Title
Parallel passageways: An assessment of salmon migration in the San Gregorio watershed

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Publication Date
2008-12-01

PARALLEL PASSAGEWAYS: AN ASSESSMENT OF SALMON MIGRATION IN THE SAN GREGORIO WATERSHED
FINAL DRAFT

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ABSTRACT

San Gregorio Creek drains approximately 51 square miles, debouching into the Pacific Ocean approximately 40 miles south of San Francisco. The San Gregorio watershed historically supported populations of steelhead (*Oncorhynchus mykiss)* and coho salmon (*O. kisutch*). These federally listed species are still present in the watershed, however; their habitat has been significantly altered due to a variety of land-uses, such as logging, grazing, and residential development. Although a variety of factors have contributed to the overall degradation of salmonid habitat in the San Gregorio watershed, the Highway 84 transportation corridor arguably has had the greatest direct impact over the past sixty years due to its location immediately adjacent to, and often crossing, the watershed's main stem.

Both regulatory agencies and local stakeholders have expressed interest in restoring habitat for salmon within the San Gregorio watershed. Understanding the overall quality and quantity of habitat within the watershed and how specific sites along the Highway 84 transportation corridor impact habitat and fish passage will assist in future efforts to restore and protect salmon populations. For this study, I collected baseline information at twelve sites where creeks are crossed by public roads as well as four additional locations within the public right-of-way where channel banks were significantly altered, and in some cases physically moved, as part of the Highway 84 road realignment project (1953-1954) or subsequent bank stabilization projects. I identified three sites where Highway 84 bridge crossings impede fish passage during periods of low flow and one site that completely blocks fish passage. All bank stabilization sites observed show evidence of lateral erosion and contributions of fine-grained sediment directly to the active creek channel. Some of the materials utilized for bank stabilization have also created unanticipated hazards. While this study did not assess private infrastructure within active creek channels,

it identifies locations where future habitat enhancement efforts and road maintenance activities on public roadways may have the greatest impact to salmon populations within the watershed.

PROBLEM STATEMENT (INTRODUCTION)

Populations of steelhead (*Oncorhynchus mykiss)* and coho salmon (*O. kisutch*) along coastal California have declined dramatically over the last 100 years due to habitat loss and degradation caused by a variety of land-use practices (DFG, 2004). As a result of these declines, salmon populations are now both federal and state listed species throughout most of Northern California. The San Gregorio watershed, located approximately forty miles south of San Francisco (Figure 1), has been documented as supporting these species and is one of the California coastal watersheds that the California Department of Fish and Game has targeted for salmon recovery (FishNet4Cet al, 2007). In addition to regulatory agency concern, local environmental groups and landowners have also stated an interest in restoring salmon habitat in the watershed.

Although the San Gregorio watershed is relatively undeveloped compared to most watersheds in the greater San Francisco Bay Area, Highway 84 runs parallel to the main channel through the entire length of the watershed and subsequently has the potential to have a significant impact on habitat quality and fish passage. This is of particular concern with the recognition that road systems often generate up to 70 percent of the sediment yield produced in most watersheds (Flosi et al, 1998). Primarily confined to steep slopes that are often immediately adjacent to a channel bank, the poor location of the highway cannot easily be addressed. However, there is still the potential to improve fish passage and habitat through the modification of existing roadway infrastructure.

Prior to the design of a habitat enhancement program for the watershed, the specific factors that impact salmonids must be identified (Flosi et al., 1998). In an effort to assist in this process I evaluated a total of sixteen sites, twelve creek crossings and four bank stabilization sites, associated with the Highway 84 transportation corridor for their potential to restrict fish migration, act as a fine-grained sediment source, or otherwise pose a threat to salmon populations. The list of sites compiled as part of this study (Table 3) is not meant to be an exhaustive list of all sites within the watershed as this study does not include privately owned infrastructure or an evaluation of public infrastructure located outside of the Highway 84 transportation corridor. I did, however; identify the primary impacts to salmon habitat associated with the Highway 84 transportation corridor such that these impacts are recognized and can be accounted for in the prioritization and implementation of future road maintenance and habitat enhancement projects.

METHODS

I identified road crossing locations on USGS 7.5-minute Quadrangles and identified bank stabilization sites both on the Highway 84 Realignment Project As-Built Plans and through recommendations by individuals familiar with the watershed (Figure 2). The San Mateo County Public Works Department provided access to copies of the Highway 84 Realignment Project As-Built Plans. Sarah Pearce, a geomorphologist with extensive field experience in the upper reaches of the San Gregorio watershed, provided assistance in locating erosion control sites. David Yam, Caltrans District 4 Environmental Division Branch Chief, noted some erosion control sites along the Highway 84 transportation corridor and provided references to Caltrans standard specifications for erosion control and bank stabilization techniques. I conducted document searches at the Water Resources Archives and through the San Gregorio Watershed Information System and conducted interviews with two local landowners in an effort to locate information pertaining to the history of salmon populations in the watershed.

During site visits conducted on November 7, 2008 and November 21, 2008 I documented both qualitative and quantitative observations relative to both site-specific conditions and watershed reach characteristics. I utilized guidelines developed by the California Department of Fish and Game to assess creek crossing sites for adequate fish passage based on culvert outlet height relative to downstream water surface, downstream pool depth, and average depth of water at each crossing site (DFG, 2004). A summary of these observations are in Table 3. I assumed that water levels measured during the site visits were representative of normal low flow conditions. I visually evaluated bank stabilization sites for their success in meeting project objectives (assumed to be erosion control and road protection) and calculated approximate channel changes over time for two of these sites based on comparisons of recently surveyed transects (one site that I surveyed and one site that was surveyed by SFEI staff in 2004) with the Highway 84 realignment as-built drawings.

