HYDROMODIFICATION SCREENING

FOR

OCEAN BREEZE RANCH

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Wayne W. Chang, MS, PE 46548

ChangConsultants

Civil Engineering ◦ Hydrology ◦ Hydraulics ◦ Sedimentation

P.O. Box 9496
Rancho Santa Fe, CA 92067
(858) 692-0760

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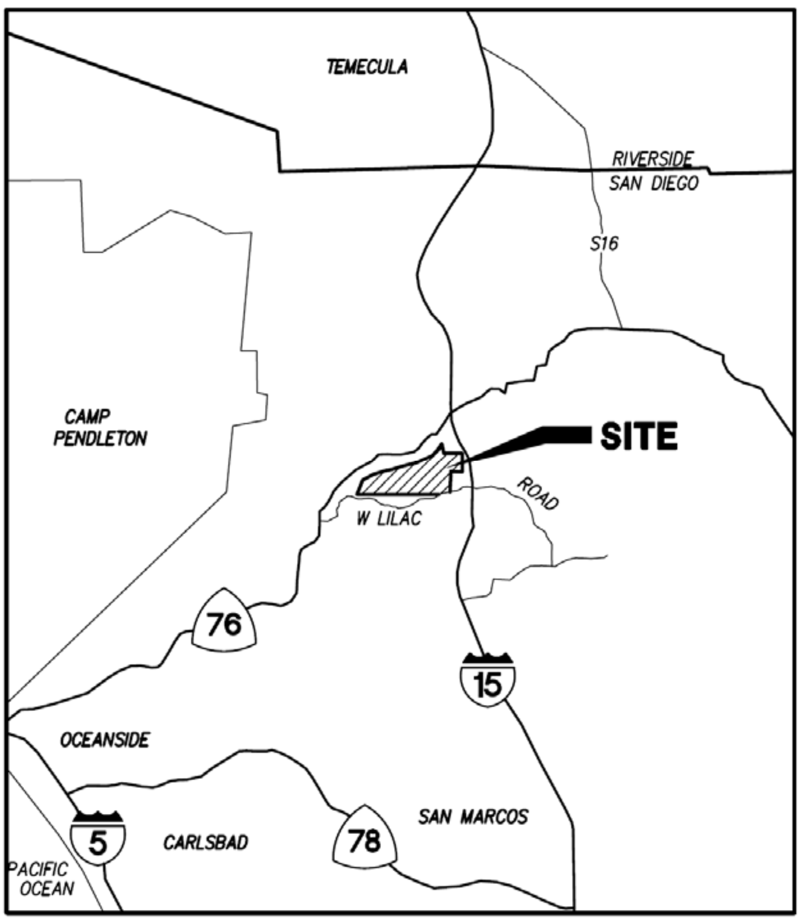
INTRODUCTION

The County of San Diego's March 2011, *Final Hydromodification Management Plan;* January 8, 2011, *Standard Urban Stormwater Mitigation Plan* (SUSMP); and January 2019, *BMP Design Manual* outline low flow thresholds for hydromodification analyses. The thresholds are based on a percentage of the pre-project 2-year flow (Q_2), i.e., $0.1Q_2$ (low flow threshold and high susceptibility to erosion), $0.3Q_2$ (medium flow threshold and medium susceptibility to erosion), or $0.5Q_2$ (high flow threshold and low susceptibility to erosion). A flow threshold of $0.1Q_2$ represents a natural downstream receiving conveyance system with a high susceptibility to bed and/or bank erosion. This is the default value used for hydromodification analyses and will result in the most conservative (largest) on-site facility sizing. A flow threshold of $0.3Q_2$ or $0.5Q_2$ represents downstream receiving conveyance systems with a medium or low susceptibility to erosion, respectively. In order to qualify for a medium or low erosion susceptibility rating, a project must perform a channel screening analysis based on the March 2010, *Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility,* developed by the Southern California Coastal Water Research Project (SCCWRP). The SCCWRP results are compared with the critical shear stress calculator results from the County of San Diego's Critical Flow Calculator spreadsheet to establish the appropriate erosion susceptibility threshold of low, medium, or high.



Vicinity Map

This report provides hydromodification screening analyses for a portion of the Ocean Breeze Ranch project for which a tentative map is being prepared by Project Design Consultants (PDC). The project site consists of approximately 1,394 acres within the Fallbrook Community Planning Area. The site is located west of Interstate 15, south of the San Luis Rey River and State Route 76, and north of West Lilac Road. The site is generally in between the cross streets of Camino del Cielo and Via Ararat Drive along West Lilac Road. Sullivan Middle School is located near the southeastern portion of the site (see the Vicinity Map).

Under pre-project conditions, Ocean Breeze Ranch is primarily a Quarter Horse and Thoroughbred breeding farm. The site contains a few residences, agricultural farms, and a large complex of barns and pastures for horses. Storm runoff from the site and surrounding tributary areas primarily occurs as sheet flow on the natural ground surface or within naturally-lined drainage courses or private drainage facilities before ultimately entering the San Luis Rey River. Since the site is large, the storm runoff flows in various directions within and near the site.

The project includes preservation of the existing residences and barns, and development of a large portion of the site into single family homes with associated improvements including streets, landscaping, and utilities. The project proposes a combination of 396 traditional and estate lots for single-family use. The proposed on-site storm drain systems will have several discharge locations into the surrounding area. This report provides a downstream channel assessment for two of the discharge locations or points of compliance requested by PDC (labeled POC 1A and 3H on the Study Area Exhibit).

The SCCWRP screening tool requires both office and field work to establish the vertical and lateral susceptibility of a downstream receiving channel to erosion. The vertical and lateral assessments are performed independently of each other although the lateral results can be affected by the vertical rating. A screening analysis was performed to assess the low flow threshold for each POC.

The initial step in performing the SCCWRP screening analysis is to establish the domain of analysis and the study reaches within the domain. This is followed by office and field components of the screening tool along with the associated analyses and results. The following sections cover these procedures in sequence.

DOMAIN OF ANALYSIS

SCCWRP defines an upstream and downstream domain of analysis, which establish the study limits. The County of San Diego's HMP specifies the downstream domain of analysis based on the SCCWRP criteria. The HMP indicates that the downstream domain is the first point where one of these is reached:

- at least one reach downstream of the first grade control point
- tidal backwater/lentic waterbody
- equal order tributary

- accumulation of 50 percent drainage area for stream systems or 100 percent drainage area for urban conveyance systems (storm drains, hardened channels, etc.). This is also defined as a two-fold increase in drainage area.

The upstream limit is defined as:

- proceed upstream for 20 channel top widths or to the first grade control point, whichever comes first. Identify hard points that can check headward migration and evidence of active headcutting.

SCCWRP defines the maximum spatial unit, or reach (a reach is circa 20 channel widths), for assigning a susceptibility rating within the domain of analysis to be 200 meters (656 feet). If the domain of analysis is greater than 200 meters, the study area should be subdivided into smaller reaches of less than 200 meters for analysis. Most of the units in the HMP's SCCWRP analysis are metric. Metric units are used in this report only where given so in the HMP. Otherwise English units are used.

Downstream Domain of Analysis
The downstream domain of analysis locations for the study areas covered by this report have been determined by assessing and comparing the four bullet items above. As discussed in the Introduction, the project runoff will be collected by a series of proposed drainage facilities that outlet at various locations around the site. PDC has identified two specific locations to be analyzed by this report (see the Study Area Exhibit in the map pocket). A downstream domain of analysis has been identified below both of PDC's requested points of compliance (see POCs 1A and 3H on the Study Area Exhibit). Each downstream domain of analysis location was selected as follows.

Per the first bullet item, the first permanent grade control in the natural drainage courses below both of the POCs was located (see the Study Area Exhibit). Grade controls can be created by several types of improvements. They can occur at road crossings where the associated culvert will maintain the channel bed elevation. They can also occur where the drainage course is lined with concrete, asphalt, riprap, etc. due to an at-grade or Arizona crossing, or a drop structure. For POC 1A, a grade control will occur at a proposed street crossing over 800 feet downstream. The crossing will contain a culvert that acts as a grade control. For POC 3H, an existing CMP culvert is located under a dirt road crossing approximately 315 feet below the POC (see Figure 5). The culvert acts as a grade control.

The second bullet item is the tidal backwater or lentic (standing or still water such as ponds, pools, marshes, lakes, etc.) waterbody location. Based on review of Google Earth, there is no tidal backwater or lentic waterbody near either of the two POCs. The nearest such waterbody is at the Pacific Ocean (all of the project runoff ultimately flows to the San Luis Rey River and then Pacific Ocean), which is over 13 miles southwest of the site. Therefore, the second bullet item criteria will not govern over the other bullet item criteria for either of the POC's.

The third bullet item is met when the natural drainage course below a POC confluences with a stream with an equal order or larger tributary area. The Study Area Exhibit contains the drainage areas tributary to each POC and/or the first reach below the POC. The drainage areas were delineated based on PDC's hydrologic analysis and topographic mapping. For POC 3H, a portion of the off-site area was delineated using USGS mapping needed to supplement the project topography. It is apparent from the Study Area Exhibit that the drainage course associated with POC 1A confluences with a receiving drainage course in a short distance. Based on a visual study of the topographic mapping, it is obvious that the drainage area tributary to the receiving drainage course at its confluence with POC 1A is greater than the drainage area tributary to POC 1A. In addition, the receiving drainage course is closer to POC 1A than its associated permanent grade controls. Therefore, the third bullet item criteria will govern over the first bullet item for POC 1A.

On the other hand, the Study Area Exhibit reveals that the drainage course below POC 3H does not confluence with a larger drainage course prior to its permanent grade control. Therefore, the third bullet item criteria will not govern over the first bullet item for POC 3H.

The fourth bullet item was assessed by comparing the drainage area tributary to each POC with the location in each downstream drainage course where an additional 50 or 100 percent drainage area is accumulated. Fifty percent applies to POC 1A because its associated drainage course is a stream system and not an urban conveyance. For POC 1A, it is clear from the Study Area Exhibit that the accumulated area between POC 1A and the larger receiving watercourse identified in the third bullet item is less than 50 percent of the drainage area tributary to the POC. Therefore, the fourth bullet item will not govern over the third for POC 1A. For POC 3H, the Study Area Exhibit shows that well over 100 percent drainage area is added between the POC and its downstream grade control. Therefore, the bullet item 4 criteria will govern over the bullet item 1 criteria for POC 3H.

