HYDROMODIFICATION SCREENING
FOR
RADY CHILDEN'S HOSPITAL –
SAN DIEGO

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Will sign and stamp upon approval

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FOR REVIEW ONLY

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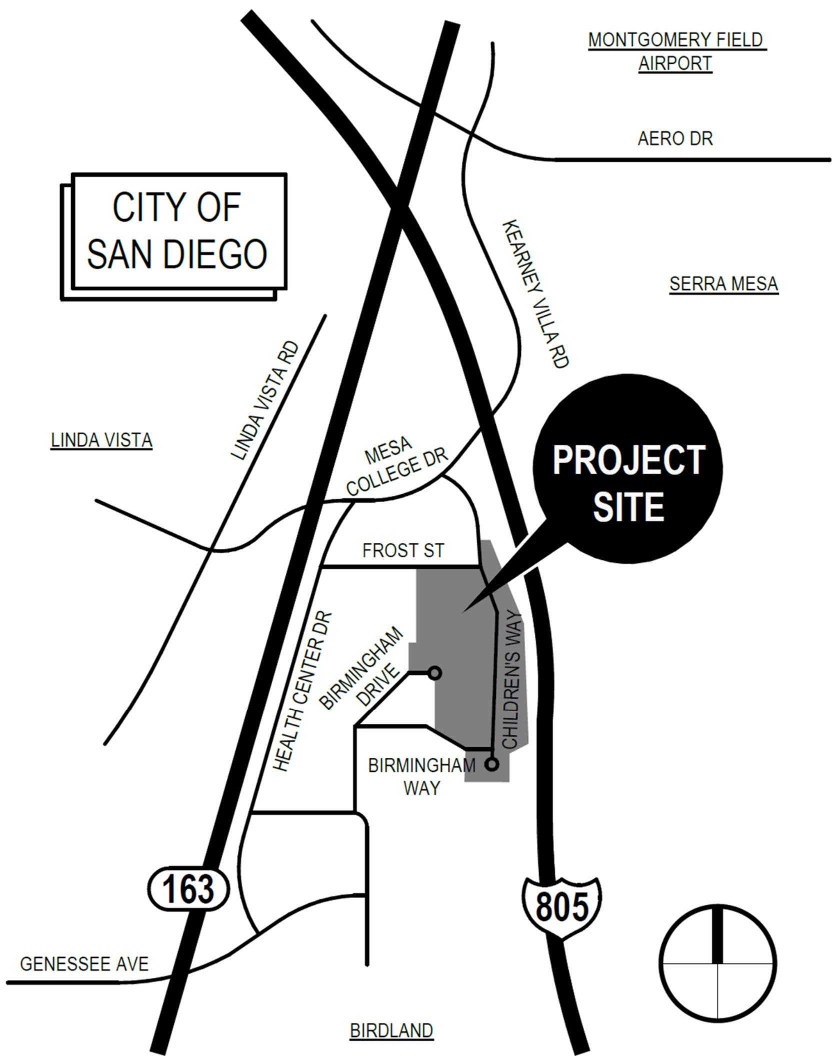
INTRODUCTION

The City of San Diego's October 1, 2018, *Storm Water Standards,* 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 results from the County of San Diego to establish the appropriate erosion susceptibility threshold of low, medium, or high.



Vicinity Map

This report provides a hydromodification screening analysis for redevelopment of the Rady Children's Hospital – San Diego Main Campus located at 3020 Children's Way. The project is on an 18.0 acre parcel and being designed by KPFF Consulting Engineers. The site currently supports hospital buildings, medical offices, pavilions, parking, and associated uses. The project will demolish a portion of the existing Nelson Hahn Building and an existing surface parking lot. The redevelopment will construct an ICU Pavilion, connector building, central utility plant, west access road, and surface improvements. In addition, a Bulk Oxygen System will be located along the north side of Birmingham Way approximately 150 feet west of Children's Way.

Under existing conditions, on-site storm water runoff is conveyed by private drainage facilities and discharges to receiving storm drain systems along the southwesterly and easterly portions of the site. No off-site storm runoff is conveyed through the site. The easterly conveyance continues off-site to the east as an underground storm drain, passes under Interstate 805 as a Caltrans culvert, and then discharges into a Caltrans concrete-lined trapezoidal channel along the east side of the freeway (see the Study Area Exhibit in the map pocket). The trapezoidal channel extends south approximately 1,500 feet where it connects to a Caltrans culvert that crosses Interstate 805 in a southwesterly direction. The Caltrans culvert is approximately 780 feet long and discharges into an unnamed natural drainage course. The flow continues in the unnamed natural drainage course and various drainage facilities south over 1.4 miles to the San Diego River.

The southwest conveyance continues off-site to the south as an underground storm drain system and discharges into a narrow natural canyon just south of Birmingham Way and the site. The narrow natural canyon flows in a southeasterly direction to a Caltrans culvert that crosses east under Interstate 805. The culvert discharges into the lower end of the aforementioned concrete-lined trapezoidal channel. The flow then continues south to the San Diego River as described above.

