SAN DIEGUITO RIVER PARK BANK AND TRAIL EROSION
Preliminary Geomorphic Review and Conceptual Solutions

Prepared for
San Dieguito River Park
Joint Powers Authority

7/7/2016
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550 Kearny Street
Suite 800
San Francisco, CA 94108
415.696.5900
www.esassoc.com

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Background
Bank erosion has severed the Coast to Crest Trail along the San Dieguito River at Del Mar Horse Park, west of El Camino Real Bridge (Figure 1). The San Dieguito River Park Joint Powers Authority (SDRP) has hired ESA to perform a qualitative assessment of underlying geomorphic conditions at the site, and to develop potential concepts for bank stabilization. The site is a bank failure approximately 80 feet long (parallel with the bank), located 570 feet downstream of El Camino Real Bridge.

Note that these concepts were developed qualitatively using best professional judgement based on limited site data, to help the SDRP and relevant stakeholders better understand the site dynamics and visualize potential solutions. Additional data collection and analysis (described below in the “Roadmap to Implementation” section) will be required to develop preliminary designs that can support permit applications and more detailed engineering design, leading to implementation of a solution.

Channel Evolution and Causes of Bank Erosion at the Site
Geomorphic conditions at the site were reviewed based on a site visit carried out on May 25th 2016, review of aerial photos of the site in Google Earth covering the period from May 1994 to March 2016, review of historic aerial photos going back to 1953, and examination of a cross section and topographic surface for the site derived from the 2010 NOAA Coastal LiDAR survey (Figures 2 and 3).

In order to understand the geomorphic context of the eroding bank, ESA reviewed aerial photos of the site in Google Earth that covered the period from May 1994 to March 2016. The edge of the north bank was traced for years in which visible changes in the location of the bank top occurred, to allow patterns of erosion to be seen (Figure 4). These are summarized below.

- Between 1994 and September 2010 the changes to the visible bank geometry were negligible and undetectable relative to slight changes in the bank appearance due vegetation canopy changes or water level.

- Between September 2010 and October 2012 approximately 12 feet of bank retreat occurred along approximately 25 feet of bank, opposite an impinging distributed channel that approaches the north bank from the south side of the channel. This created an area of steep bank that is just downstream of the apex of the January 2016 erosion. There were large flows on Dec 22nd 2010 that may account for this erosion.

- Between October and November 2012 a second embayment was eroded from the bank about 30 feet upstream when a large tree toppled, tearing out the bank behind it for a distance of about 20 feet and a retreat distance of about 6 feet. No especially large flows occurred during this period so this may represent a delayed response to earlier flows that led to progressive failure of the bank.

- Between April 2015 and March 2016 a 95 foot length of bank was eroded by an average distance of about 20 feet (maximum 35 feet), triggering the current study. Large flows occurred on January 5th 2016.
Reviewing aerial photos from 1953 to the present it is apparent that the channel has been confined over time by placement of fill along the banks, and reviewing the LiDAR topography (Figure 2) it is clear that the existing channel becomes progressively more confined downstream as the river approaches the project site. In the upstream reaches of Fairbanks Ranch Country Club the channel is more than 500 feet wide. Half a mile upstream of the El Camino Real Bridge the channel constricts to around 360 feet wide. At the eroded bank the channel is about 300 feet wide, narrowing to almost 200 feet further downstream. At a macro scale this narrowing likely creates flow concentration and acceleration through the reach by the equestrian center. Combined with the non-cohesive nature of the fill making up the banks this is likely the main cause of erosion within the reach adjacent to the equestrian center.

At a medium-scale the eroding site appears to be both a slight outside bend in the main low flow channel, and a location where a secondary flow channel rejoins the main channel, concentrating flow against the north bank. Vegetation growth in the main channel appears to have played a role in deflecting flows locally against the north bank.

Review of the 2010 LiDAR topographic data (Figure 3) shows that prior to erosion and failure the river bank was about 5 feet high in its steepest section and had a gradient of around 5:1, while under existing conditions there is an almost vertical section of about 6 feet height. Based on this the failure mechanism appears to have been a combination of toe erosion that undercut the bottom of the bank followed by geotechnical failure (bank slumping) of the upper bank.