Watershed Character: In an effort to understand the character of the watershed I reviewed a geologic map of the La Honda and San Gregorio Quadrangles (Brabb, 1980) and took note of both plant communities and land use observed in the field and from aerial photography. For the purpose of describing distinct character of areas within the watershed, I identified three distinct reaches based on topographic characteristics, vegetation communities, and land-use (Appendix A).

RESULTS/DISCUSSION

LOWER REACH: The lower reach of the San Gregorio watershed includes the drainage areas for the Coyote Creek and Clear Creek tributaries as well as two other small intermittent unnamed tributaries. This area is dominated by agricultural fields and rolling hills. Geology in this area is primarily defined by the San Gregorio Fault Zone which runs almost parallel to the coastline and is exposed in the area between the coast and the town of San Gregorio (Brabb, 1990). Poorly consolidated marine terrace deposits and alluvial fan deposits are dominant in the lower elevations (Brabb, 1980).

1. Stage Road Crossing– The Stage Road Bridge does not impede fish passage and does not contribute any noticeable quantities of sediment into the creek. The bed of the crossing is continuous with both the upstream and downstream channel bed surfaces. Vines and rooting vegetation are well established on the channel banks. The only area of this site where sediment transport to the channel is evident, albeit minimal, appears to be at the steep path that is used as an access point for stream monitors. (*Note: this crossing is not on Highway 84 but is a public bridge located immediately adjacent to Highway 84)

2. Coyote Creek Crossing (SM84 2^{10}) – There is a 1 meter height difference between the downstream water surface and the culvert outlet, impeding all fish passage during low flows. There is no flow data available or recorded observations of fish in this creek that would indicate whether or not fish passage is possible during winter flows although the upstream channel is gullied and devoid of most vegetation due to grazing activity, making spawning habitat in this creek of poor quality even if it is accessible to fish during high flows.

3. Clear Creek Crossing (SM84 2^{89}) – In November 2008, Clear Creek was dry at the Highway 84 crossing. Dense chaparral and riparian vegetation occupy the channel banks immediately surrounding the road crossing although vegetation is much sparser upstream where livestock grazing is evident. There is a small drop (0.05 m) from the culvert outlet to the downstream bed although no water was present, so it is likely that this creek is intermittent and not likely to provide summer rearing habitat.

MIDDLE REACH: The middle reach of the watershed transitions to steeper hillslopes that are primarily grazed in the lower elevations and forested in the upper elevations. Unlike the lower reach tributaries, flowing water was observed in all tributaries located within this reach.

4. El Corte de Madera Creek Crossing (SM84 4^{08}) – There are no impediments to fish passage at this site. Rip rap lines both sides of the channel at this bridge crossing although the bridge pilings are far enough apart that they do not restrict channel flow and no local scour is evident. There is a swath 4-5 meters wide in the center of the crossing that is not rip-rapped and contains a pool and riffle sequence that is consistent with areas immediately upstream and downstream.

5. Bogess Creek Crossing (SM84 4^{60}) – There was adequate water depth upstream and downstream to support fish when observed November 2008, however, the wide culvert at this site spreads out flows, making the depth of the water within the culvert (<0.05m) too shallow for fish passage.

6. San Gregorio Creek Crossing (SM84 6^{20}) – This bridge crossing does not impede fish passage. The three-pillar concrete bridge is wide and the low flow channel bed is continuous both upstream and downstream. Rip rap armors the sloped banks under the bridge.

7. San Gregorio Creek Crossing (SM84 7^{55}) – This bridge crossing does not impede fish passage. This bridge is wide and the low flow channel bed is continuous both upstream and downstream. Rip rap armors the sloped banks under the bridge, which may induce scouring due to channel constriction during high flow events but otherwise there is minimal disturbance to the creek channel.

UPPER REACH : Highway 84 and La Honda Creek become confined to a narrow canyon in this upper reach, therefore increasing the areas in which the road and creek interact. At the same time, erosion caused by overland flow and landsliding in these upper slopes are common (Wieczorek, G.F., 1982). The soils in this reach are similar to the ones in the middle reach with fine-grained siltstone and sandstone being dominant.

8. La Honda Creek Crossing (SM84 8^{12}) –The footings of this bridge crossing protrude somewhat into the channel, constricting the channel during high flows. The bank of the slope immediately under the bridge is devoid of vegetation and does show some signs of localized scour. Adjacent banks also show signs of slight undercutting and scour although the upper portions of these banks are vegetated. The base of the bed is natural and is continuous with upstream and downstream bed morphology. Fish passage is not impeded by this crossing.

9. La Honda Creek Crossing below Playbowl (SM84 8^{x}) –The base elevation of the double box culverts at this site is low enough that there is a continuous flow of water through the culvert to downstream. Immediately upstream the channel is confined by bedrock and forced to make a sharp turn towards the bridge crossing. A scour pool (0.8m deep) immediately upstream of the bridge has formed at the point of this turn. No barriers to fish passage are present and small fish were present in the pool.