Under proposed conditions, the project will use on-site Modular Wetland System Linear and detention pipes for pollutant and flow control. The storm runoff will continue to be directed to the southwesterly and easterly portions of the site, and then conveyed off-site similar to existing conditions.

The SCCWRP screening tool requires both office and field work to establish the vertical and lateral susceptibility of a natural 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 the project's points of compliance (POC), which are the first locations downstream of the site containing a natural stream with the potential for erosion and hydromodification impacts. The project has two POCs as shown on the Study Area Exhibit. The first, POC A, is where the easterly storm runoff discharges into the unnamed natural drainage course. The second, POC B, is where the southwesterly storm runoff discharges into the narrow natural canyon.

The initial step in performing the SCCWRP screening analysis for POC A and POC B is to establish the domain of analysis for each and then the study reaches within each 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 (preferably second grade control location)
- 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.)

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 can be subdivided into smaller reaches of less than 200 meters for analysis, as appropriate. 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 for the two points of compliance (POC A and POC B) have been determined by assessing and comparing the four bullet items above. POC A is located where the hardened, non-erodible drainage facilities from the easterly portion of the site outlet into the unnamed natural drainage course. POC B is located where the hardened, non-erodible drainage facilities from the southwesterly portion of the site outlet into the narrow natural canyon. The downstream domain of analysis locations are determined below POC A and POC B as follows.

Per the first bullet item, the first grade control in the unnamed natural drainage course and narrow natural canyon below POC A and POC B, respectively, was determined. For POC A, the unnamed natural drainage course flows south 820 feet before reaching an articulated concrete block grade control across the channel bed and banks (see Figure 4). This grade control is a permanent improvement that prevents upstream channel bed erosion. A second grade control occurs approximately 130 feet downstream of the first grade control. The second grade control is created by the upper end of a concrete-lined channel along the unnamed natural drainage course (see Figure 7), which also prevents upstream channel bed erosion.

For POC B, the narrow natural canyon flows 825 feet before entering a Caltrans culvert that crosses Interstate 805. The culvert entrance will prevent upstream channel bed erosion, so it is the first grade control below POC B. As discussed in the Introduction, the storm runoff continues in the Caltrans culvert east to a Caltrans concrete-lined trapezoidal channel along the east side of Interstate 805. The trapezoidal channel flows south and connects to another Caltrans culvert that extends southwest across Interstate 805. The outlet of this second Caltrans culvert is POC A. Therefore, the articulated concrete block grade control downstream of POC A is the second grade control below POC B.

The second bullet item is the tidal backwater or lentic (standing or still water such as ponds, pools, marshes, lakes, etc.) waterbody location. The project's storm runoff below both POC A and POC B ultimately enters the San Diego River just upstream of Highway 163. This river segment was part of the First San Diego River Improvement Project and contains permanent ponds resulting from historic instream mining activities. The ponds are the first lentic waterbody below POC A and POC B. This lentic waterbody is much further downstream from POC A and POC B than both of their first permanent grade controls. Therefore, the second bullet item will not govern over the first bullet item in establishing the downstream domain of analysis location for POC A and POC B.

The third bullet item is met when the drainage path below a POC confluences with a stream with an equal order or larger tributary area. The unnamed natural drainage course confluences with a larger stream at the San Diego River. The narrow natural canyon confluences with a larger stream at the Caltrans concrete-lined trapezoidal channel. Both confluence locations are further downstream of their associated POCs than their permanent grade controls. Therefore, the third bullet item will not govern over the first in establishing the downstream domain of analysis location for POC A or POC B.

The fourth bullet item is met when the natural stream below a POC accumulates 50 or 100 percent drainage area for natural or urban drainage systems, respectively. The unnamed natural drainage course and narrow natural canyon below the POCs are both natural stream systems, so 50 percent applies. The drainage areas tributary to both streams below their respective POCs are relatively narrow and confined to the proximity of each stream. As a result, the areas accumulated below POC A and POC B will not exceed 50 percent of the areas tributary to POC A and POC B prior to their respective first grade controls. Therefore, the fourth bullet item will not govern over the first in establishing the downstream domain of analysis location for POC A or POC B.

From the above information, the downstream domain of analysis locations for POC A and POC B are both based on the grade control criteria. Of the four bullet criteria, this is the first point reached below both POC A and POC B. The grade control criteria requires the downstream domain of analysis location to extend one reach below the first grade control below the POC or preferably to the next grade control. As described above, a second grade control for POC A occurs approximately 130 feet downstream of the first grade control and is associated with the upper end of a concrete-lined channel. In addition, the second grade control for POC B corresponds to POC A's first grade control (see the Study Area Exhibit).

Upstream Domain of Analysis

The upstream domain of analysis must be established for the POCs. POC A is at an existing Caltrans culvert outlet into the uppermost end the unnamed natural drainage course. POC B is at an existing public storm drain outlet into the uppermost end the narrow natural canyon. Since the unnamed natural drainage course and narrow natural canyon do not extend upstream of their respective culvert and storm drain outlets, the upstream domain of analysis location is at POC A and POC B.