**Anticipated Site Evolution Under a No-Action Alternative**

The combination of flow concentration (channel narrowing) and highly erodible bank material means that some degree of ongoing bank erosion is likely to be expected adjacent to the equestrian center, including potentially at new locations such as the next eroding bend 290 feet downstream of the project site discussed in this memo.

Under existing conditions the bank at the project site is vertical in places, with bare exposed earth. The earth is highly erodible fill material dominated by sands and decomposed granite, with little cohesion. The erosion in winter of 2016 has made the outside bend (as viewed at the medium scale) more pronounced and thus more likely to continue eroding in future if no action is taken to stabilize the bank. There is a high probability that, if no action is taken, the existing oversteepened bank will continue to retreat through two processes;

- Bank flattening behind the existing toe. Even if the focus of river erosion moves elsewhere because of instream vegetation patterns or human action, or if vegetation becomes established on the toe of the bank preventing future erosion, the existing oversteepened bank is likely to retreat towards the equestrian center until the bank reaches an equilibrium angle (angle of repose). For sand and gravel this might be expected to be around 35 degrees (approximately 1.5:1 gradient). We might therefore expect an additional 7-10 feet of retreat from the top of the existing vertical bank sections. This is likely the most optimistic scenario and so as a minimum should be accounted for in management plans for the site.
- Bank toe erosion and further bank retreat. The current geometry of the eroding bank and the highly erodible nature of the bank material makes future toe erosion highly likely. Additional erosion and bank retreat is most likely to focus on the apex of the eroded bend as well as to migrate downstream, but expansion of the eroded area
upstream is also possible. Expansion of the eroded area upstream and downstream must be taken into consideration if an alternative involving a bridge and abutments is proposed, to reduce the risk of undermining such a bridge.

**California Coastal Commission Permit Conditions**
The project site is covered by a Coastal Development Permit, issued by the California Coastal Commission for the construction of the San Dieguito River Park’s Coast to Crest Trail extension through the “Horsepark” segment of the river valley. This permit included special conditions that do not allow “channelization (i.e. berms, walls, riprap, shotcrete, etc.)” or “substantial alteration of a river or stream” to protect the development from flooding or erosion of the riverbank. This condition seems to be somewhat open to different interpretations depending on whether the goal is to prevent channelization and the placement of “hardscape” materials, or the goal is to prevent anything that limits bank erosion. Since the condition is called “No Future Channelization” rather than, for example, “No Bank Stabilization” we have interpreted our conceptual designs on the former basis rather than the latter in attempting to show which alternatives are likely to best meet the Special Conditions.

**Conceptual Approaches to Bank Stabilization**
Although the project site and surrounding sections of bank are inherently susceptible to ongoing bank erosion because of the reach-scale geomorphic setting described above, there is potential to locally increase bank stability and the longevity of the current trail alignment by creating a lower gradient bank with more vegetation and a more resistant toe. Such an approach will buy additional time for the Coast to Crest Trail, but will not reduce the factors causing erosion in this reach of the river (i.e. they will reduce the symptoms and rate of bank erosion but not the causes).

ESA initially developed three conceptual approaches to stabilizing the area of bank that failed in January 2016. For Alternatives 1-3 the following goals were adopted per discussions with the SDRP:

- Use biotechnical methods to the extent feasible (live vegetation rather than ‘hard’ bank protection).
- Avoid any encroachment on property north of the Coast to Crest Trail.

In the three conceptual approaches described below, the proposed construction methods and materials for the banks are identical, with the main difference being the alignment and bank angle, as well as the approach to restoring access along the Coast to Crest Trail. The common construction details are described first, followed by the differences in alignment. Note that because encroachment onto property north of the Coast to Crest Trail footprint was considered a fixed constraint, all alternatives are based on filling the bank out from its current location to somewhere at, or landward of, the pre-January 2016 bank edge. No alternatives based on cutting back into the bank were initially assessed. Following review of a draft report ESA added a fourth alternative based on realignment of the trail. This alternative would involve encroachment on property north of the trail.
**Design Elements Common to all Alternatives – Bank Reconstruction**

For all three alternatives the river bank would be constructed by re-filling some or all of the area that was eroded away in January 2016. No alternatives would place fill riverwards of the bank as it existing immediately prior to the January 2016 bank erosion.