From the above information, the downstream domain of analysis locations for the POCs are based on different criteria. For POC 1A, the closest location from the four bullet items is established by the third criteria, which is at a confluence with an equal order or larger tributary area. For POC 3H, the closest location is established by the fourth criteria, which is accumulation of 50 percent drainage area below the POC.

Upstream Domain of Analysis

The proposed drainage facilities tributary to both POCs outlet into the uppermost end of their receiving drainage courses. Since the natural drainage courses do not extend upstream of the drainage facility outlets, the upstream domain of analysis location for these two POC's will be at each POC.

Study Reaches within Domain of Analysis

After the upstream and downstream domain of analysis locations are established for each POC, the study reaches are identified (see the Study Area Exhibit). One or more study reaches can occur below each POC. The following describes the study reaches associated with each POC.

Reach 1A (127 feet long) is the study reach below POC 1A. It extends from the upstream domain of analysis location at the proposed storm drain outlet at POC 1A to the confluence with the larger receiving watercourse.

Reach 3H (315 feet long) extends from the upstream domain of analysis location at the storm drain outlet at POC 3H downstream to where at least 50 percent drainage area is accumulated. For Reach 3H, the study reach was extended to the nearest grade control. The Study Area Exhibit shows that the added area at the grade control exceeds 50 percent by a considerable amount (it is closer to 200 percent), so the results will be conservative.

All of the study reaches are within the 656 foot (200 meters) maximum reach length recommended by SCCWRP.

INITIAL DESKTOP ANALYSIS

After the domain of analysis is established, SCCWRP requires an "initial desktop analysis" that involves office work. The initial desktop analysis establishes the watershed area, mean annual precipitation, valley slope, and valley width. These terms are defined in Form 1, which is included in Appendix A. SCCWRP recommends the use of National Elevation Data (NED) to determine the watershed areas, valley slopes, and valley widths. The NED data is similar to USGS mapping. For the project, PDC provided their grading plans and 2-foot contour interval topographic mapping for the project site and adjacent areas. This mapping is more detailed that NED data, so will provide more accurate results. A portion of the off-site drainage area tributary to Reach 3H is not covered by the PDC mapping, so USGS mapping was used for this area.

The mapping sources and watershed delineations are included on the Study Area Exhibit in the map pocket.

The mean annual precipitation was obtained from the rain gage closest to the site. This is the Western Regional Climate Center's Vista 2 NNE gage (see Appendix A). The average annual rainfall measured at this gage for the period of record from 1957 to 2016 is 13.1 inches.

Reach	Tributary Drainage Area, sq. mi.	Valley Slope, m/m	Valley Width, m
1A	0.0722	0.0472	1.52
3H	0.1078	0.0387	3.05

Table 1. Summary of Drainage Area, Valley Slope, and Valley Width

The valley slope and valley width were determined for each study reach from the 2-foot contour interval topographic mapping. NED data was not used because it is not very accurate for these parameters. The valley slope is the longitudinal slope of the channel bed along the flow line, so it is determined by dividing the elevation difference within a study reach by the length of the flow line. The valley width is the valley bottom width dictated by breaks in the hillslope. The valley slope and valley width within each reach are included in Table 1.

These values were input to a spreadsheet to calculate the simulated peak flow, screening index, and valley width index outlined in Form 1. The input data and results are tabulated in Appendix A. This completes the initial desktop analysis.

FIELD SCREENING

After the initial desktop analysis is complete, a field assessment must be performed. The field assessment is used to establish a natural channel's vertical and lateral susceptibility to erosion. SCCWRP states that although they are admittedly linked, vertical and lateral susceptibility are assessed separately for several reasons. First, vertical and lateral responses are primarily controlled by different types of resistance, which, when assessed separately, may improve ease of use and lead to increased repeatability compared to an integrated, cross-dimensional assessment. Second, the mechanistic differences between vertical and lateral responses point to different modeling tools and potentially different management strategies. Having separate screening ratings may better direct users and managers to the most appropriate tools for subsequent analyses.

The field screening tool uses combinations of decision trees and checklists. Decision trees are typically used when a question can be answered fairly definitively and/or quantitatively (e.g., $d_{50} < 16$ mm). Checklists are used where answers are relatively qualitative (e.g., the condition of a grade control). Low, medium, high, and very high ratings are applied separately to the vertical and lateral analyses. When the vertical and lateral analyses return divergent values, the most conservative value shall be selected as the flow threshold for the hydromodification analyses.

Vertical Stability

The purpose of the vertical stability decision tree (Figure 6-4 in the County of San Diego HMP) is to assess the state of the channel bed with a particular focus on the risk of incision (i.e., down cutting). The decision tree is included in Figure 8. The first step is to assess the channel bed resistance. There are three categories defined as follows:

1. Labile Bed – sand-dominated bed, little resistant substrate.

2. Transitional/Intermediate Bed – bed typically characterized by gravel/small cobble, Intermediate level of resistance of the substrate and uncertain potential for armoring.

3. Threshold Bed (Coarse/Armored Bed) – armored with large cobbles or larger bed material or highly-resistant bed substrate (i.e., bedrock).

Based on the photographs and site investigation, the bed material and resistance is generally within the transitional/intermediate bed category. There was no evidence of a threshold bed condition. However, some bed areas contained smaller grain sizes typically found in a labile bed.

In addition to the material size and compaction, there are several factors that establish the erodibility of a channel such as the flow rate (i.e., size of the tributary area), grade controls, channel slope, vegetative cover, channel planform, etc. The Introduction of the SCCWRP *Hydromodification Screening Tools: Field Manual* identifies several of these factors. When multiple factors influence erodibility, it is appropriate to perform the more detailed SCCWRP analysis, which is to analyze a channel according to SCCWRP's transitional/intermediate bed procedure. This requires the most rigorous steps and will generate the appropriate results given the range of factors that define erodibility. The transitional/intermediate bed procedure takes into account that bed material may fall within the labile category (the bed material size is used in SCCWRP's Form 3 Figure 4), but other factors may trend towards a less erodible condition. Dr. Eric Stein from SCCWRP, who co-authored the *Hydromodification Screening Tools: Field Manual* in the *Final Hydromodification Management Plan* (HMP), indicated that it would be appropriate to analyze channels with multiple factors that impact erodibility using the transitional/intermediate bed procedure. Consequently, this procedure was used to produce more accurate results.

Transitional/intermediate beds cover a wide susceptibility/potential response range and need to be assessed in greater detail to develop a weight of evidence for the appropriate screening rating. The three primary risk factors used to assess vertical susceptibility for channels with transitional/intermediate bed materials are:

1. Armoring potential – three states (Checklist 1)

2. Grade control – three states (Checklist 2)

3. Proximity to regionally-calibrated incision/braiding threshold (Mobility Index Threshold – Probability Diagram)

These three risk factors are assessed using checklists and a diagram (see Appendix B), and the results of each are combined to provide a final vertical susceptibility rating for the intermediate/transitional bed-material group. Each checklist and diagram contains a Category A, B, or C rating. Category A is the most resistant to vertical changes while Category C is the most susceptible.

Checklist 1 determines armoring potential of the channel bed. The channel bed along each of the six study reaches is within Category B, which represents intermediate bed material within unknown armoring potential due to a surface veneer and/or vegetation. Figures 1 through 4 reveal that the study reaches contain a relatively uniform cover of grasses, weeds, and bushes. The soil was probed and penetration was relatively difficult through the underlying layer.

Checklist 2 determines grade control characteristics of the channel bed. This is reliant on the spacing of the grade controls. The categories for Checklist 2 are related to a grade control spacing of $2/S_v$ and $4/S_v$, where S_v is the valley slope from Appendix A. The $2/S_v$ and $4/S_v$ results are in meters, so a factor is applied to convert to feet. A reach is in Category A if it has a spacing of less than $2/S_v$. A reach is in Category B if it has a spacing between $2/S_v$ and $4/S_v$. Finally, a reach is in Category C if it has a spacing greater than $4/S_v$. Table 2 summarizes the S_v, $2/S_v$ and $4/S_v$ values for the two study reaches along with the maximum grade control spacing in each reach. Table 3 also identifies each reach's category, which are either A or B.

Reach	S_v, feet/feet	$2/S_v$, feet	$4/S_v$, feet	Grade Control Spacing, feet	Category
1A	0.0472	139	278	127	A
3H	0.0387	169	339	315	B

Table 2. Checklist 3 Values based on Grade Control Spacing

The Screening Index Threshold is a probability diagram that depicts the risk of incising or braiding based on the potential stream power of the valley relative to the median particle diameter. The threshold is based on regional data from Dr. Howard Chang of Chang Consultants and others. The probability diagram is based on d_{50} as well as the screening index value determined in the initial desktop analysis (see Appendix A). The Form 1 results in Appendix A determined an INDEX values for all six reaches.

For Reach 1A and 3H, the d_{50} has to be determined to assess the Screening Index Threshold. d_{50} can be derived from a pebble count in which a minimum of 100 particles are obtained along transects at the site. SCCRWP states that if fines less than ½-inch thick are at a sample point, it is appropriate to sample the coarser buried substrate. The d_{50} value is the particle size in which 50 percent of the particles are smaller and 50 percent are larger. The pebble count results for Reach 1A and 3H are included in Appendix B. The results show a d_{50} of 8 millimeters for both reaches. The screening index for the reaches are tabulated in Appendix A. Plotting the d_{50} and screening index values on the Mobility Index Threshold diagram shows that both of these reaches have a less than 50 percent probability of incising or braiding, which falls within Category A.

The overall vertical rating is determined from the above described Checklist 1, Checklist 2, and Mobility Index Threshold results. The scoring is based on the following values:

Category A = 3, Category B = 6, Category C = 9

The vertical rating score is based on these values and the equation:

$$\text{Vertical Rating} = [(\text{armoring} \times \text{grade control})^{1/2} \times \text{screening index score}]^{1/2}$$

Table 3 summarizes the Checklist 1, 2, and 3 values for each reach as well as their vertical rating. The results show the vertical rating for both study reaches is less than 4.5, so these reaches have a low threshold for vertical susceptibility.