Study Reaches within Domain of Analysis

The entire domain of analysis for POC A extends 950 feet along the unnamed natural drainage course from the POC to its second downstream grade control. The entire domain of analysis was modeled as two reaches, Reach 1 and Reach 2. Reach 1 extends 820 feet from POC A to its first grade control created by the articulated concrete block grade control. Reach 2 extends 130 feet from the first grade control to the second grade control created at the upper end of the concrete-lined channel.

The entire domain of analysis for POC B should extend from the POC to its second downstream grade control. The upstream reach extends 825 feet along the narrow natural canyon from the POC to the first downstream grade control at the Caltrans culvert entrance. This was modeled as Reach 3. The reach between POC B's first and second downstream grade controls is the same as Reach 2.

Reach 1 and 3 are longer than the 656-foot reach length suggested by SCCWRP. Review of topographic mapping, aerial photographs, and field conditions reveals that the physical (channel geometry and longitudinal slope), vegetative, hydraulic, and soil conditions within Reach 1 and 3 are relatively uniform. Therefore, the results will be identical for shorter subreaches within Reach 1 and 3.

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 area, valley slope, and valley width. NED data is similar to USGS quadrangle mapping. For this project, more detailed topographic information was available, so it was used in lieu of USGS mapping for the valley slope and valley width. It was also used to determine the watershed area of Reach 3. The watershed area of Reach 1 and 2 is much larger, so USGS data was used. The following outlines the initial desktop analysis.

The watershed area tributary to Reach 1 and 2 was delineated from the USGS' StreamStats program, which is based on their Digital Elevation Model and a digital representation of the stream network. The watershed area tributary to these will be similar since Reach 2 is adjacent to Reach 1 and short, so the larger watershed area tributary to Reach 2 was used for both. This will yield slightly conservative results for Reach 1, i.e., more potential for erosion due to the assumption of a larger watershed area. The StreamStats results are included in Appendix A. The watershed delineation is consistent with current USGS quadrangle mapping and shows that the watershed area tributary to Reach 1 and 2 covers 1.776 square miles.

The watershed area tributary to Reach 3 was determined from 1-foot contour interval topographic mapping prepared for the site supplemented with SANGIS' 2-foot contour interval topographic mapping (see the watershed delineation on the Study Area Exhibit). The watershed area covers 41.98 acres (0.066 square miles).

The mean annual precipitation was obtained from the rain gage closest to the site. This is the Western Regional Climate Center's Lindbergh Field gage at the San Diego International Airport (see Appendix A). The average annual rainfall measured at the Lindbergh Field gage over the period of record starting in 1939 is 10.13 inches.

The valley slopes of Reach 1, 2, and 3 were determined from the 1- and 2-foot contour interval topographic mapping. 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 Reach 1, 2, and 3 by the flow lengths.

The valley width is the bottom width of the unnamed natural drainage course. The average valley widths within Reach 1, 2, and 3 were estimated from the topographic mapping, field observations, and review of aerial photographs. The watershed area, valley slope, and valley widths for Reach 1, 2, and 3 are summarized in Table 1.

Reach	Tributary Watershed Area, sq. mi.	Valley Slope, m/m	Valley Width, m
1	1.7764	0.0921	3.05
2	1.7764	0.0272	2.44
3	0.0656	0.0162	2.44

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

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 14. 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 in Figures 1 through 13 and a site investigation, the bed material and resistance (associated with the dense, uniform vegetation and cobbles) in Reach 1, 2, and 3 are generally within the transitional/intermediate bed to primarily within the threshold bed categories.

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 appropriate results given the range of factors that define erodibility. 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 natural channel bed along Reaches 1, 2, and 3 are assigned to Category A, which represents a mix course of gravels and cobbles. The soil was probed and penetration was relatively difficult through the underlying cobble layer. The channel bed along each reach was mostly covered with a uniform layer of cobbles (see Figures 11, 12, and 13). The cobbles supported mature vegetation in many areas, whose root structure provides channel bed armoring similar to cobbles.

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 maximum grade control spacing of less than $2/S_v$. A reach is in Category B if it has a maximum spacing between $2/S_v$ and $4/S_v$. Finally, a reach is in Category C if it has a maximum spacing greater than $4/S_v$. Table 2 summarizes the S_v, $2/S_v$, and $4/S_v$ values for all three study reaches along with the maximum grade control spacing within each study reach. The associated category is also included.

Reach	**S_v, feet/feet**	**$2/S_v$, feet**	**$4/S_v$, feet**	**Max. Grade Control Spacing, feet**	**Category**
1	0.0195	336	673	820	C
2	0.0138	474	948	130	A
3	0.0922	71	142	825	C

Table 2. Checklist 2 Values based on Grade Control Spacing

The Screening Index Threshold in Appendix B 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 was developed from 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 determined in the initial desktop analysis (see Appendix A). The Screening Index values for Reaches 1, 2, and 3 from Appendix A are 0.044, 0.031, and 0.049, respectively. These values correspond to a d_{50} of 16 mm or less (16 mm has a value of 0.049). Since the d_{50} in each reach well exceeds 16 mm (0.63 inches) as evidenced by the figures, each reach has less than a 50 percent probability of incision and is in Category A.