10. Gabion Bank Stabilization (SM84 8[x]) – This site is not labeled on any of the Highway 84 realignment plans and discussions with David Yam of Caltrans revealed that the gabions at this site were initially installed within the past decade to stop channel migration towards the highway and had been replaced in the last couple years. Sarah Pearce noted that when she visited the site in 2004, the gabions had failed, likely due to the use of the local bed material, which contains mudstones that readily break apart, as fill. When I visited the site in November 2008, approximately 30 meters of the left bank of La Honda Creek was lined with gabions. These gabions contian granite cobbles ~45-90mm wide, which are unlikely to erode like the previous installation, however; the gabions are protruding into the creek channel and the bank behind them is already cut at least a meter both upstream and downstream.

11. Entrada Road Bridge Crossing –This bridge crossing is the main access to the community of La Honda. The channel bed is continuous through this crossing and there are no barriers to fish passage at this site. One potential source of significant fine sediment at this site that is of concern is the drainage water from the de-watering of the Weeks Landslide above La Honda. This water is directed to a culvert whose outlet goes to an open culvert on the side of Entrada Road and drains directly into La Honda Creek along the left bank of the Entrada Road bridge.

12. Sackcrete Bend (SM84 9[22]) – This bank stabilization project was installed as part of the Highway 84 transportation corridor realignment (Figure 3). At this site the channel bend was moved approximately 40 meters, a sackcrete wall was constructed across approximately 120 meters of the new channel bank, and fill material was used to backfill the site. Approximately 90 meters of the sackcrete wall has completely failed and the channel has since migrated back towards its previous location, transporting most of the original fill material downstream (Figure 4). The channel continues to cut at the base of the channel and the pool below the bend contains a layer of silt deposits. From transects that I surveyed, I calculated that approximately 540 m^3 of fill material has been transported downstream from this site since 1954.

13. Rip Rap Bend (SM84 9^{34}) – The channel immediately downstream of this site was straightened and narrowed as part of the Highway 84 transportation corridor realignment. Measurements that I took from the as-built plans show that the former channel at this particular area was moved up to 20 meters from its original position. The shift of this portion of the channel turned the bend immediately upstream from the realigned channel from what was a 110 degree turn to a 90 degree turn. Since that time, the channel has eroded the bank at this turn and rip rap has been added to the site several times to keep the bank from eventually undercutting the road (Yam personal communication, Nov. 2008). During my site visit I did not see any indication that any of the rip rap on the bank was keyed in and clusters of rip rap were present in several areas within the channel bed, likely due to the instability of the steep slope of the bank. The movement of rip rap to the channel bed has changed channel flow over time and left the bank vulnerable to increased erosion, hence the repeated additions of rip rap to cover areas left bare. This maintenance action is likely to have actually increased erosion on this bend by increasing the local channel slope and narrowing the cross section profile. Based on comparisons between the Highway 84 realignment as-built plans and cross-sections surveyed in 2004 by SFEI (Pearce et al, 2004) I have estimated that there has been approximately 2-3 meters of lateral erosion at this bend since the initial channel realignment in 1954. This site does not restrict fish passage although the addition of rip rap has reduced the quality of habitat and repeated failure of the bank is likely to discharge pulses of sediment into the channel.

14. La Honda Culvert Crossing (SM84 9^{68}) – This road crossing consists of two concrete box culverts that are each approximately 3.5 meters wide, 4 meters tall, and 30 meters long. At the time of the site visit there was a sheet of water approximately 0.04m flowing through the culverts and dropping down approximately 0.25meters into a 0.6 meter deep scour pool at the outlet. This crossing inhibits fish passage during low flows. Even though adult salmon could overcome the obstacle of the elevation change, they would not be able to travel the following 30 meters of culvert.

15. Hanging Tributary Culvert (SM84 9^{78}) – This 0.75 meter diameter culvert is the outlet of a small tributary. The outlet is approximately 0.6 meters above the pool that it is draining into and I estimate that the culvert is approximately 25 meters long with a slope between 10-15%. Although this tributarty is providing a steady stream of water, it is completely inaccessible to fish due to the height of the culvert opening. Even during higher flows when this outlet may be submerged by the La Honda Creek, its steep slope and long confined profile make passage unlikely for fish at any life stage.

16. Landslide Bend (SM84 9^{85}) – This bank stabilization project was constructed after a landslide occurred in 1998. The project includes a concrete retaining wall on the upper portions of the bank, jute netting and grass seeding on the middle section of the bank, and the installation of black polyethelyne geogrid fabric. Dewatering drains are also located along several portions of this site. The bank at this site is extremely steep, particularly at the lower four meters of the bank where the channel is active. The geogrid fabric has failed and the channel has undercut its bank up to 1.5meters in some areas. Some of the geogrid fabric pieces that remain on the bank are bulging, which may be a sign of continued soil creep. Three pieces of geogrid fabric were found deposited near Sackcrete Bend (SM84 9^{22}), over half a mile downstream.

This site has a significant impact on habitat both within the immediate area and downstream. A fan of fine sediment covers the majority of the gravels in this section of the channel and sediment deposits are also found in the pools downstream. The geogrid fabric has become litter in downstream areas and could potentially trap fish. Although this site does not completely impede fish passage, the addition of large amounts of sediment has smoothed and widened the channel in this area making the water depth shallower. Additional bank failures at this site could create a fish passage barrier.