The fill would create a prism of imported native soil suitable for planting riparian vegetation between the existing vertical bank and the pre-January 2016 bank (riverward limit varying between Alternatives), graded at a stable angle (also varying between Alternatives). The bank would be constructed using Vegetated Soil Lifts (VSLs, sometimes referred to as Encapsulated Soil Lifts or Fabric Soil Wraps). VSLs are typically 1 foot high lifts of native soil that are wrapped in layers of biodegradable coir fabric, stacked on top of each other to build up the river bank as a series of terraces. Between each lift, a horizontal layer of live riparian plant stems (e.g. willows) is placed that germinate and grow into the soil lifts, providing root reinforcement, erosion protection and habitat. An advantage of refilling the bank is to reduce the embayment that was created after the January 2016 erosion: this likely creates an eddy at high flows which perpetuates erosion.

**Design Elements Common to all Alternatives – Toe Protection**

Depending on the erosive stresses anticipated and the desired design life of the bank, some form of toe protection may be needed below the purely vegetation-based protection of the VSL. Protection is likely to be needed because strong roots and surface vegetation cover associated with riparian trees are unlikely to grow submerged below the typical water level, and aquatic plants that grow in this location provide less reinforcement, creating a line of weakness. The specific nature of the toe protection would require more detailed data analysis and design than the scope of this conceptual memo, but would likely be some combination of the following:

- **a) Rock-filled toe trench.** A rock-filled toe trench would likely be constructed beneath the lowest layer of VSL, to reduce its vulnerability to undercutting. While more site and hydraulic model data are needed to size the trench and rock for this site, typical dimensions for this type of feature might be 3-6 feet deep below the base of the bank toe, with a width of 6-12 feet, and rock 2-3 feet in diameter. This approach is resistant and likely has the highest design life of the toe alternatives, but involves importing and burying large rock and so may be a regulatory challenge. Since the rock would be buried below grade to facilitate a biotechnical approach on the above-grade bank, this sub-alternative should not be considered as channelization, and should be in compliance with the special conditions of the Coastal Development Permit. However, a more expansive reading of the special conditions could consider this as placement of riprap, particularly if the rock size exceeds 12 inches in diameter.

- **b) Log revetment.** The toe of the bank might also be protected by a log revetment. This would likely take the form of combinations of horizontal logs laid down parallel with the bank toe and logs driven at an angle into the bank perpendicular to the bank toe. The logs would typically be secured with cables or ballasted by large rocks to reduce the chance of them undermining the stability of the structure by becoming buoyant. Construction of a log revetment is probably the most expensive approach to toe protection, and using large logs in juxtaposition with fine sediment can create...
local scour that undermines the log structures during high flows. Though challenging to design and construct, this approach is probably the most environmentally-beneficial approach to toe protection. This approach appears to be compatible with the terms of the Coastal Development Permit, since it is not channelization or substantial alteration of the river, and none of the methods given as examples include logs and other natural materials.

c) **Aquatic vegetation.** Aquatic vegetation could be used to provide some protection to the lowest part of the bank toe. This is the least invasive approach to construction, but field evidence at the site suggests that previous aquatic vegetation was insufficient to prevent toe erosion. This approach appears to be very compatible with the terms of the Coastal Development Permit, since only vegetation or biodegradable coir fabric is used for erosion reduction.

**Fill lowest VSLs with coarse sediment.** In all the above sub-alternatives, if needed the lowest 1-3 VSLs might also be filled with a mixture of native soil and coarser material (cobbles and boulders) to provide additional erosion resistance.

Where coarse material was used (rock toe or lowest VSLs) the voids would be filled with native soil to provide a growing matrix for native vegetation.

**Alternative 1. Reconstruct pre-2016 bank profile**
This approach would use VSLs to reconstruct the bank as it was immediately prior to the January 2016 erosion (approximately 18 feet at the most eroded part of the bank). The bank would have a gradient of approximately 5:1 and would be planted with native vegetation. To prevent the bank from undergoing toe erosion and retreat again the toe would likely be protected by either a log revetment and/or buried rock toe trench, with potentially some boulder and cobble placed in the lowest 1-3 feet of VSL to provide additional erosion resistance.

Reconstructing the pre-2016 bank would provide space for the Coast to Crest Trail to be reconstructed in its original alignment.

Pros: Provides the most stable bank; allows the trail to be reconstructed; ties in to existing bank edge (removes embayment that may self-perpetuate eroding eddy)

Cons: Greatest temporary impact; most expensive for bank stabilization (excluding cost of trail or bridge); potentially hardest to permit due to encroachment into existing jurisdictional waters.