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

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

The vertical rating score for Reach 1, 2, and 3 are 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 Reaches 1 through 3 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
1	3	9	3	3.9
2	3	3	3	3.0
3	3	9	3	3.9

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 15) 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 extensive mass wasting nor extensive fluvial erosion was evident within Reach 1, 2, or 3 during a field investigation. The channel banks are intact as indicated in the figures.

The next step in the Form 4 decision tree is to assess the consolidation of the bank material. The banks in Reach 1, 2, and 3 were moderate to well-consolidated. This determination was made because the ground surface was difficult to penetrate with a probe. In addition, the banks showed no evidence of crumbling and were composed of relatively well-packed particles and/or cobbles.

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 site investigation and topographic mapping, the average bank angle in Reach 1, 2, and 3 is 1.5:1 (33.7 degrees) or flatter. Form 6 shows that the probably of mass wasting and bank failure has less than 10 percent risk for a 33.7 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 Reach 1, 2, and 3 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 calculation in the spreadsheet in Appendix A shows that the VWI for Reach 1 (0.21), Reach 2 (0.17), and Reach 3 (0.60) are much less than 2.

From the above steps, the lateral susceptibility rating is low for Reach 1, 2, and 3 (colored circles are included on the Form 4: Lateral Susceptibility Field Sheet decision tree in Appendix B showing the decision path).

CONCLUSION

The SCCWRP channel screening tools were used to assess the downstream channel susceptibility for the Rady Children's Hospital – San Diego redevelopment project being designed by KPFF Consulting Engineers. The project runoff will be collected by existing easterly and southwesterly storm drain systems that discharge into an unnamed natural drainage course (POC A) and a narrow natural canyon (POC B), respectively. A downstream channel assessment was prepared for the unnamed natural drainage course below POC A, i.e., for Reach 1 and Reach 2. An assessment was also prepared for the narrow natural canyon below POC B, i.e., for Reach 3. The channel assessments were performed based on office analyses and field work. The results indicate a low threshold for vertical and lateral susceptibility for Reach 1, 2, and 3.

The HMP requires that the SCCWRP results be compared with the critical stress calculator results outlined in the County of San Diego HMP. The critical stress results are included in Appendix B for Reach 1, 2, and 3 using the spreadsheet provided by the County. The channel dimensions were estimated from the topographic mapping, proposed grading, and a site visit. Based on these values, the critical stress results returned a low threshold. Therefore, the SCCWRP analyses and critical stress calculator demonstrate that a low overall threshold ($0.5Q_2$) is applicable to all portions of the project tributary to POC A and POC B.

Figure 1 Looking Downstream towards Reach 1 from Upper End at POC A

Figure 2. Looking Downstream from Middle of Reach 1

Figure 3. Looking Upstream towards Reach 1 from Lower End at its First Grade Control

Figure 4. Articulated Concrete Block Grade Control between Reach 1 and 2

Figure 5. Looking Downstream towards Reach 2 from Upper End at First Grade Control

Figure 6. Middle of Reach 2

Figure 7. Concrete Channel at Lower End of Reach 2 (Second Grade Control)