CONCLUSIONS

My investigation of the ways in which public infrastructure along the Highway 84 transportation corridor impact fish passage and habitat quality revealed that there are three sites (Site 2, 5, and 14) where Highway 84 bridge crossings impede fish passage during periods of low flow and one site (Site 15) that completely blocks fish passage (Figure 8). All bank stabilization sites (Sites 10, 12, 13, and 16) and several of the bridge crossing sites (Sites 3, 5, 8, and 9) show evidence of lateral erosion and fine-grained sediment contributions directly to the active creek channel. Bank scour and channel incision is also evident immediately downstream at sites where bank structures encroach in the active channel or otherwise confine flows. Two exceptions to this are the La Honda Creek Site below Playbowl (Site 9) and the Sackcrete Bend Site (Site 12) which both have exposed bedrock that acts as a grade control.

It is important to recognize that any single migration barrier can potentially cut off large areas of habitat. Though this study provides information that can assist Caltrans and County staff determining modifications and maintenance for public sites along the Highway 84 transportation corridor that would benefit salmon populations, it is important that all infrastructure within the active creek channels be examined and projects be prioritized based on their impacts to the watershed as a whole, regardless of ownership.

An unanticipated result of some of the bank stabilization methods used is that some of the materials utilized for these projects have also created hazards or have increased erosion. The wire baskets used for gabions that were put in place along La Honda Creek may deteriorate over time due to abrasion, resulting in loose or exposed wires that are a hazard to fish as well as humans (Flosi et al, 1998). The sackcrete wall constructed at sackrete bend was meant to hold the channel in place and keep it from migrating towards Highway 84. The sackcrete wall, however; was not keyed in to anything and once undermined, delivered large amounts of sediment directly to the channel. The geogrid fabric at Landslide Bend was similarly meant to hold the bank in place. Instead, the fabric is falling off the bank creating piles of material that could trap fish and that are swept downstream during storm events. These sites each failed for different reasons, however; they all provide a valuable lesson that site conditions must be carefully evaluated and materials must be appropriately applied in order to prevent erosion control structures from becoming hazards and/or propagating the erosion processes that they were intended to prevent.

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FIGURE CAPTIONS

FIGURE 1: San Gregorio Watershed location map

FIGURE 2: San Gregorio Watershed and evaluation site locations

FIGURE 3: Sackcrete Bend as-built drawing (Caltrans,1956)

FIGURE 4: Sackcrete Bend current plan view

FIGURE 5: Sackcrete Bend 2008 profile with estimate of 1956 profile and fill area.

FIGURE 6: Examples of fish passage barriers due to disconnect between culvert outlet and downstream channel (Site 2 and Site 15)

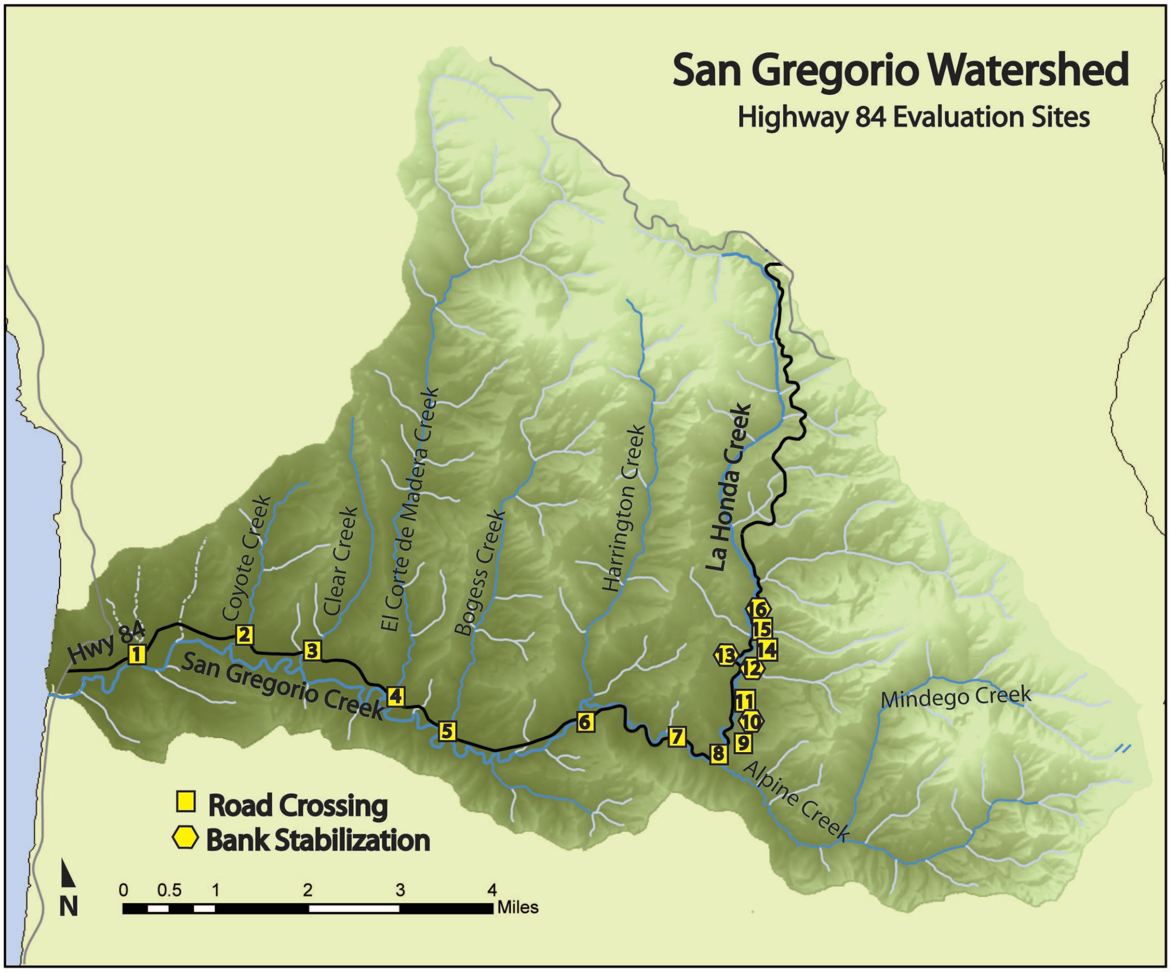
FIGURE 7: Examples of seasonal fish passage barrier due to insufficient water depth in culvert crossing (Site 14)

