortest 10-foot span.

Figure 7. Photo of a debris sweeper being installed on bridge in Virginia

Figure 8. Photo close-up of a debris sweeper in Washington

Debris Fins

Debris fins are thin walls built in the stream channel just upstream of the bridge to help align large floating trees so that their length is parallel to the flow (Figure 9). The fins' purpose is to align the debris to the openings so that debris will move through. Debris fins have been successfully used to align debris within the waterway opening and to avoid the accumulation of debris on bridge piers. They are used when the debris consists mostly of floating material. An angled debris fin is recommended for the Stockton Avenue Bridge to direct debris to the larger, center span. Debris fins require maintenance for debris removal. If debris is not removed, flow conveyance is reduced.

Figure 9. Photo of timber debris fins with sloping leading edge.

Debris Deflectors

Debris deflectors are structures placed upstream of the bridge piers to deflect and guide debris through the bridge opening. They are normally "V"-shaped in plan with the apex upstream. The effectiveness of the structure is dependent on flow patterns which are difficult to predict. An example of this type of structure is shown in Figure 10. The Stockton Avenue Bridge would require several deflectors to direct debris through the larger center span.

Figure 10. Photo of debris deflectors used in Indiana

Bridge Replacement

Debris accumulation at bridges restricts the span openings and causes the water level to rise. The combination of debris accumulation and elevated water levels can damage the bridge and flood the surrounding area. The debris countermeasures discussed above can reduce debris accumulation; however, the most effective solution to mitigating debris accumulation is a full bridge replacement. Replacing the existing multi-span Stockton Bridge with an elevated bridge deck and a single clear span would increase flow and allow debris to pass without getting caught at the piers.

The Stockton Bridge is a major thoroughfare providing community access between Soquel Creek, and closing the bridge for replacement would be potentially disruptive for residents and businesses in the Capitola Downtown Village. A typical bridge construction project takes between six to nine months assuming traffic is closed and the bridge follows the same roadway alignment. Certain construction alternatives such as using prefabricated bridge sections to accelerate the construction timeline or phasing construction to have traffic open during construction can mitigate the disruptive impact but would add additional cost to the project. In addition to cost, environmental, and construction impacts, maintenance accessibility for debris removal should also be considered during design of a new bridge.

Summary and Recommendations

The debris control countermeasures designed to redirect and/or reorient medium and large floating debris include debris sweepers, debris fins, debris deflectors, or a full bridge replacement. Table 1 shown below summarizes the advantages, disadvantages, and preliminary project cost between each countermeasure.

Based on the comparative results from Table 1, it is recommended that the City consider installing debris fins to direct debris through the larger, center span of the Stockton Avenue Bridge. Debris fins are recommended over the other countermeasures due to the high failure potential of debris sweepers, the potential for debris deflectors to trap instead of redirect debris upstream of the bridge, and the high cost/impacts of bridge replacement.

Modeling of channel flows and possible debris should be considered for proper design of the recommended method and to determine flow conditions at bridge during low and high flow events. This analysis will help determine the vertical clearance under the bridge during higher flow events to identify if there is enough space to pass the range in diameters expected (between 9 inches and 2 feet). Developing a two-dimensional hydraulic model is recommended to evaluate the hydraulic characteristics upstream and downstream of the bridge and to define the possible flow paths of floating debris.

Table 1. Summary of Advantages and Disadvantages of Selected Debris Control Countermeasures

Debris Countermeasure	Advantages	Disadvantages	Annual Cost over 10-year Period	Estimated Project Cost (Preliminary)
Debris Sweepers	Active system (rotates); may alleviate additional maintenance; requires little disturbance of the stream channel; relatively easy to design and install.	High failure rate; Failure of system can increase potential for debris accumulation; failures due to clogging, being crushed by large debris, and being dislodged from their mounts; some maintenance required.	Low to Moderate	$64,000 (Total) $40,000/pair[1] (Construction) +$24,000 (60% for contingency, administration, design cost)
Debris Fins	May not require stream modification or continuing maintenance; may alleviate or reduce maintenance requirements; simple design and construction.	Low reliability if not aligned properly with flow; some maintenance required; moderate/minimal disturbance to stream channel; known to fail under high lateral forces of trapped debris.	Moderate	$160,000 (Total) $100,000/pair (Construction) +$60,000 (60% for contingency, administration, design cost)
Debris Deflectors	Simple design and construction; minimal disturbance to stream channel.	May trap debris upstream of bridge requiring maintenance removal; known to fail under high lateral forces of trapped debris; low reliability if not design to account for two-dimensional surface flow paths.	Low	$80,000 (Total) $50,000/pair (Construction) +$30,000 (60% for contingency, administration, design cost)
Bridge Replacement	Increase flow capacity from wider span length, may alleviate or reduce maintenance requirements	High construction and design cost, requires environmental permitting, long project schedule to implement	High	$2,800,000 (Total) $1,750,000 (Construction) +$1,050,000 (60% for contingency, administration, design cost)

Notes:

1. Price for debris sweeper may increase if a sweeper is designed and manufactured solely for this project.

References

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