Figure 8. Looking Downstream towards Reach 3 from Upper End at POC B

Figure 9. Middle of Reach 3

Figure 10. Looking Upstream towards Reach 3 from Lower End at its First Grade

Figure 11. Cobble Lining Along Reach 1

Figure 12. Cobble Lining Along Reach 2

Figure 13. Cobble Lining Along Reach 3

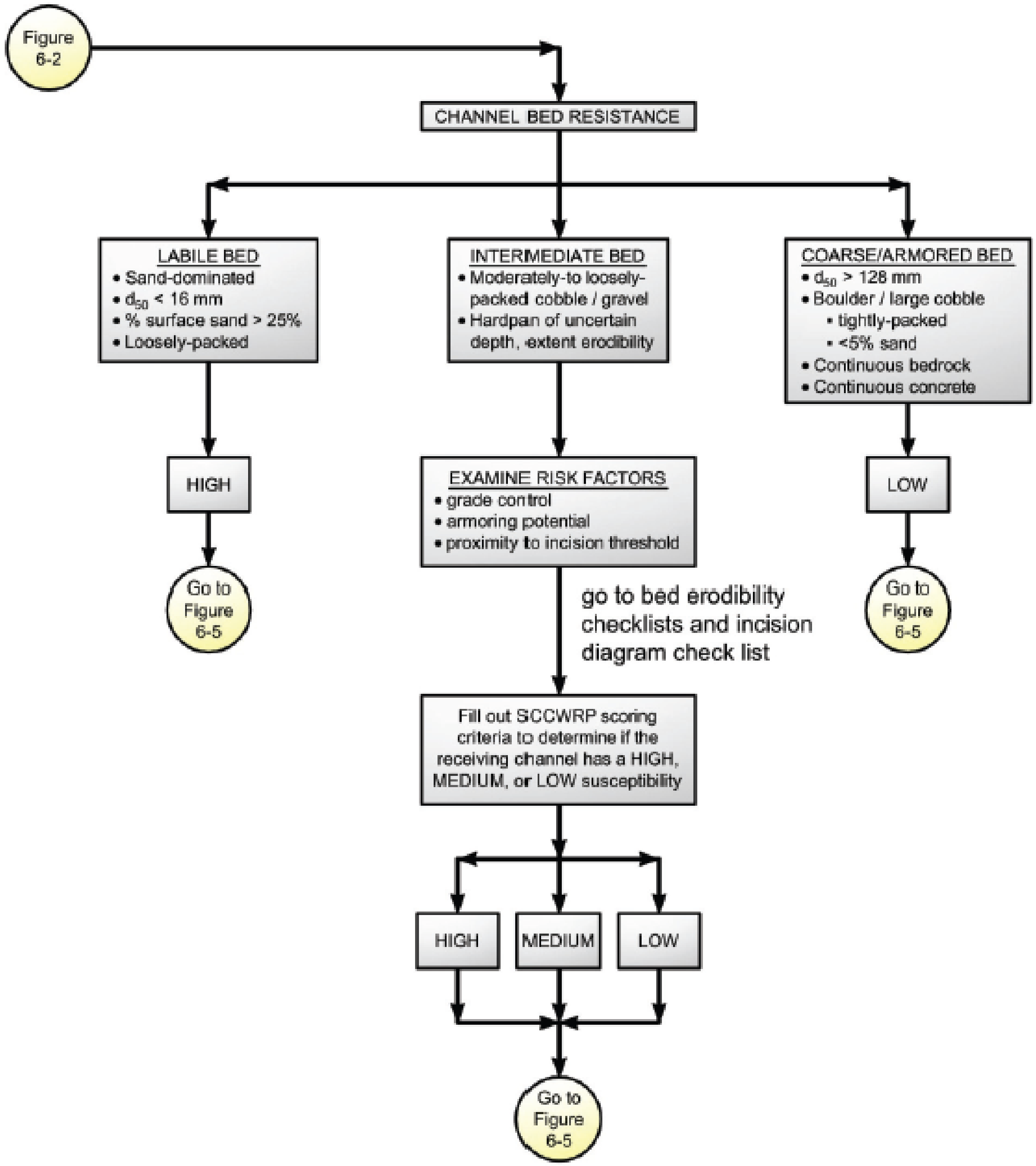


Figure 6-4. SCCWRP Vertical Susceptibility

Figure 14. SCCWRP Vertical Channel Susceptibility Matrix

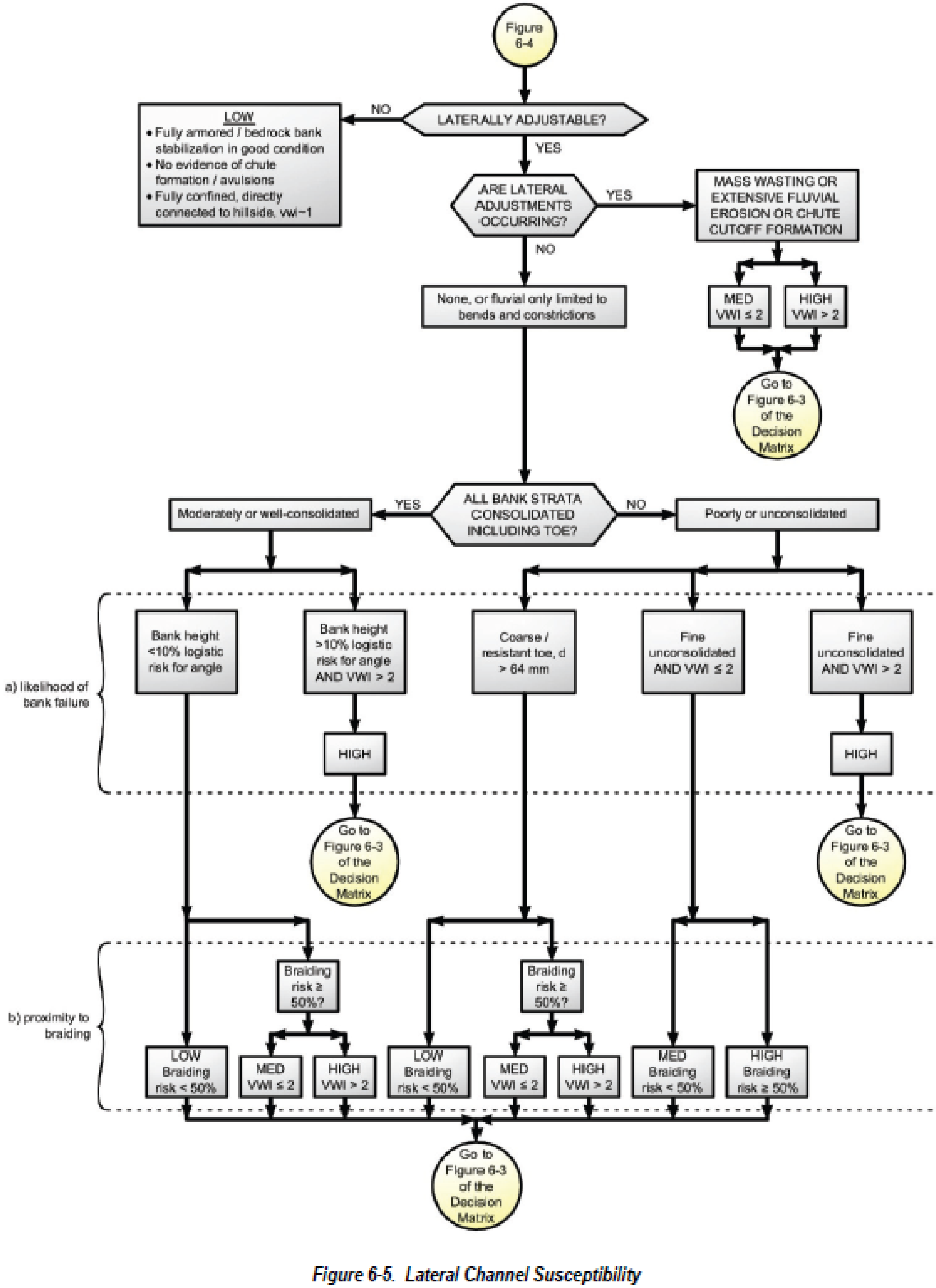


Figure 15. SCCWRP Lateral Channel Susceptibility Matrix

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: 32.79191 Longitude: -117.15066

Description (river name, crossing streets, etc.): Rady Children's Hospital - Unnamed Natural Drainage Course and Narrow Natural Canyon.

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 Tabl e 2. Simplif ied peak flo w, 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
1	1.7764	10.13	0.0195	3.05	178.4	5.05
2	1.7764	10.13	0.0138	2.44	178.4	5.05