FIGURE 8: Fish passage and sediment source evaluation site assessment results

FIGURES

FIGURE 1: San Gregorio Watershed location map

FIGURE 2: San Gregorio Watershed and evaluation site locations



1. Stage Road Crossing
2. Coyote Creek Crossing (SM84 2.10)
3. Clear Creek Crossing (SM84 2.89)
4. El Corte de Madera Creek Crossing (SM84 4.08)
5. Bogess Creek (SM84 4.60)
6. San Gregorio Creek Crossing (SM84 6.20)
7. San Gregorio Creek Crossing (SM84 7.55)
8. La Honda Creek Crossing (SM84 8.12)
9. La Honda Creek Crossing below Playbowl (~SM84 8.5)
10. Gabion Bank Stabilization (~SM84 8.8)
11. Entrada Road Crossing
12. Sackcrete Bend (SM84 9.22)
13. Rip Rap Bend (SM84 9.34)
14. La Honda Culvert Crossing (SM84 9.68)
15. Hanging Tributary Culvert (SM84 9.78)
16. Landslide Bend (SM84 9.85)

FIGURE 3: Sackcrete Bend As-Built Drawing (Caltrans,1956)

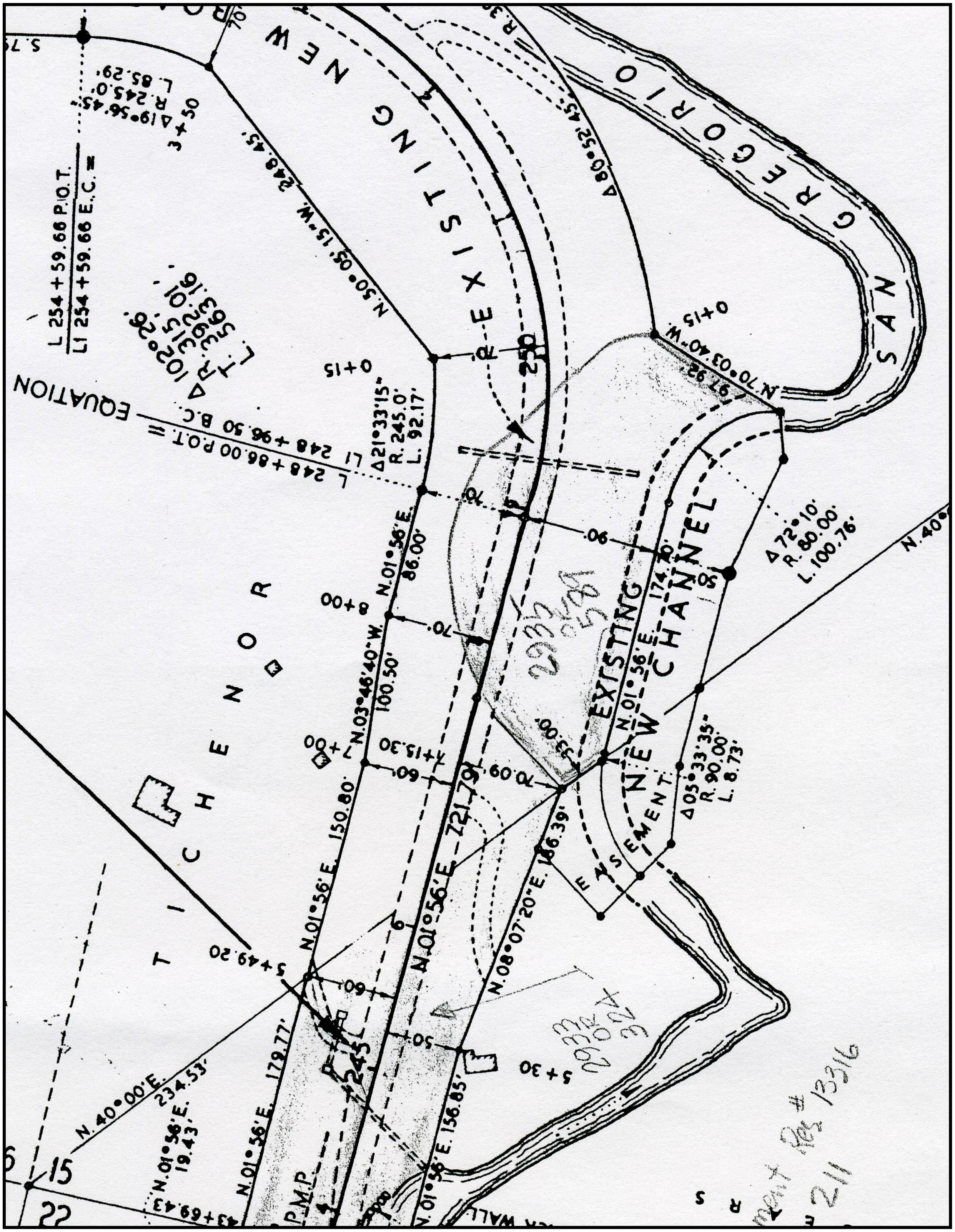


FIGURE 4: Sackcrete Bend current plan view

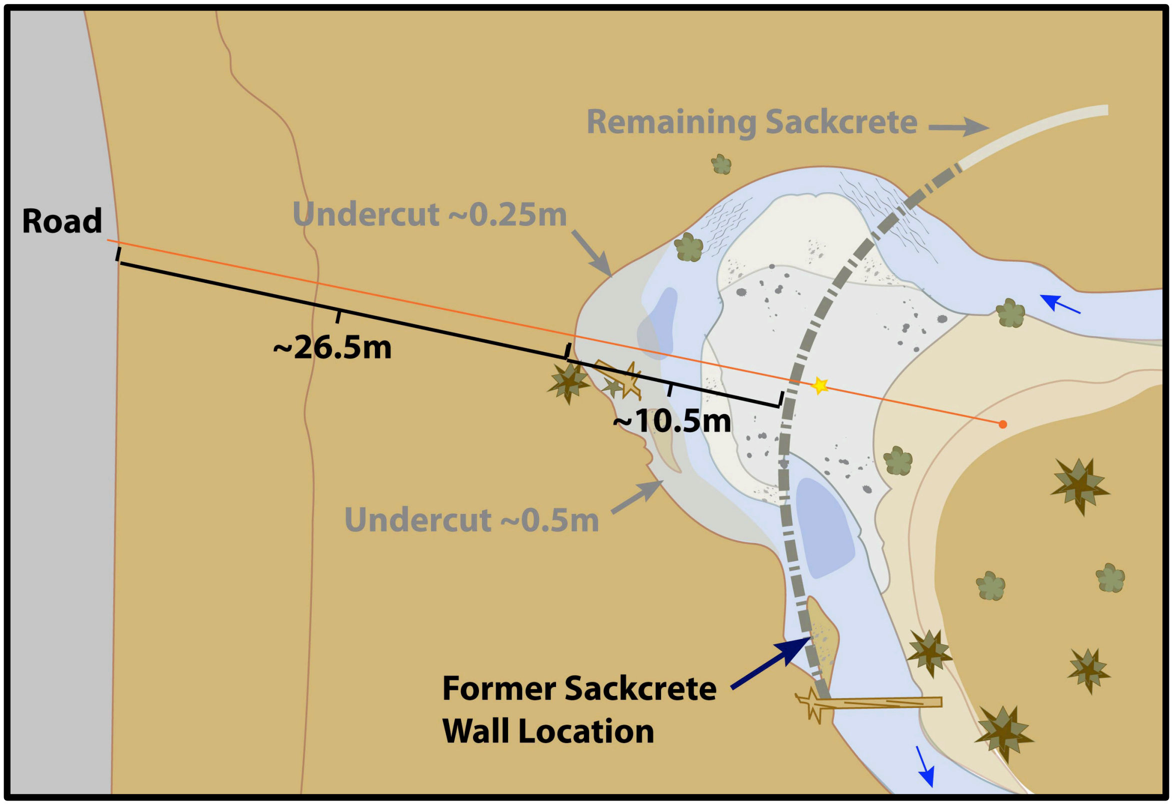


FIGURE 5: Sackcrete Bend 2008 profile with estimate of 1956 profile and fill area