Reach	Checklist 1 (armoring)	Checklist 2 (grade control)	Checklist 3 (screening index)	Vertical Rating
1A	6	3	3	3.6
3H	6	6	3	4.2

Table 3. Overall Vertical Rating

Lateral Stability

The purpose of the lateral decision tree (Figure 6-5 from County of San Diego HMP included in Figure 9) is to assess the state of the channel banks with a focus on the risk of widening. Channels can widen from either bank failure or through fluvial processes such as chute cutoffs, avulsions, and braiding. Widening through fluvial avulsions/active braiding is a relatively straightforward observation. If braiding is not already occurring, the next logical step is to assess the condition of the banks. Banks fail through a variety of mechanisms; however, one of the most important distinctions is whether they fail in mass (as many particles) or by fluvial detachment of individual particles. Although much research is dedicated to the combined effects of weakening, fluvial erosion, and mass failure, SCCWRP found it valuable to segregate bank types based on the inference of the dominant failure mechanism (as the management approach may vary based on the dominant failure mechanism). A decision tree (Form 4 in Appendix B) is used in conducting the lateral susceptibility assessment. Definitions and photographic examples are also provided below for terms used in the lateral susceptibility assessment.

The first step in the decision tree is to determine if lateral adjustments are occurring. The adjustments can take the form of extensive mass wasting (greater than 50 percent of the banks are exhibiting planar, slab, or rotational failures and/or scalloping, undermining, and/or tension cracks). The adjustments can also involve extensive fluvial erosion (significant and frequent bank cuts on over 50 percent of the banks). Neither mass wasting nor extensive fluvial erosion was evident within any of the reaches during a field investigation. As seen in the figures, the banks are either well vegetated or relatively low confirming that mass wasting and extensive fluvial erosion has not occurred.

The next step in the Form 4 decision tree is to assess the consolidation of the bank material. The banks were moderate to well-consolidated. This determination was made because the ground surface was difficult to penetrate with a probe. The banks were densely vegetated and/or relatively level and stable as seen in the figures. In addition, the banks showed no evidence of crumbling and were composed of relatively well-packed particles.

Form 6 (see Appendix B) is used to assess the probability of mass wasting. Form 6 identifies a 10, 50, and 90 percent probability based on the bank angle and bank height. From the topographic mapping and site investigation, the average bank angles in both reaches are flatter than 2:1 (26.6 degrees). Form 6 shows that the probably of mass wasting and bank failure has less than 10 percent risk for a 26.6 degree bank angle or less regardless of the bank height.

The final two steps in the Form 4 decision tree are based on the braiding risk determined from the vertical rating as well as the Valley Width Index (VWI) calculated in Appendix A. If the vertical rating is high, the braiding risk is considered to be greater than 50 percent. Excessive braiding can lead to lateral bank failure. For the both reaches the vertical rating is low, so the braiding risk is less than 50 percent. Furthermore, a VWI greater than 2 represents channels unconfined by bedrock or hillslope and, hence, subject to lateral migration. The VWI calculations in the spreadsheet in Appendix A show that the VWI for all six reaches is less than 2.

From the above steps, the lateral susceptibility rating is low for Reaches 1A and 3H (colored circles are included on the Form 4: Lateral Susceptibility Field Sheet decision tree sheets in Appendix B showing the decision path).

CONCLUSION

The SCCWRP channel screening tools were used to assess the downstream channel susceptibility for a portion of the Ocean Breeze Ranch tentative map by Project Design Consultants. The project's storm runoff will be collected by proposed on-site drainage systems and conveyed to various outfalls. PDC selected two of the outfalls (POC 1A and 3H) for this report. A downstream channel assessment for each POC was performed based on office analyses and field work. The results indicate a low threshold for vertical and lateral susceptibility for POC 1A and 3H.

The HMP requires that the low threshold results be compared with the critical stress calculator results. The Critical Flow Calculator (spreadsheet provided by the County of San Diego) results are included in Appendix B for the associated study reaches. The channel dimensions were estimated from the topographic mapping and site visit, while the additional input parameters are from Form 1 in Appendix A. The critical stress results returned a low threshold for each reach. Therefore, the SCCWRP analyses will govern and demonstrate that a low overall threshold is applicable to POC 1A and 3H (i.e., $0.5Q_2$).