3	0.0656	10.13	0.0922	2.44	10.1	0.29

Reach	10-Year Screening Index INDEX	Reference Width Wref, m	Valley Width Index VWI, m/m
1	0.044	14.21	0.21
2	0.031	14.21	0.17
3	0.049	4.04	0.60

SAN DIEGO LINDBERGH FLD, CALIFORNIA (047740)

Period of Record Monthly Climate Summary

Period of Record : 07/01/1939 to 06/09/2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	64.8	65.2	65.9	67.4	68.6	70.9	74.8	76.3	75.7	72.9	69.9	65.8	69.9
Average Min. Temperature (F)	48.1	49.7	51.9	54.7	58.1	60.8	64.4	65.7	63.9	59.3	52.9	48.7	56.5
Average Total Precipitation (in.)	2.00	1.98	1.63	0.78	0.21	0.05	0.02	0.06	0.17	0.51	0.97	1.77	10.13
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	0.0
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.: 99.9% Min. Temp.: 99.9% Precipitation: 99.9% Snowfall: 83.3% Snow Depth: 83.3%
Check Station Metadata or Metadata graphics for more detail about data completeness.

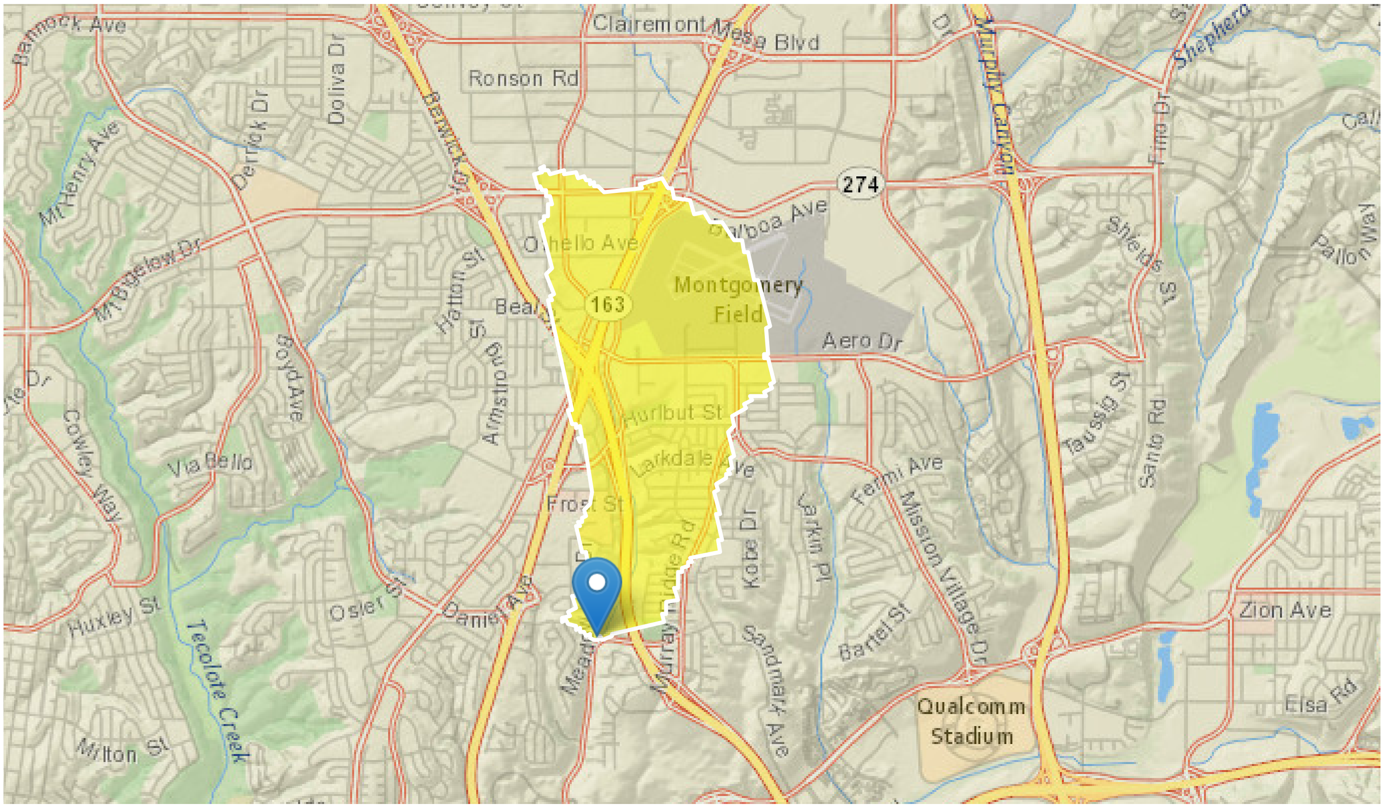
Western Regional Climate Center, wrcc@dri.edu