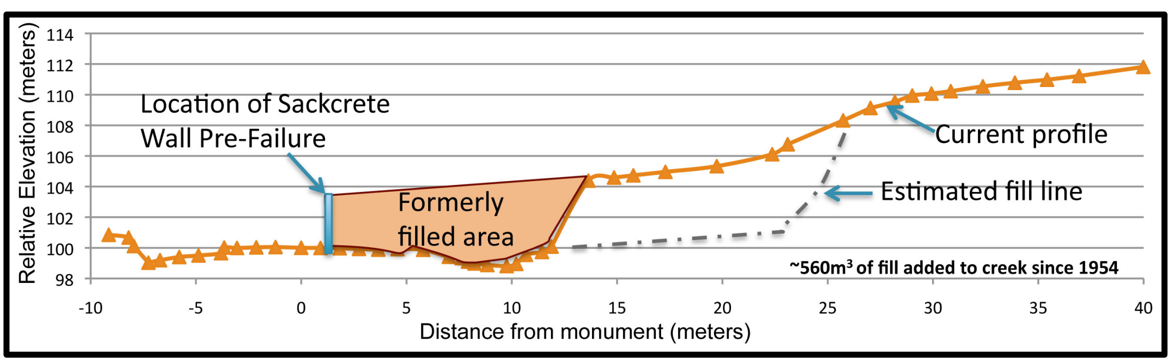


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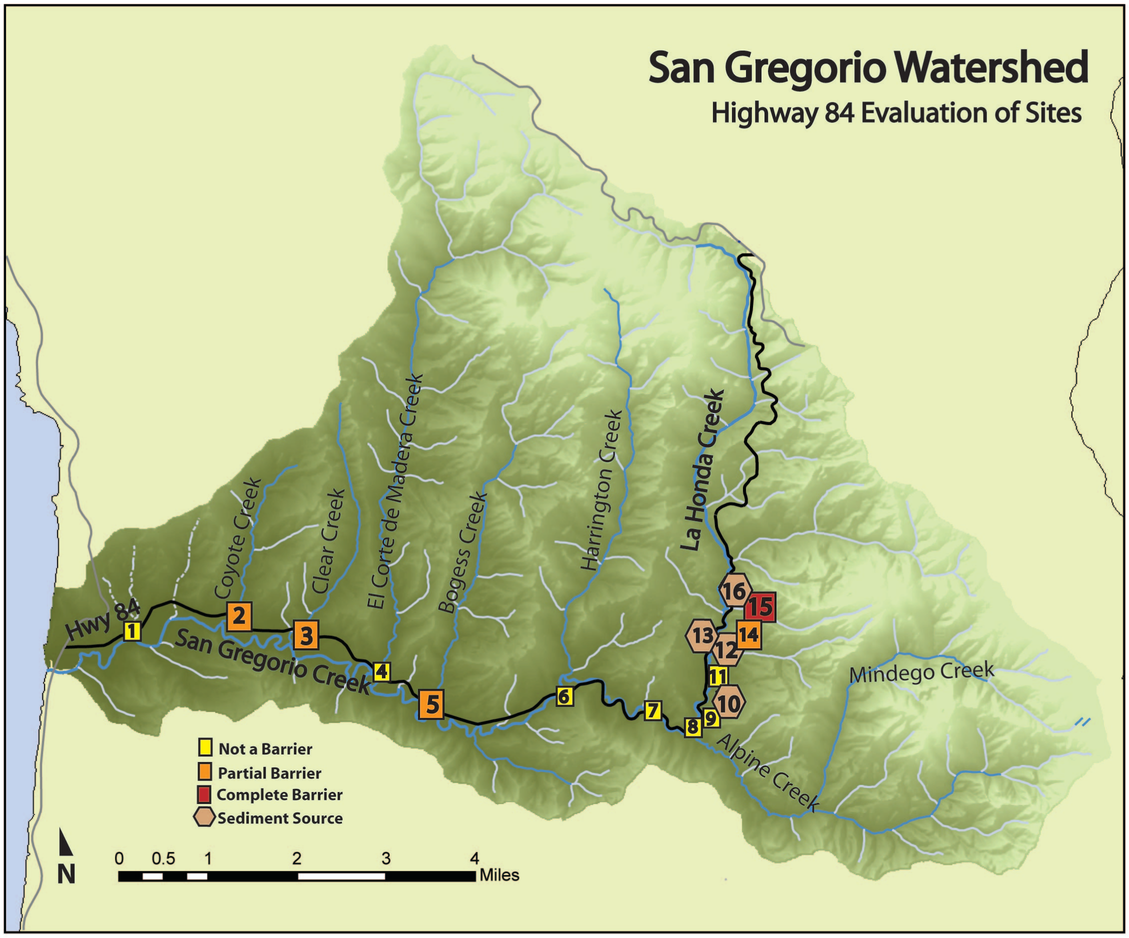
FIGURE 7: Examples of seasonal fish passage barrier due to insufficient water depth in culvert crossing (Site 14)

FIGURE 8: Fish passage and sediment source evaluation site assessment results



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15. Hanging Tributary Culvert (SM84 9.78)
16. Landslide Bend (SM84 9.85)

TABLES

TABLE 1: Drainage and channel length of San Gregorio Creek and its primary tributaries

Creek	Drainage (sq mi)	Channel Length (mi.)
San Gregorio	51	45
Coyote Creek	2.5	2.1
Clear Creek	2.9	3
El Corte de Madera	9.8	9.7
Bogess	3.3	4.7
Harrington	4.8	3.5
La Honda	12.2	7.6
Apline/Mindego	9.5	9.4
Kingston	1.2	1.75

TABLE 2: Seasonal presence of Coho in California watersheds (DFG, 2004)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration												
Spawning												
Egg Incubation												
Emergence/Fry												
Juvenile Rearing												
Emigration												

TABLE 3: Infrastructure Sites Evaluated along the Highway 84 Transportation Corridor

Site #	Hwy 84 Marker ID	Name	Creek	Outlet drop to pool (m)*	Outlet Pool Depth (m)**	Low Flow Water Depth in Crossing (m) ***	Potential Impact
1	NA	Stage Road Bridge	San Gregorio	NA - no drop	NA - no drop	0.6	Minor to none
2	SM 84 2.10	Coyote Creek Crossing	Coyote Creek	1	0.6	0.05	Fish passage barrier during low flow