Figure 1. Looking Downstream towards Reach 1A from Upper End near POC 1A

Figure 2. Lower End of Reach 1A

Figure 3. Looking Downstream towards Reach 3H from Upper End near POC 3H

Figure 4. Looking Upstream towards Reach 3H from Lower End

Figure 5. Roadway Culvert at Lower End of Reach 3H

Figure 6. Gravelometer along Reach 2A

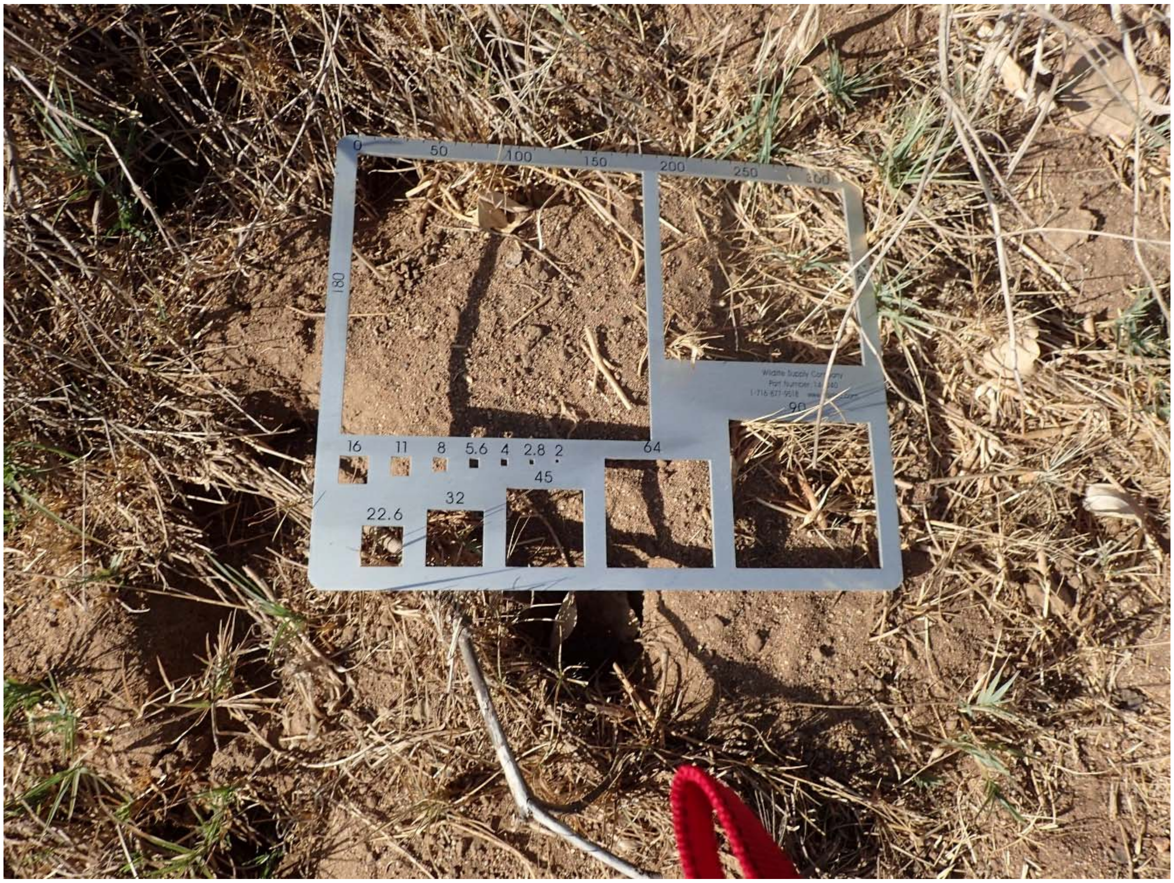


Figure 7. Gravelometer along Reach 3H

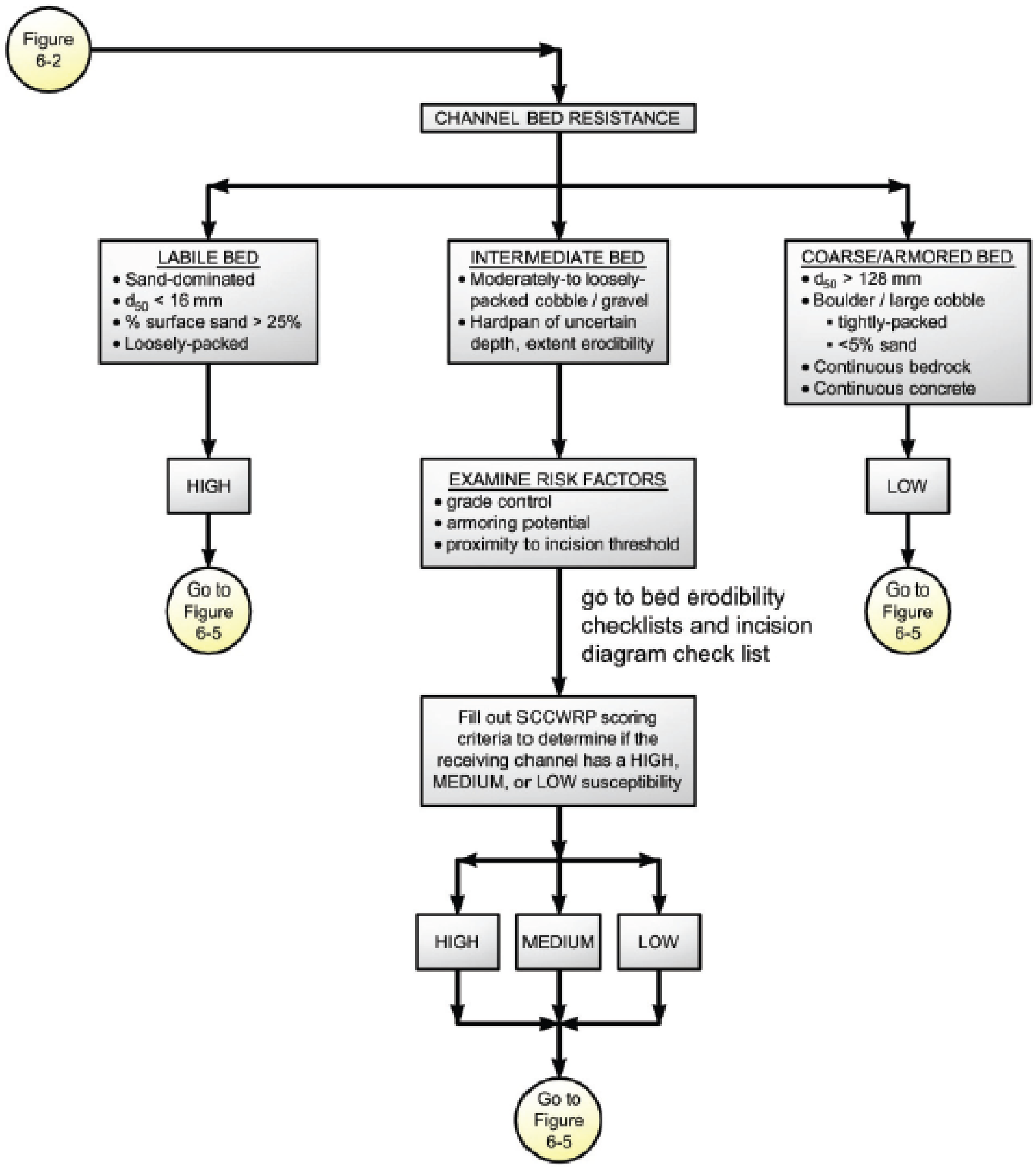


Figure 6-4. SCCWRP Vertical Susceptibility

Figure 8. SCCWRP Vertical Channel Susceptibility Matrix

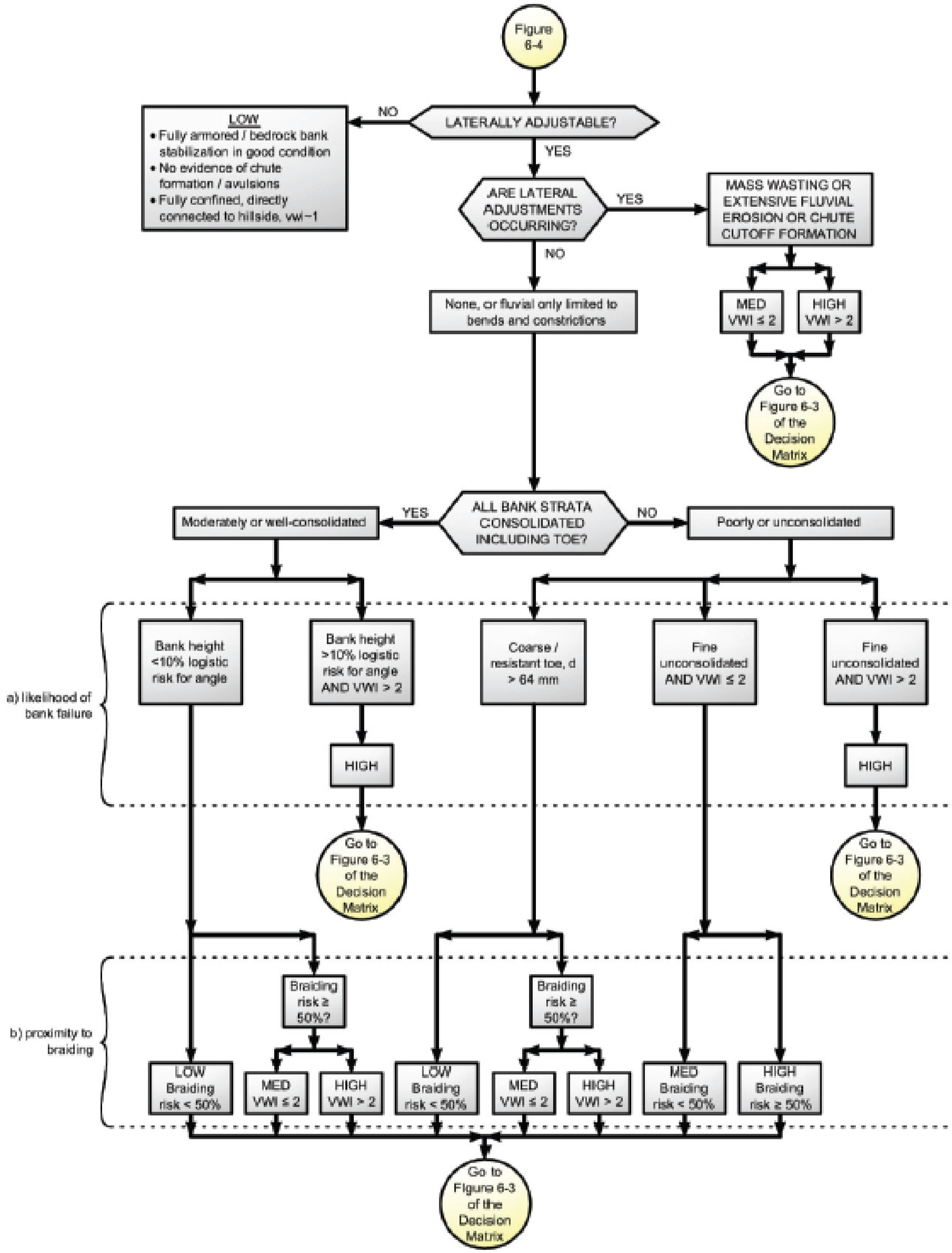


Figure 6-5. Lateral Channel Susceptibility

Figure 9. SCCWRP Lateral Channel Susceptibility Matrix

APPENDIX A

SCCWRP INITIAL DESKTOP ANALYSIS

FORM 1: INITIAL DESKTOP ANALYSIS

Complete all shaded sections.

IF required at multiple locations, circle one of the following site types:

Applicant Site / Upstream Extent / Downstream Extent

Location: Latitude: 33.3070 Longitude: -117.1918

Description (river name, crossing streets, etc.): Ocean Breeze Ranch

North of West Lilac Road and south of San Luis Rey River

GIS Parameters: The International System of Units (SI) is used throughout the assessment as the field standard and for consistency with the broader scientific community. However, as the singular exception, US Customary units are used for contributing drainage area (A) and mean annual precipitation (P) to apply regional flow equations after the USGS. See SCCWRP Technical Report 607 for example measurements and "Screening Tool Data Entry.xls" for automated calculations.

Form 1 Table 1. Initial desktop analysis in GIS.

	Symbol	Variable	Description and Source	Value
Watershed properties (English units)	A	Area (mi^2)	Contributing drainage area to screening location via published Hydrologic Unit Codes (HUCs) and/or ≤ 30 m National Elevation Data (NED), USGS seamless server	See attached Form 1 table on next page for calculated values for each reach.
	P	Mean annual precipitation (in)	Area-weighted annual precipitation via USGS delineated polygons using records from 1900 to 1960 (which was more significant in hydrologic models than polygons delineated from shorter record lengths)	
Site properties (SI units)	S_v	Valley slope (m/m)	Valley slope at site via NED, measured over a relatively homogenous valley segment as dictated by hillslope configuration, tributary confluences, etc., over a distance of up to ~500 m or 10% of the main-channel length from site to drainage divide	
	W_v	Valley width (m)	Valley bottom width at site between natural valley walls as dictated by clear breaks in hillslope on NED raster, irrespective of potential armoring from floodplain encroachment, levees, etc. (imprecise measurements have negligible effect on rating in wide valleys where VWI is >> 2, as defined in lateral decision tree)	

Form 1 Table 2. Simplified peak flow, screening index, and valley width index. Values for this table should be calculated in the sequence shown in this table, using values from Form 1 Table 1.

Symbol	Dependent Variable	Equation	Required Units	Value
Q_{10cfs}	10-yr peak flow (ft^3/s)	$Q_{10cfs} = 18.2 * A^{0.87} * P^{0.77}$	A (mi^2) P (in)	See attached Form 1 table on next page for calculated values for each reach.
Q_{10}	10-yr peak flow (m^3/s)	$Q_{10} = 0.0283 * Q_{10cfs}$	Q_{10cfs} (ft^3/s)	
INDEX	10-yr screening index ($m^{1.5}/s^{0.5}$)	$INDEX = S_v * Q_{10}^{0.5}$	Sv (m/m) Q_{10} (m^3/s)	
W_{ref}	Reference width (m)	$W_{ref} = 6.99 * Q_{10}^{0.438}$	Q_{10} (m^3/s)	
VWI	Valley width index (m/m)	$VWI = W_v/W_{ref}$	W_v (m) W_{ref} (m)	

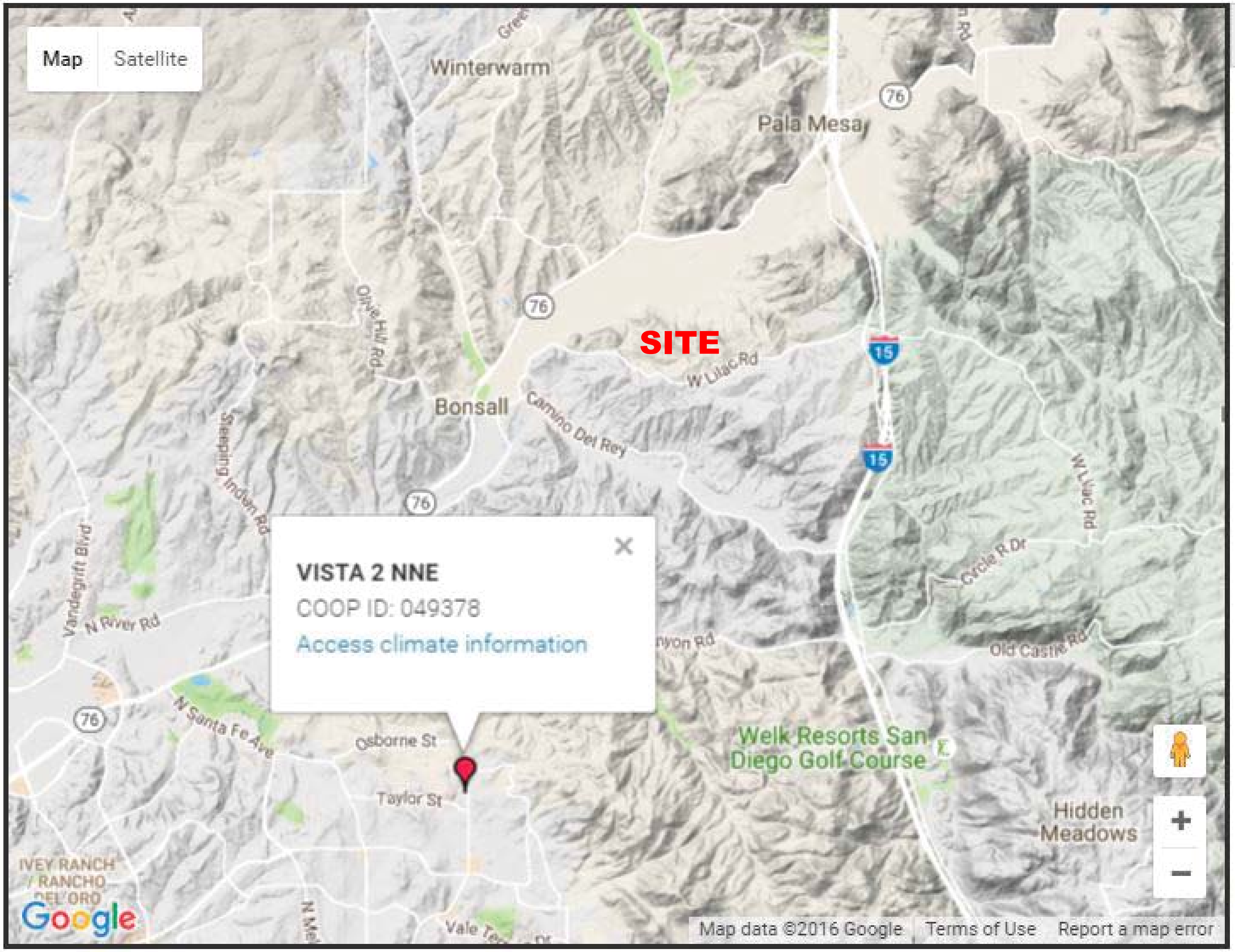
(Sheet 1 of 1)