SAN DIEGO INTERNATIONAL AIRPORT RAIN GAGE

Reach 1 and 2 Watershed Area

StreamStats Report

Region ID: CA
Workspace ID: CA20220111170926046000
Clicked Point (Latitude, Longitude): 32.78966, -117.15219
Time: 2022-01-11 09:09:48 -0800



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.7764	square miles

General Disclaimers

APPENDIX B

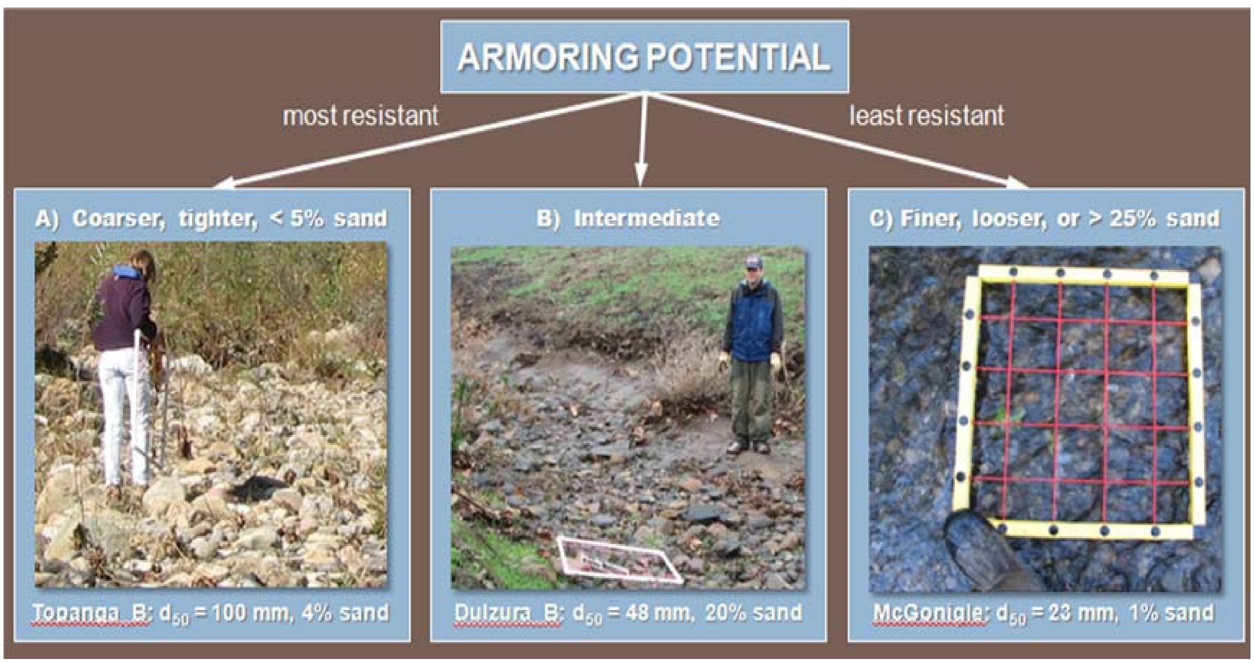
SCCWRP FIELD SCREENING DATA

<u>**Form 3 Support Materials**</u>

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

X	A	A mix of coarse gravels and cobbles that are tightly packed with <5% surface material of diameter <2 mm
□	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)