3	SM 84 2.89	Clear Creek Crossing	Clear Creek	0.15	NA - dry	NA - dry	Minor impacts to rearing and smolt migration
4	SM 84 4.08	El Corte de Madera Creek Crossing	El Corte de Madera	0	NA - no drop	0.2	None identified
5	SM 84 4.60	Bogess Creek Crossing	Bogess Creek	0	0.15	0.05	Fish passage barrier during low flow
6	SM 84 6.20	San Gregorio Creek Crossing	San Gregorio	NA - no drop	NA - no drop	0.15-0.4	Minor to none
7	SM 84 7.55	San Gregorio Creek Crossing	San Gregorio	NA - no drop	NA - no drop	0.3	Minor to none
8	SM 84 8.12	La Honda Creek Crossing	La Honda Creek	NA - no drop	NA - no drop	0.35	Minor to none
9	SM 84 8.5	La Honda Creek Crossing Below Playbowl	La Honda Creek	0	0.8	0.25	Minor to none
10	SM 84 8.8	Gabion Bank Stabilization	La Honda Creek	NA - no drop	NA - no drop	NA	Sediment/Hazard
11	NA	Entrada Road Bridge	La Honda Creek	NA - no drop	NA - no drop	0.3	Minor to none
12	SM 84 9.22	Sackcrete Bend Bank Stabilization	La Honda Creek	NA - no drop	NA - no drop	NA	Sediment/Habitat Loss
13	SM 84 9.34	Rip Rap Bend Bank Stabilization	La Honda Creek	NA - no drop	NA - no drop	NA	Sediment/Habitat Loss
14	SM 84 9.68	La Honda Culvert Crossing	La Honda Creek	0.25	0.35	0.04	Fish passage barrier during low flow
15	SM 84 9.78	Hanging Tributary	La Honda Creek	0.6	0.3	NA	Complete barrier to fish passage
16	SM 84 9.85	Landslide Bend	La Honda Creek	NA - no drop	NA - no drop	NA	Sediment/Hazard / Potential Future Barrier