SCCWRP FORM 1 ANALYSES

Reach	Area A, sq. mi.	Mean Annual Precip. P, inches	Valley Slope Sv, m/m	Valley Width Wv, m	10-Year Flow Q10cfs, cfs	10-Year Flow Q10, cms
1A	0.0799	13.1	0.0472	1.52	15	0.41
3H	0.1078	13.1	0.0387	3.05	19	0.54

Reach	10-Year Screening Index INDEX	Reference Width Wref, m	Valley Width Index VWI, m/m
1A	0.0304	4.75	0.32
3H	0.0284	5.33	0.57

US COOP Station Map



RAIN GAGE NEAR STUDY AREA

VISTA 2 NNE, CALIFORNIA (049378)

Period of Record Monthly Climate Summary

Period of Record : 08/01/1957 to 05/12/2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	67.4	67.8	68.2	70.8	72.9	76.3	81.3	83.0	82.2	77.9	72.3	67.4	74.0
Average Min. Temperature (F)	44.0	45.0	46.3	48.5	53.5	56.6	60.3	61.6	60.0	55.0	48.3	44.0	51.9
Average Total Precipitation (in.)	2.76	2.55	2.24	1.05	0.22	0.11	0.06	0.07	0.25	0.54	1.40	1.83	13.09
Average Total SnowFall (in.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 86.6% Min. Temp.: 87% Precipitation: 87.6% Snowfall: 87.7% Snow Depth: 87.3%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

APPENDIX B

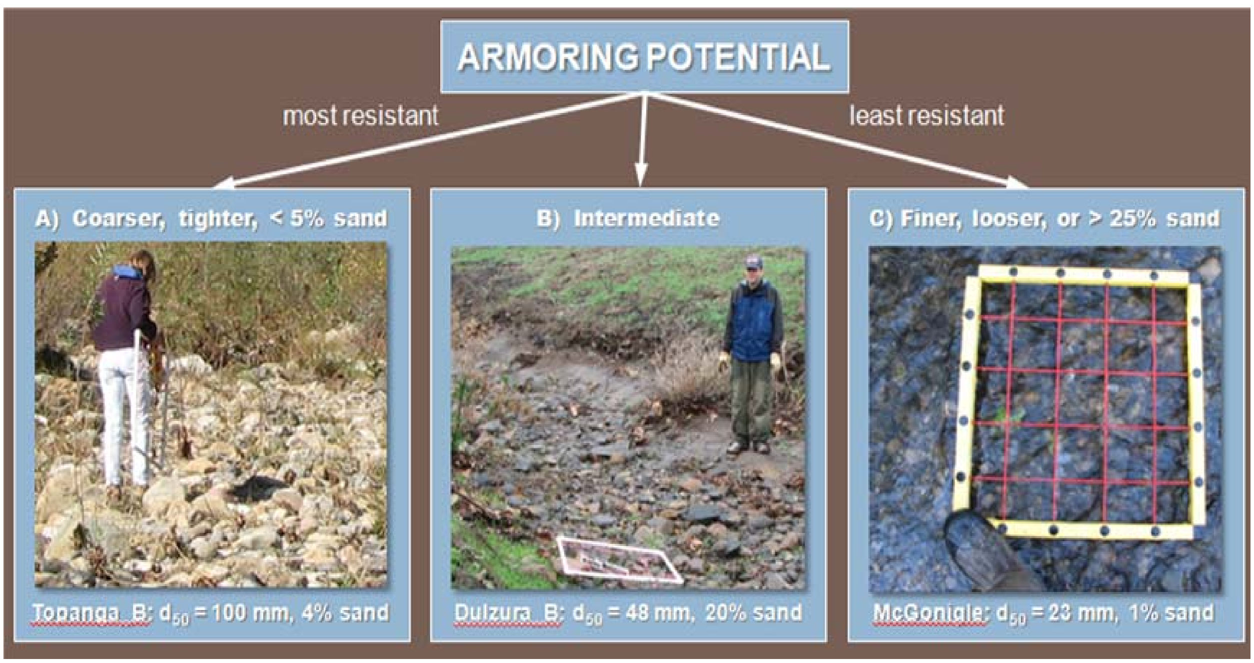
SCCWRP FIELD SCREENING DATA

Form 3 Support Materials

Form 3 Checklists 1 and 2, along with information recording in Form 3 Table 1, are intended to support the decisions pathways illustrated in Form 3 Overall Vertical Rating for Intermediate/Transitional Bed.

Form 3 Checklist 1: Armoring Potential

□	A	A mix of coarse gravels and cobbles that are tightly packed with <5% surface material of diameter <2 mm
X	B	Intermediate to A and C or hardpan of unknown resistance, spatial extent (longitudinal and depth), or unknown armoring potential due to surface veneer covering gravel or coarser layer encountered with probe
□	C	Gravels/cobbles that are loosely packed or >25% surface material of diameter <2 mm



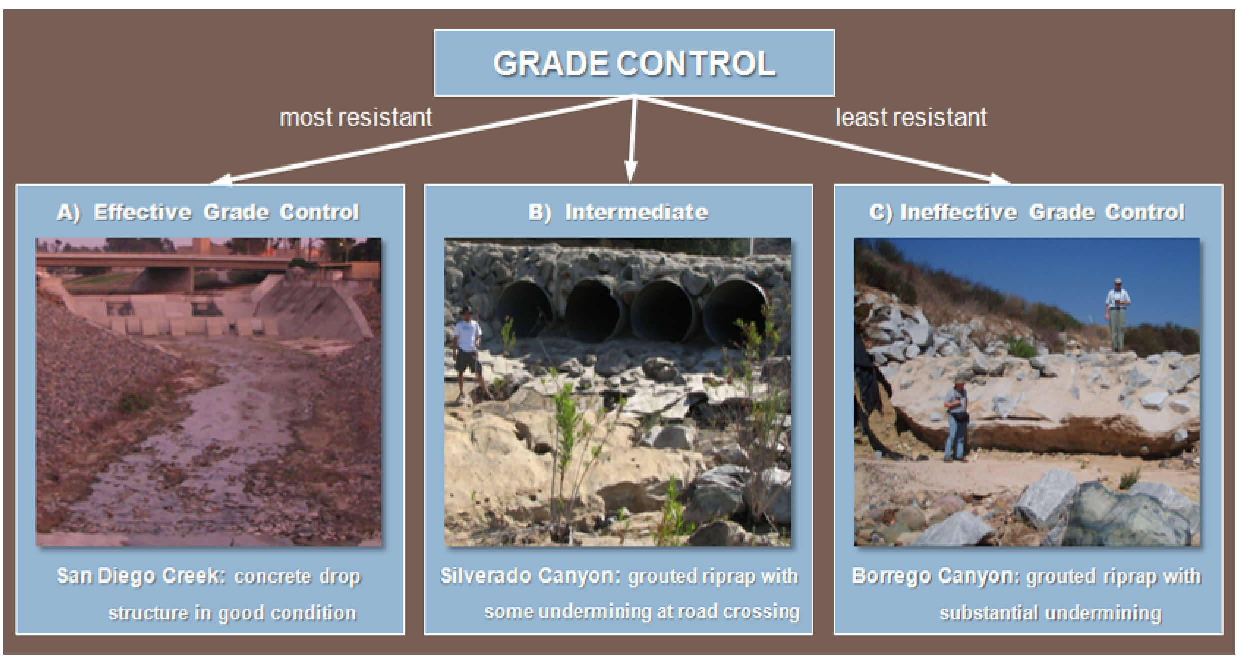
Form 3 Figure 2. Armoring potential photographic supplement for assessing intermediate beds (16 < d_{50} < 128 mm) to be used i**n conjunction with Form 3 Checklist 1.**

(Sheet 2 of 4)

RESULT FOR ALL STUDY REACHES

Form 3 Checklist 2: Grade Control

X	A	Grade control is present with spacing <50 m or $2/S_v$ m • No evidence of failure/ineffectiveness, e.g., no headcutting (>30 cm), no active mass wasting (analyst cannot say grade control sufficient if mass-wasting checklist indicates presence of bank failure), no exposed bridge pilings, no culverts/structures undermined • Hard points in serviceable condition at decadal time scale, e.g., no apparent undermining, flanking, failing grout • If geologic grade control, rock should be resistant igneous and/or metamorphic; For sedimentary/hardpan to be classified as 'grade control', it should be of demonstrable strength as indicated by field testing such as hammer test/borings and/or inspected by appropriate stakeholder
X	B	Intermediate to A and C – artificial or geologic grade control present but spaced 2/Sv m to 4/Sv m or potential evidence of failure or hardpan of uncertain resistance
□	C	Grade control absent, spaced >100 m or $>4/S_v$ m, or clear evidence of ineffectiveness



Form 3 Figure 3. Grade-control (condition) photographic supplement for assessing intermediate beds (16 < d_{50} < 128 mm) to be used in conjunction with Form 3 Checklist 2.