**Alternative 2. Intermediate option: reconstruct bank profile to allow trail reconstruction**
This approach would use VSLs to reconstruct the bank sufficiently to provide room for the Coast to Crest Trail to be reconstructed (approximately 12 feet at the most eroded portion of the bank). The bank would have a gradient of approximately 3:1 and would be planted with native vegetation. Construction at 3:1 rather than 5:1 would reduce the amount of encroachment into the post-January 2016 channel. To prevent the bank from undergoing toe erosion and retreat again the toe would likely be protected by either a log revetment and/or buried rock toe trench,
with potentially some boulder and cobble placed in the lowest 1-3 feet of VSL to provide additional erosion resistance.

Pros: Provides the intermediate level of bank stability; allows the trail to be reconstructed.

Cons: Medium temporary impact; medium expense for bank stabilization (excluding cost of trail or bridge); medium to permit due to slight encroachment into existing jurisdictional waters.

**Alternative 3. Minimalist stabilization of existing bank with trail relocated to bridge**
This approach would tie in with existing conditions at the current top of bank, but would add a small amount of VSL-reinforced soil fill below that to attain a stable bank (3:1 gradient) that could be planted with native vegetation. This alignment would not create enough room at top of bank for the Coast to Crest Trail; the trail would have to be relocated onto a bridge over the eroded bank section. The purpose of bank stabilization would be to prevent further erosion of the trail and to increase the longevity of the bridge section.

Pros: Minimizes impact and encroachment into jurisdictional wetland; lowest expense for the bank stabilization (excluding cost of bridge). Minimizes permitting complexity.

Cons: Requires a bridge in addition to the bank stabilization. Leaves embayment in place (may be self-perpetuating eddy).

Alternatives 1-3 appear to be compatible with the Coastal Development Permit, in that they do not constitute channelization or substantial alteration of a river.

**Alternative 4. Trail realignment**
Given the likely role of channel confinement as a long-term cause of bank erosion and the high probability of future bank erosion along the Horsepark reach of the trail in future, an alternative approach is to realign the trail further away from the existing top of bank. Setting the trail back from the top of bank would allow for either gradual bank retreat or bank stabilization approaches that involved laying back the bank to a gentler angle and replanting with natives. Alternative alignments were not considered for this study.

Pros: Potentially eliminates the need for any action within the riparian corridor or USACE/RWQCB regulated areas. Compatible with an expansive interpretation of the Coastal Development Permit Special Conditions (i.e. one that restricts what is permissible).

Cons: Depending on location, would encroach on property north of the current trail.

**Recommendations for Planting**
As part of potentially implementing any bank reconstruction alternative that would include re-filling the area with soil (e.g., VSLs), native planting and seeding would be included to help stabilize the soil surface and bank, and provide habitat. Planting would primarily include
perennial woody species with larger root systems but would also include annual species for initial ground surface erosion control, and also potentially some perennial herb species (e.g., *Schoenoplectus* sp. or *Typha* sp.) at the bank toe. The primary factors for species selection include (1) native species that occur in this portion of the river (species adapted to brackish conditions and salinity on-site), (2) species that will help stabilize the bank, and (3) species that establish and grow relatively fast.

As stated earlier in the case of VSLs, between each lift a horizontal layer of live riparian plant stems (e.g., willows) is placed to grow and provide root reinforcement. Vertical planting and seeding would also be conducted to supplement plant growth, root development, and bank reinforcement.

A preliminary list of potential species include:

- **Bank Toe**: *Schoenoplectus* sp. (bulrush) or *Typha domingensis* (southern cattail). These species could dissipate water flow energy and shear stresses during storm events, and could layover and act as a vegetative blanket during larger storm events.

- **Lower Bank**: *Salix lasiolepis* (arroyo willow), *Salix laevigata* (red willow), *Salix exigua* (thin-leaved willow), *Baccharis salicifolia* (mule fat), and perennial grasses including *Elymus triticoides* (beardless wild rye grass) and *Distichlis spicata* (saltgrass)

- **Upper Bank**: Mule fat, *Baccharis pilularis* (coyote brush), *Isocoma menziesii* (coastal goldenbush), *Lupinus* sp. (lupine), *Acmispon glaber* var. *brevialatus* (deerweed), and *Vulpia microstachys* (small fescue).