* *Maximum jump height of adult coho salmon is ~0.3m (DFG, 2004)*

** *Pool depth at least twice the height of the jump height is recommended, minimum 0.3m (DFG, 2004)*

*** *Depth of at least 0.18m recommended as minimum depth for coho salmon passage (DFG, 2004)*

Note: All measurements were taken November 2008 and are assumed to be consistent with average low flows

APPENDIX A: REACH DESCRIPTIONS

LOWER REACH

The lower reach of the San Gregorio watershed includes the drainage areas for the Coyote Creek and Clear Creek tributaries as well as two other small intermittent unnamed tributaries. Agricultural fields spread over the valley and low-lying areas of the southwest portion of the watershed while a lagoon lies at the mouth of San Gregorio Creek. Small rolling hills and steep canyons dominated by annual grasslands line up almost parallel to the coastline on the northwest side of the watershed while a single ridgeline runs perpendicular to the coastline on the southernmost edge of the watershed. Head cuts from gully erosion are easily visible in drainage areas that are grazed. Terracettes and hillslope slumping are also readily visible. Drainage channels where grazing is restricted by fencing contain dense clusters of chaparral shrub species such as coyote bush (*Baccharis pilularis*) and California Yerba Santa *(Eriodictyon californicum)*.

Geology in this area is primarily defined by the San Gregorio Fault Zone which runs almost parallel to the coastline and is exposed in the area between the coast and the town of San Gregorio (Brabb, 1990). The hill and canyon formations in the northern portion of this watershed run parallel to these fault lines. Poorly consolidated marine terrace deposits and alluvial fan deposits are dominant in the lower elevations (Brabb, 1980). I observed thin layers of both fine-grained sand and silt deposits on the channel bed surface and approximately 30-40% of the bed material consists of weathered mudstone clasts that can eaily be broken in one’s hands at the sites where Highway 84 crosses Clear Creek and El Corte de Madera Creek.

Middle Reach

The middle reach of the watershed transitions to steeper hillslopes that are primarily grazed in the lower elevations and forested in the upper elevations. Unlike the lower reach tributaries, flowing water was observed in all tributaries located in the middle reach.

Grazed grasslands dominate the lower hillslopes of the middle reach while willow (*Salix spp.*), Maple (*Acer spp*.), alder (*Alnus rhombifolia*), redwood (*Sequoia sempervirens*), and Douglas fir (*Pseudotsuga menziesii*) dominate the canyon slopes and main drainage areas. The headwaters of the tributaries located within the middle reach are within forests dominated by redwood (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*), and tan oak (*Lithocarpus densiflorus*). As the name of the El Corte de Madera Creek tributary implies, the higher elevations in this reach once contained dense old-growth forests that were heavily logged during the 1800's (Richards, 1973).

The middle reach is primarily underlain by Pomponio mudstone and Tahana, a fine-grained siltstone and sandstone containing some silty mudstone, although basaltic volcanic rock spans across the middle of the Harrington Creek drainage along the La Honda Fault and coarse grained alluvial deposits are found along the San Gregorio Creek channel (Brabb, 1980). I readily found rounded mudstone clasts 22-45mm wide along with solid gravels (basalt?) of similar size classes in the tributary channels at each road crossing and an exposed siltstone and mudstone deposit in the bed of El Corte de Madera Creek upstream from the Highway 84 crossing.

Upper Reach

Highway 84 and La Honda Creek become confined to a narrow canyon in this upper reach, therefore increasing the areas in which the road and creek interact. At the same time, erosion caused by overland flow and landsliding in these upper slopes are common (Wieczorek, G.F., 1982). The soils in this reach are similar to the ones in the middle reach with fine-grained siltstone and sandstone being dominant. I observed silty mudstones in the creek channels in the upper reaches although not as abundant as in middle reach channels. Basaltic volcanic rock is also present in this reach, particularly along the Woodhaven fault which runs perpendicular to La Honda Creek and crosses the creek near its headwaters above Weeks Creek (Brabb, 1980).

Although homes and ranchettes are scattered throughout the watershed, the upper reach of the watershed contains the majority of the residential development in the watershed. Slightly upstream from the confluence of Alpine Creek and La Honda Creek is the town of La Honda with a population of approximately 1,500. The hillslopes are primarily grazed in the lower elevations and forested in the upper elevations and along drainages. Dominant forest species in the upper reach include redwood (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*), bay (*Umbellularia californica*) and tan oak (*Lithocarpus densiflorus*). I observed that the vegetative canopy over La Honda Creek was generally greater than 85% in the places that I visited. I also noticed that La Honda Creek undergoes a geomorphic change throughout this reach with mild slopes and bar/pool processes dominating the lower portions of the reach while step/pool sequences were more prominent in the higher elevations of this reach.