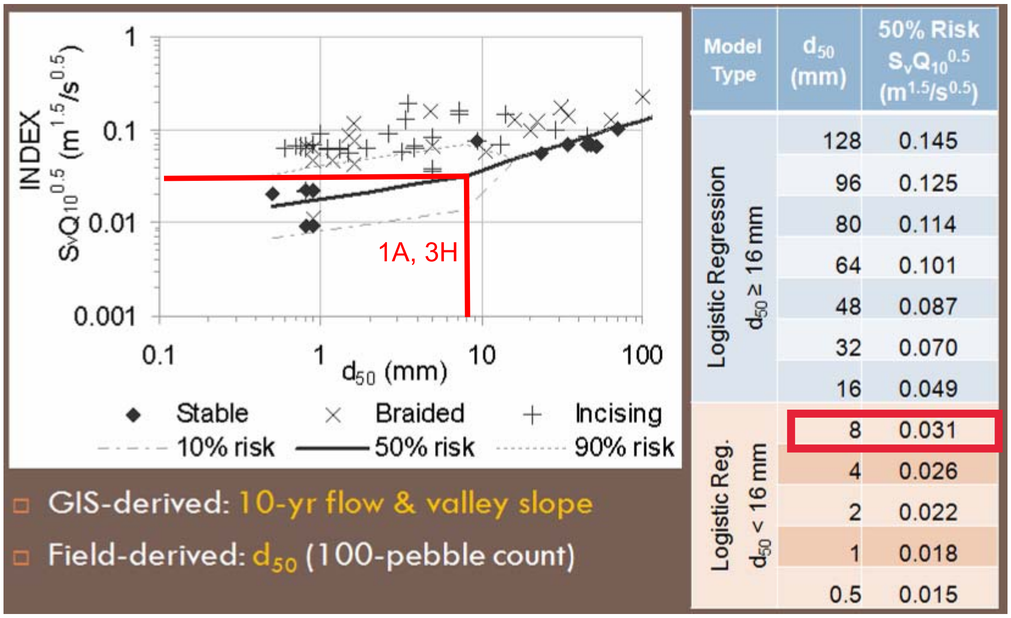
(Sheet 3 of 4)

REACH 1A RESULTS

REACH 3H RESULTS

Regionally-Calibrated Screening Index Threshold for Incising/Braiding

For transitional bed channels (d_{50} between 16 and 128 mm) or labile beds (channel not incised past critical bank height), use Form 3 Figure 3 to determine Screening Index Score and complete Form 3 Table 1.



Form 3 Figure 4. Probability of incising/braiding based on logistic regression of Screening Index and d_{50} to be used in conjunction with Form 3 Table 1.

Form 3 Table 1. Values for Screening Index Threshold (probability of incising/braiding) to be used in conjunction with Form 3 Figure 4 (above) to complete Form 3 Overall Vertical Rating for Intermediate/Transitional Bed (below).. Screening Index Score: A = <50% probability of incision for current Q_{10}, valley slope, and d_{50}; B = Hardpan/d_{50} indeterminate; and C = $\geq$50% probability of incising/braiding for current Q_{10}, valley slope, and d_{50}.

d_{50} (mm) *From Form 2*	**$S_v{*}Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)** *From Form 1*	**$S_v{*}Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)** *50% risk of incising/braiding from table in Form 3 Figure 3 above*	**Screening Index Score (A, B, C)**

Overall Vertical Rating for Intermediate/Transitional Bed

Calculate the overall Vertical Rating for Transitional Bed channels using the formula below. Numeric values for responses to Form 3 Checklists and Table 1 as follows: A = 3, B = 6, C = 9.

$$Vertical\ Rating = \sqrt{\left\{\left(\sqrt{armoring * grade\ control}\right) * screening\ index\ score\right\}}$$

Vertical Susceptibility based on Vertical Rating: <4.5 = LOW; 4.5 to 7 = MEDIUM; and >7 = HIGH.

(Sheet 4 of 4)

RESULT FOR ALL STUDY REACHES

PEBBLE COUNT

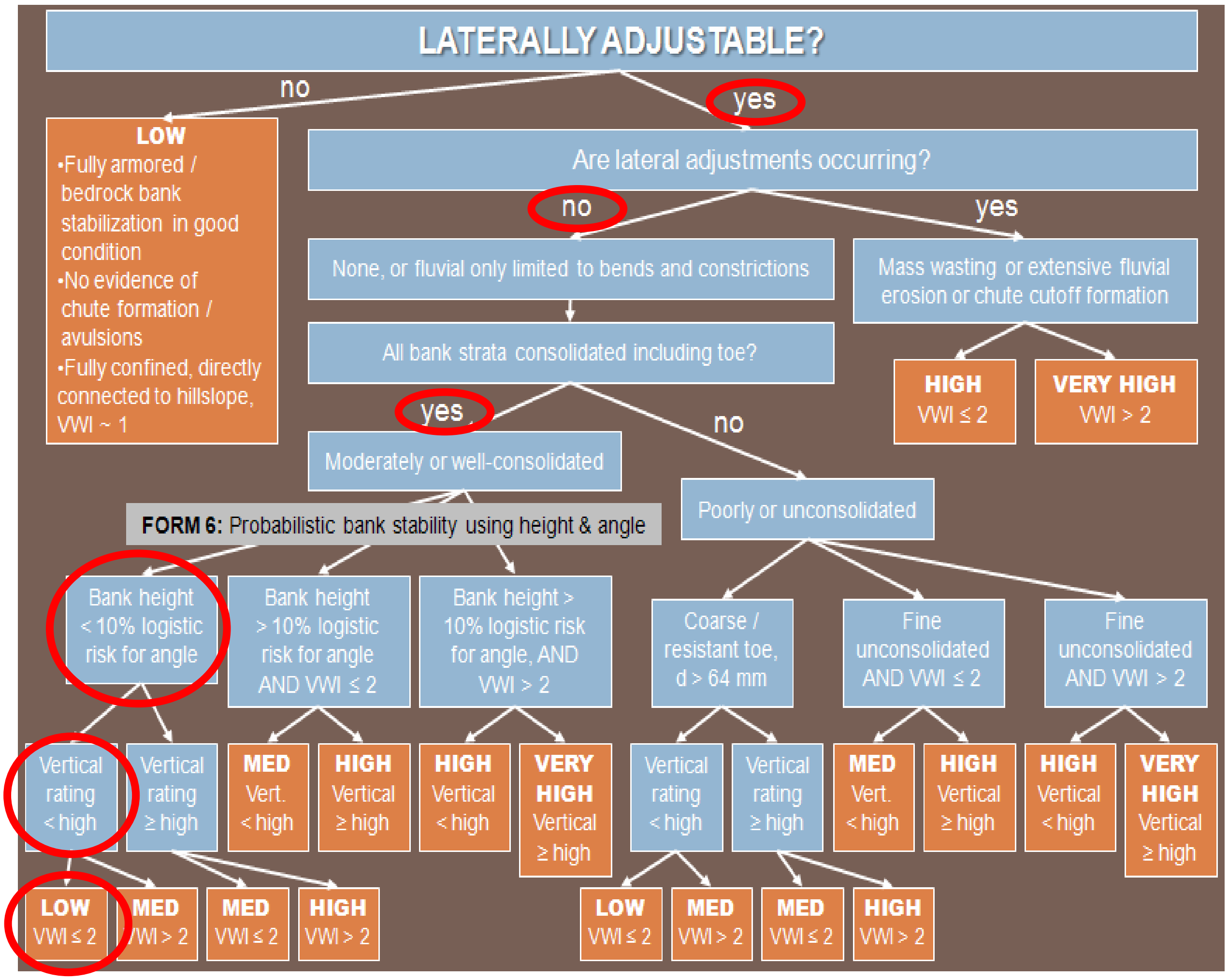
#	Reach 1A Diameter, mm	Reach 3H Diameter, mm
1	2	2
2	2	2
3	2	2
4	2	2
5	2	2
6	2	2
7	2	2
8	2.8	2
9	2.8	2.8
10	2.8	2.8
11	2.8	2.8
12	2.8	2.8
13	2.8	2.8
14	2.8	2.8
15	2.8	2.8
16	2.8	2.8
17	2.8	2.8
18	2.8	2.8
19	2.8	2.8
20	4	2.8
21	4	2.8
22	4	2.8
23	4	2.8
24	4	2.8
25	4	4
26	4	4
27	4	4
28	4	4
29	4	4
30	4	4
31	4	4
32	5.6	4
33	5.6	4
34	5.6	4
35	5.6	4
36	5.6	4
37	5.6	4
38	5.6	4
39	5.6	4
40	5.6	4
41	5.6	4
42	5.6	4
43	5.6	4

#	Reach 1A Diameter, mm	Reach 3H Diameter, mm
44	5.6	4
45	8	4
46	8	4
47	8	4
48	8	8
49	8	8
50	8	8
51	8	8
52	8	8
53	8	8
54	8	8
55	8	8
56	8	8
57	8	8
58	8	8
59	8	8
60	8	8
61	8	8
62	8	8
63	8	8
64	8	8
65	8	8
66	8	8
67	11	8
68	11	8
69	11	8
70	11	8
71	11	8
72	11	8
73	11	8
74	11	8
75	11	8
76	11	8
77	11	11
78	11	11
79	16	11
80	16	11
81	16	11
82	16	11
83	16	11
84	16	11
85	16	11
86	16	11
87	16	11
88	16	11

#	Reach 1A Diameter, mm	Reach 3H Diameter, mm
89	16	11
90	16	11
91	16	11
92	16	11
93	16	11
94	16	11
95	16	11
96	22.6	11
97	22.6	11
98	22.6	11
99	22.6	16
100	22.6	16

FORM 4: LATERAL SUSCEPTIBILTY FIELD SHEET

Circle appropriate nodes/pathway for proposed site
OR use sequence of questions provided in Form 5.