Planting and seeding would be conducted in a manner to minimize bank disturbance. To assist with soil surface stability, either a natural fiber matting (e.g., coir blanket) could be installed over a portion of the reconstructed bank in conjunction with planting and seeding, or an organic fiber mulch or bonded fiber matrix (BFM) could be applied after planting and seeding.

It is expected temporary irrigation would be needed to help establish plants on the upper bank and portions of the lower bank. Although the lower bank will have moist soil for all or most of the year, periodic freshwater irrigation will help with plant establishment and initial growth. Periodic hand-watering using a hose (with a low pressure nozzle) from the top of the bank would be expected to be a better option than installation of a temporary, automated irrigation system.

It is expected at least two years of periodic maintenance would be needed to establish the plant material. To minimize walking and disturbance on the bank, it is recommended weed control would focus on treatment and eradication (by hand-removal or use of herbicide approved for an aquatic setting) of the most problematic exotic species (e.g., salt-cedar, giant reed, tree tobacco, fennel, perennial pepperweed, and acacia).
Roadmap to Implementation

In order to advance towards implementation the following steps would be required.

1. Obtain feedback on preferred approach (including permittability of different alternatives)
2. Collect survey data on existing topography $6K
3. Use existing hydraulic model (assuming the site is close to a cross section or computational element) to compare shear stresses with design shear resistances for biotechnical materials.
4. Develop 30% design
5. Perform CEQA: A determination would need to be made regarding which entity would be the Lead Agency under CEQA. The Lead Agency could potentially be the SDRP JPA or California Department of Fish and Wildlife (CDFW). Based on the potential bank reconstruction alternative that may be chosen and the project description relative to the amount of fill and project activities (i.e., restoring a channel bank and native habitat), the project may qualify for a CEQA Exemption. If not, a Mitigated Negative Declaration may be needed.
6. Initiate Permitting: If a project design is prepared that includes the placement of fill into waters of the U.S. and state, permits and authorizations would be needed including a Clean Water Act (CWA) 404 Permit from U.S. Army Corps of Engineers (USACE), a CWA 401 Water Quality Certification from Regional Water Quality Control Board (RWQCB), and a Section 1602 Streambed Alteration Agreement from CDFW. In regard to the 404 Permit, authorization may potentially be provided under Nationwide Permit (NWP) 18: Minor Discharges, or NWP 27: Aquatic Habitat Restoration, Establishment, and Enhancement Activities. Depending on the project design and input from the California Coastal Commission (CCC), the existing CCC permit for the Horse Park Segment of the Coast to Crest Trail could be amended or a new CCC permit may be required. To complete permitting, RWQCB and CDFW will need CEQA documentation or confirmation of an Exemption. Due to the type of proposed activity, it is expected the project would be self-mitigating and would not require any supplemental mitigation. If design for a channel bank reconstruction project proceeds, it is recommended the project schedule a site meeting with the resource agencies to obtain input and expedite the permitting process. It is not known at this time if a grading permit would be needed from the local jurisdiction.
7. Advance design to 65%
8. 100% design
9. Construction support (if applicable)

Conceptual Estimate of Costs

The following approximate cost estimate has been provided, recognizing that at this point such estimates are very conceptual and depend on what design approach is taken, how much support there is for the preferred approach from regulators and stakeholders etc.

Preliminary Design to support permit application
Topographic survey, concept refinement, analysis of existing hydraulic information, 30% design $14,000
Environmental documentation, CEQA and preparation of permits
The estimated cost of the required permits and wetland delineation is approximately $12-14,000. If required, a Mitigated Negative declaration is estimated to cost around $12-18,000.

Final Design
The estimated cost of advancing the 30% design through 60% and final design is $10,000.

Estimate of Probable Construction Costs
Note that construction costs are very sensitive to the state of the local economy and so can vary greatly depending on timing.

100 linear feet of VSL bank reconstruction with buried rock toe protection ~$96,000
100 linear feet of VSL bank reconstruction with log revetment ~$312,000

Note: these costs do not include a bridge for Alternative 3.
Figure 3
LiDAR-derived topography at the eroding bank site (2010)
San Dieguito River
Figure 4
Bank Alignment Showing January 2016 Erosion
Figure 5

Alternative Toe Protection Approaches
Figure 6
Conceptual Cross Sections Showing Three Alternative Bank Stabilization Alignments