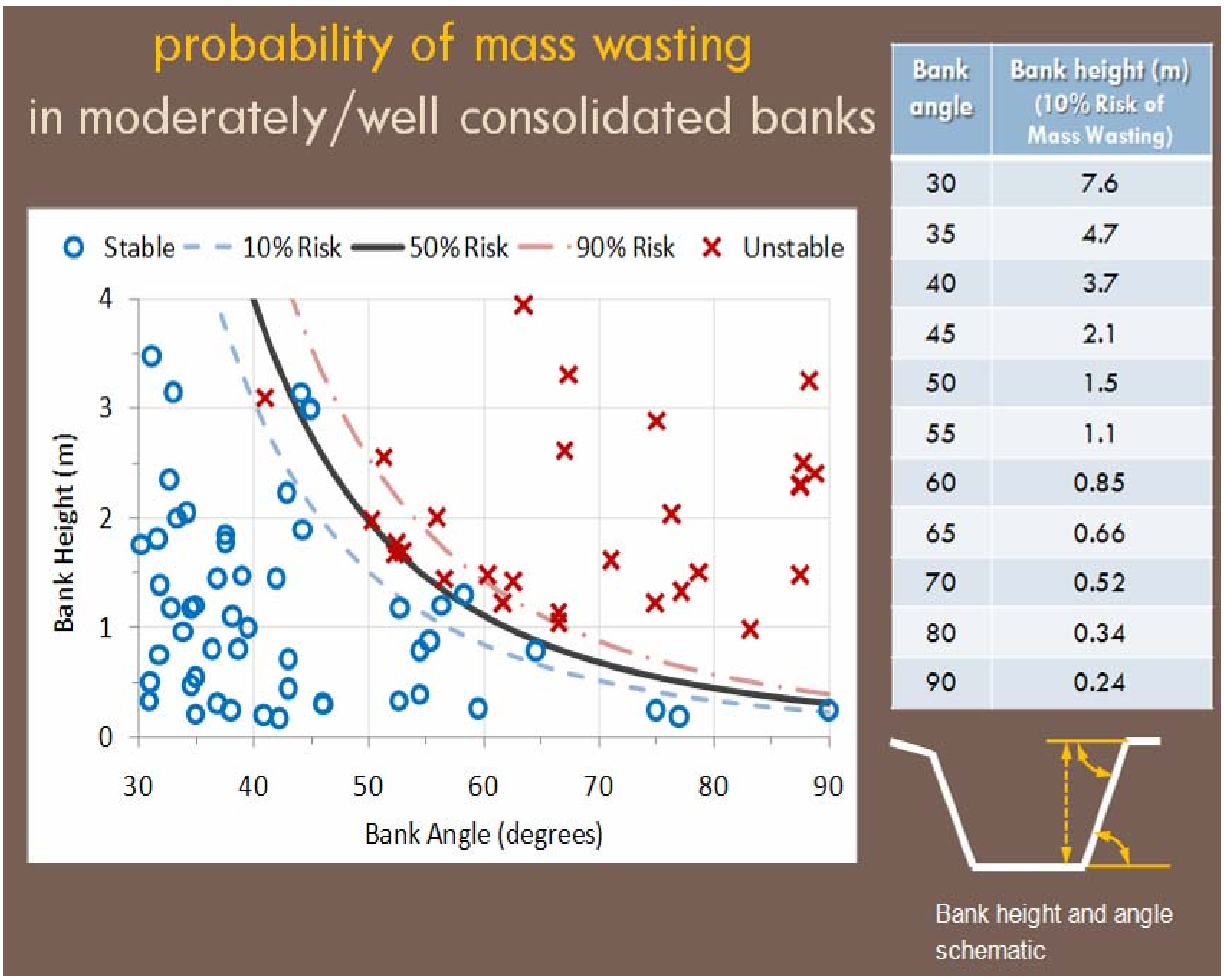
(Sheet 1 of 1)

RESULT FOR ALL STUDY REACHES

FORM 6: PROBABILITY OF MASS WASTING BANK FAILURE

If mass wasting is not currently extensive and the banks are moderately- to well-consolidated, measure bank height and angle at several locations (i.e., at least three locations that capture the range of conditions present in the study reach) to estimate representative values for the reach. Use Form 6 Figure 1 below to determine if risk of bank failure is >10% and complete Form 6 Table 1. Support your results with photographs that include a protractor/rod/tape/person for scale.

	Bank Angle (degrees) *(from Field)*	**Bank Height (m)** *(from Field)*	**Corresponding Bank Height for 10% Risk of Mass Wasting (m)** *(from Form 6 Figure 1 below)*	**Bank Failure Risk** *(<10% Risk)* *(>10% Risk)*
Left Bank	<26.6 (2:1)	---	---	<10%
Right Bank	<26.6 (2:1)	---	---	<10%



Form 6 Figure 1. Probability Mass Wasting diagram, Bank Angle:Height/% Risk table, and Band Height:Angle schematic.

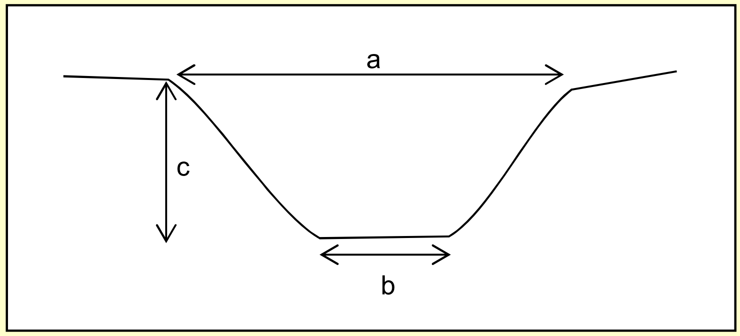
(Sheet 1 of 1)

RESULT FOR ALL STUDY REACHES

Critical Flow Calculator

enter all values in green cells
and drop down boxes

Reach 1A



Inputs

a) Receiving channel width at top of bank (ft) - see figure on right	25.0
b) Channel width at bed (ft)	5.0
c) Bank height at top of bank (ft)	1.0
Channel gradient (ft/ft)	0.0472
Receiving channel roughness	Clean, straight channel, no riffles or deep pools n=0.03

Channel materials (use weakest of bed or banks). If materials are varied use weakest material covering more than 20% of channel.

- unconsolidated sandy loam 0.035 lb/sq ft
- alluvial silt (non coloidal) 0.045 lb/sq ft
- medium gravel 0.12 lb/sq ft
- alluvial silt/clay 0.26 lb/sq ft
- 2.5 inch cobble 1.1 lb/sq ft
- enter own d50 (variable)
- vegetation (bed and banks) 0.6 lb/sq ft

Select method of calculating Q2

- Input own Q2
- Calculate Q2 using USGS regression

Receiving water watershed annual precip (inches)	13.1	Receiving water watershed area at PoC (sq mi)	0.0799
Project watershed annual precipitation (inches)	13.1	Project watershed area draining to PoC (sq mi)	0.0799

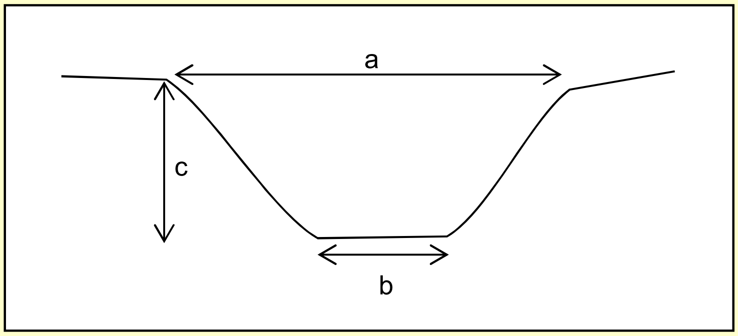
Outputs - Flow control range

Receiving water Q2	1.5	**Point of Compliance low flow rate (cfs)**	**0.7**
Project site Q2	1.5	**Low flow class**	**0.5Q2**
		Channel vulnerability	**Low**

Critical Flow Calculator

enter all values in green cells
and drop down boxes

Reach 3H



Inputs

a) Receiving channel width at top of bank (ft) - see figure on right	34.0
b) Channel width at bed (ft)	10.0
c) Bank height at top of bank (ft)	3.0
Channel gradient (ft/ft)	0.0387
Receiving channel roughness	Clean, straight channel, no riffles or deep pools n=0.03

Channel materials (use weakest of bed or banks). If materials are varied use weakest material covering more than 20% of channel.

- unconsolidated sandy loam 0.035 lb/sq ft
- alluvial silt (non coloidal) 0.045 lb/sq ft
- medium gravel 0.12 lb/sq ft
- alluvial silt/clay 0.26 lb/sq ft
- 2.5 inch cobble 1.1 lb/sq ft
- enter own d50 (variable)
- vegetation (bed and banks) 0.6 lb/sq ft

Select method of calculating Q2

- Input own Q2
- Calculate Q2 using USGS regression

Receiving water watershed annual precip (inches)	13.1	Receiving water watershed area at PoC (sq mi)	0.1078
Project watershed annual precipitation (inches)	13.1	Project watershed area draining to PoC (sq mi)	0.1078

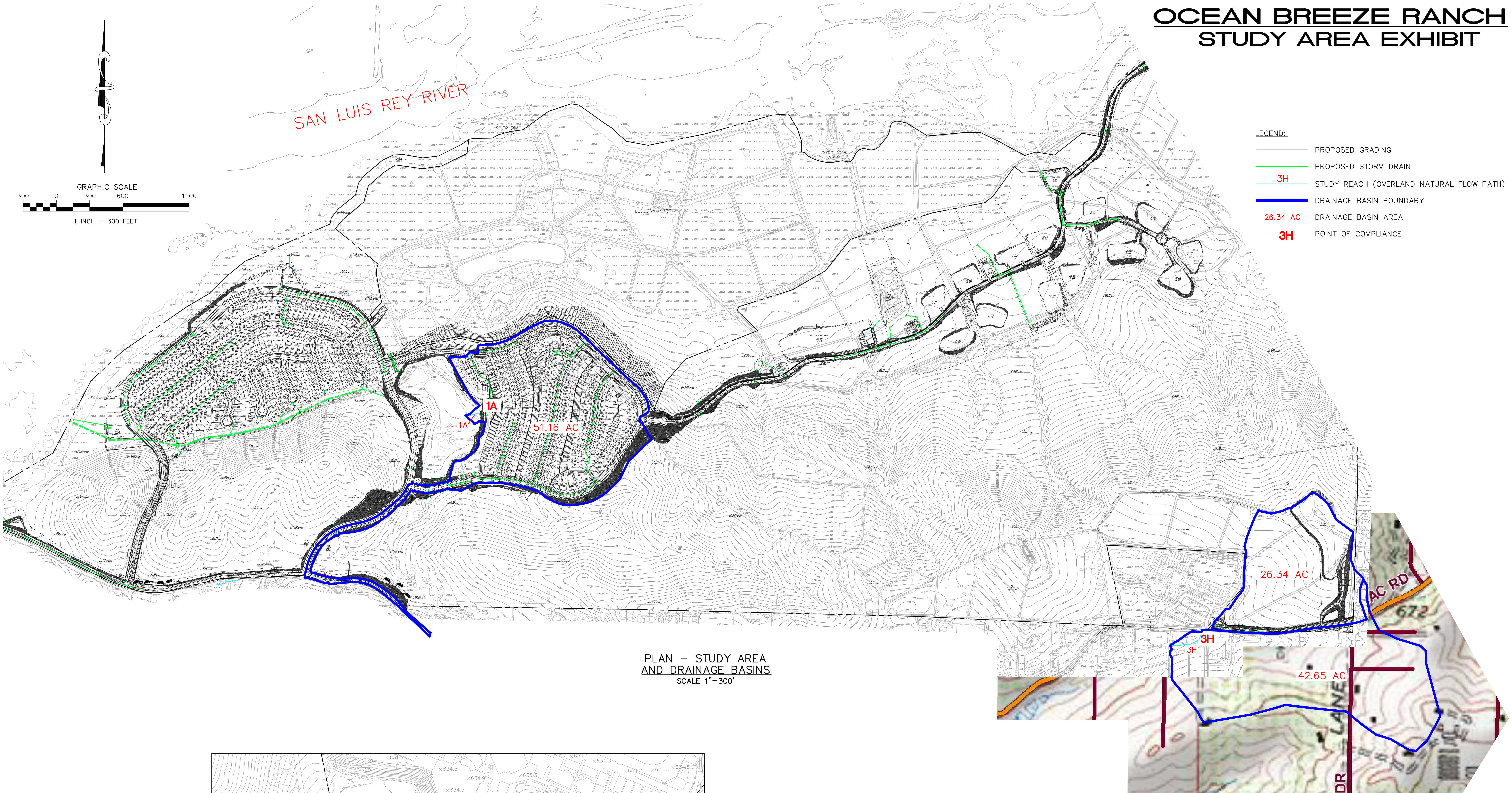
Outputs - Flow control range

Receiving water Q2	1.8	**Point of Compliance low flow rate (cfs)**	**0.9**
Project site Q2	1.8	**Low flow class**	**0.5Q2**
		Channel vulnerability	**Low**

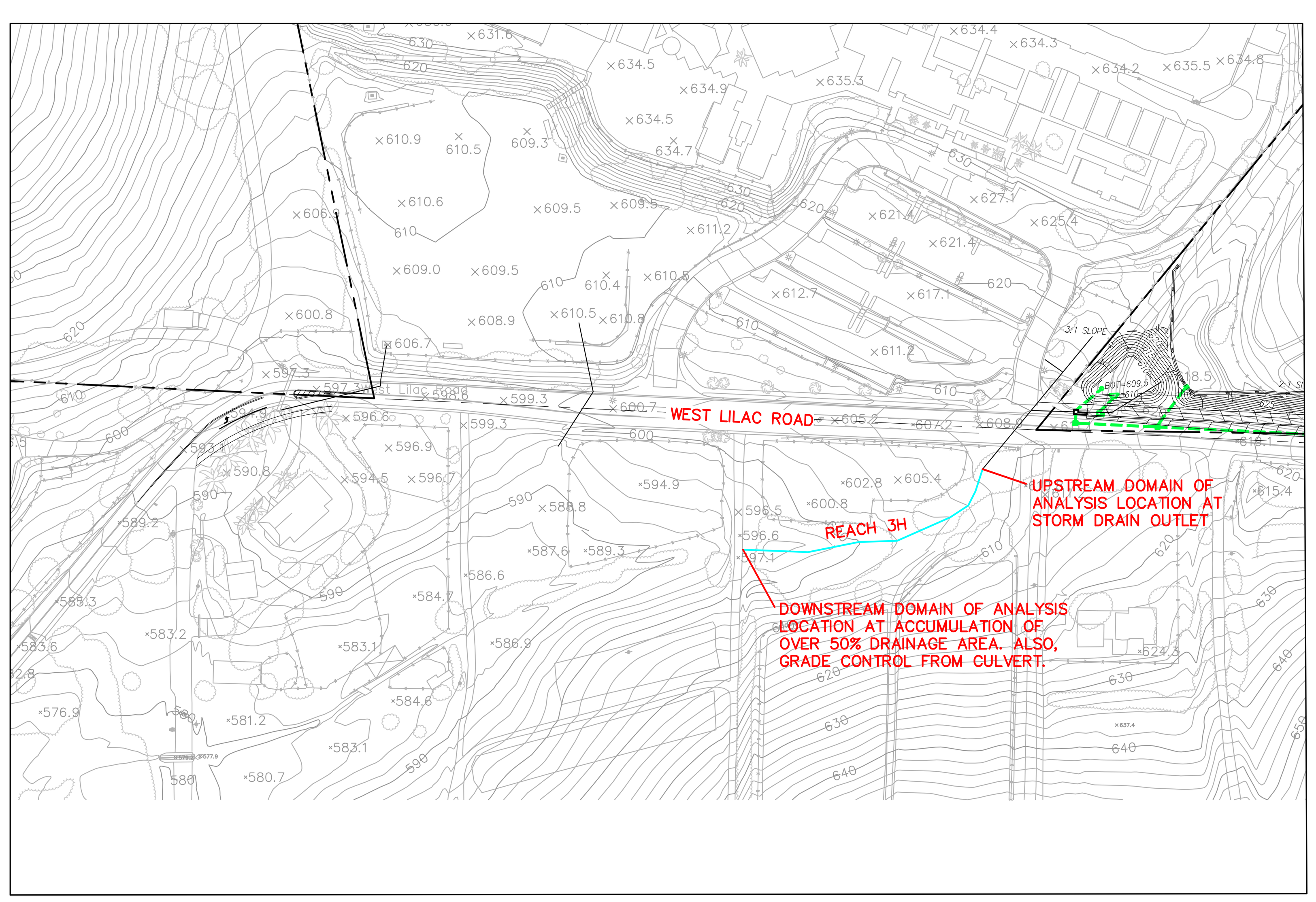
OCEAN BREEZE RANCH
STUDY AREA EXHIBIT

LEGEND:

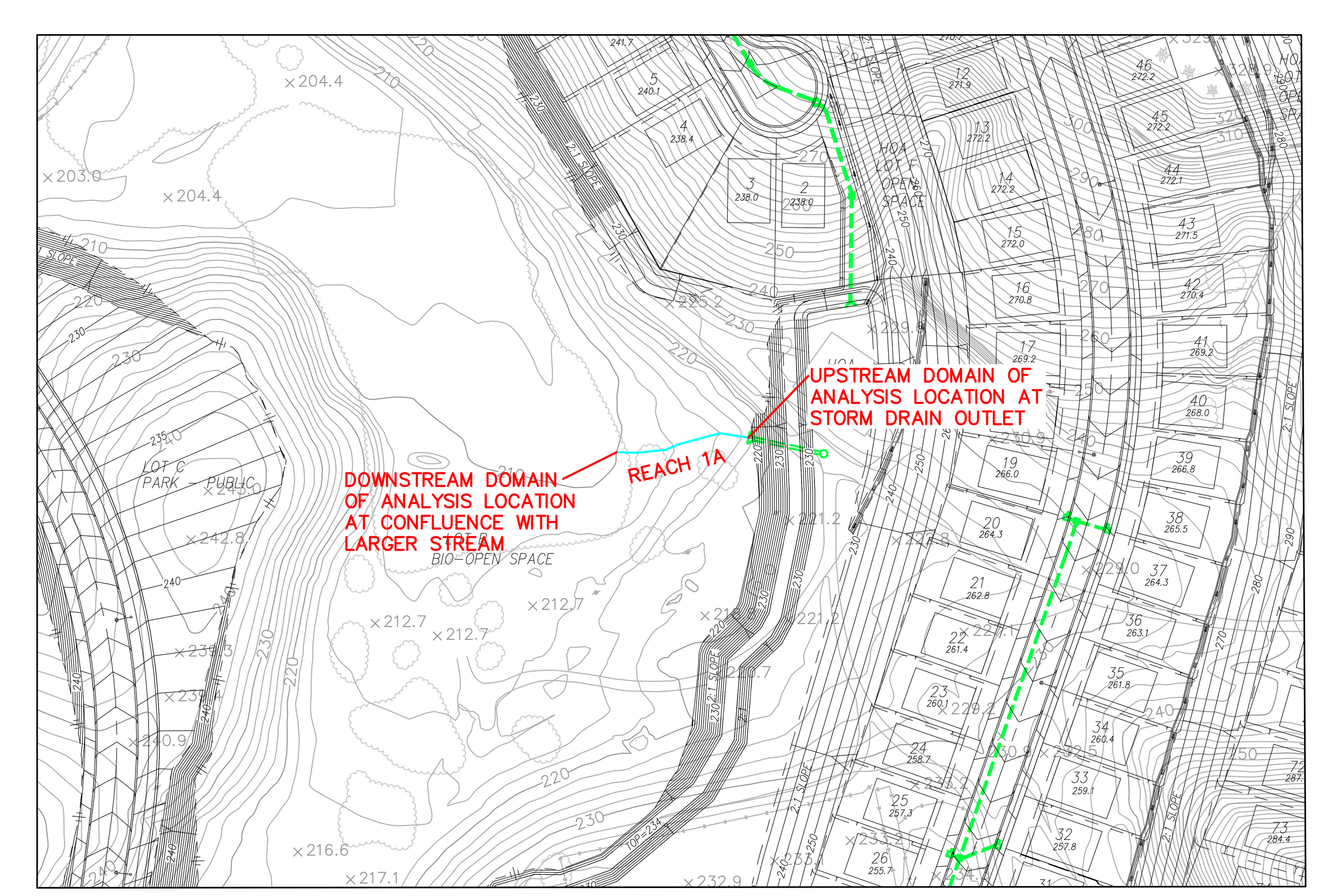
- PROPOSED GRADING
- PROPOSED STORM DRAIN
- 3H — STUDY REACH (OVERLAND NATURAL FLOW PATH)
- DRAINAGE BASIN BOUNDARY
- 26.34 AC — DRAINAGE BASIN AREA
- 3H — POINT OF COMPLIANCE



PLAN – STUDY AREA
AND DRAINAGE BASINS
SCALE 1"=300'



DETAIL – REACH 4B AND 4C
SCALE 1"=100'



DETAIL – REACH 2A
SCALE 1"=100'