REACH 1, 2, AND 3 RESULTS

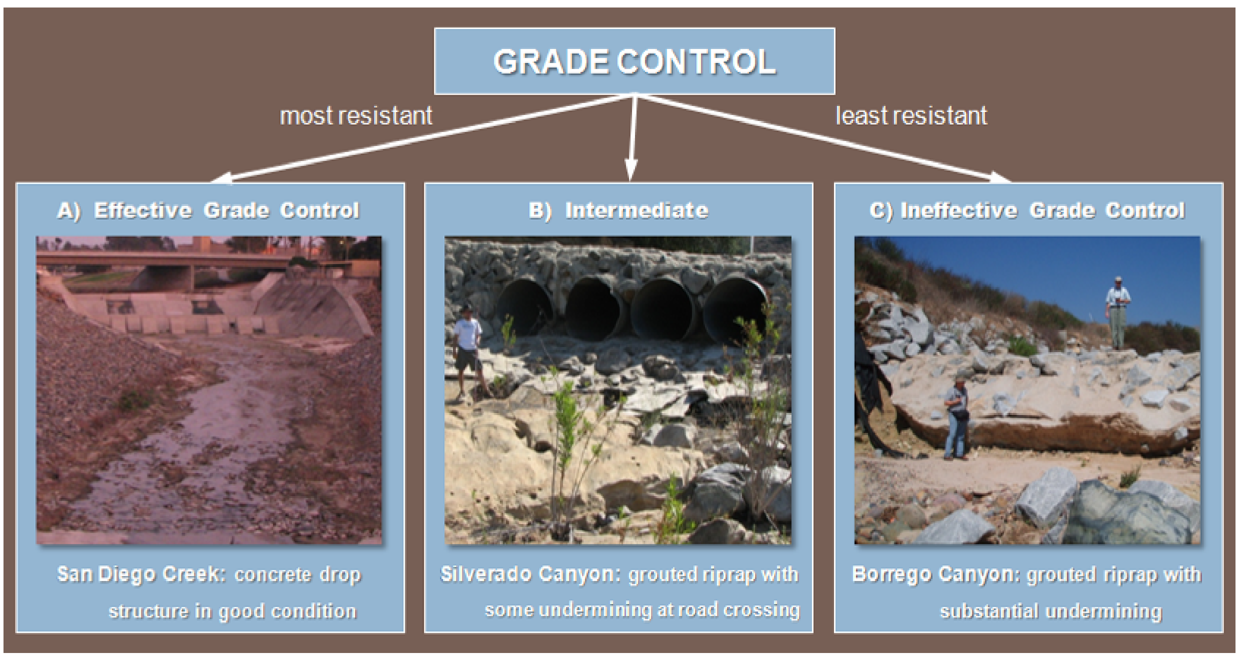
Form 3 Checklist 2: Grade Control

☒ **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

☐ **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.

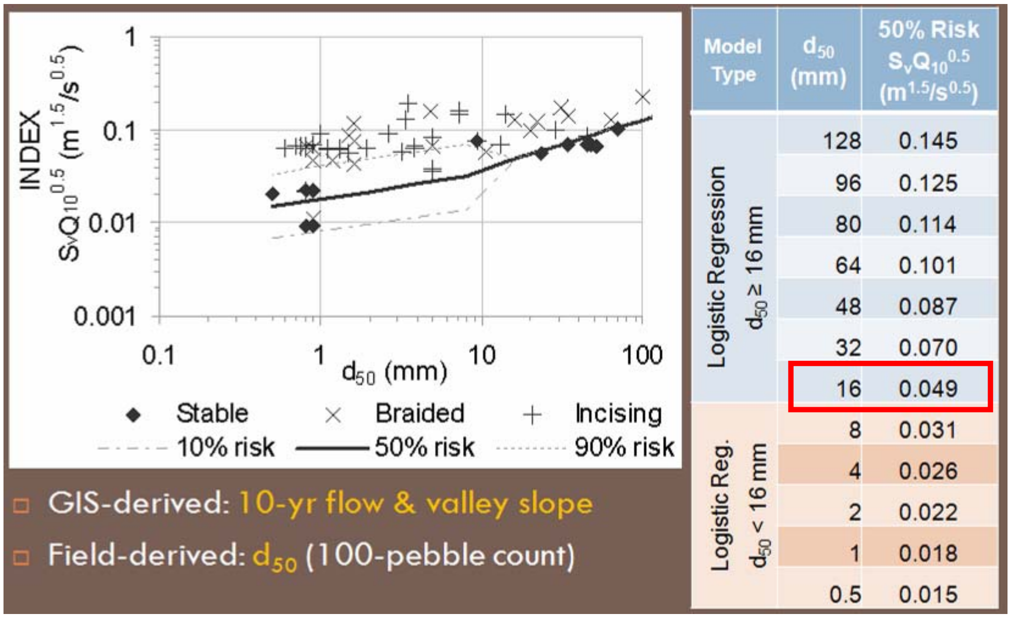
(Sheet 3 of 4)

REACH 1 AND 3 RESULTS

REACH 2 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 = ≥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.

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

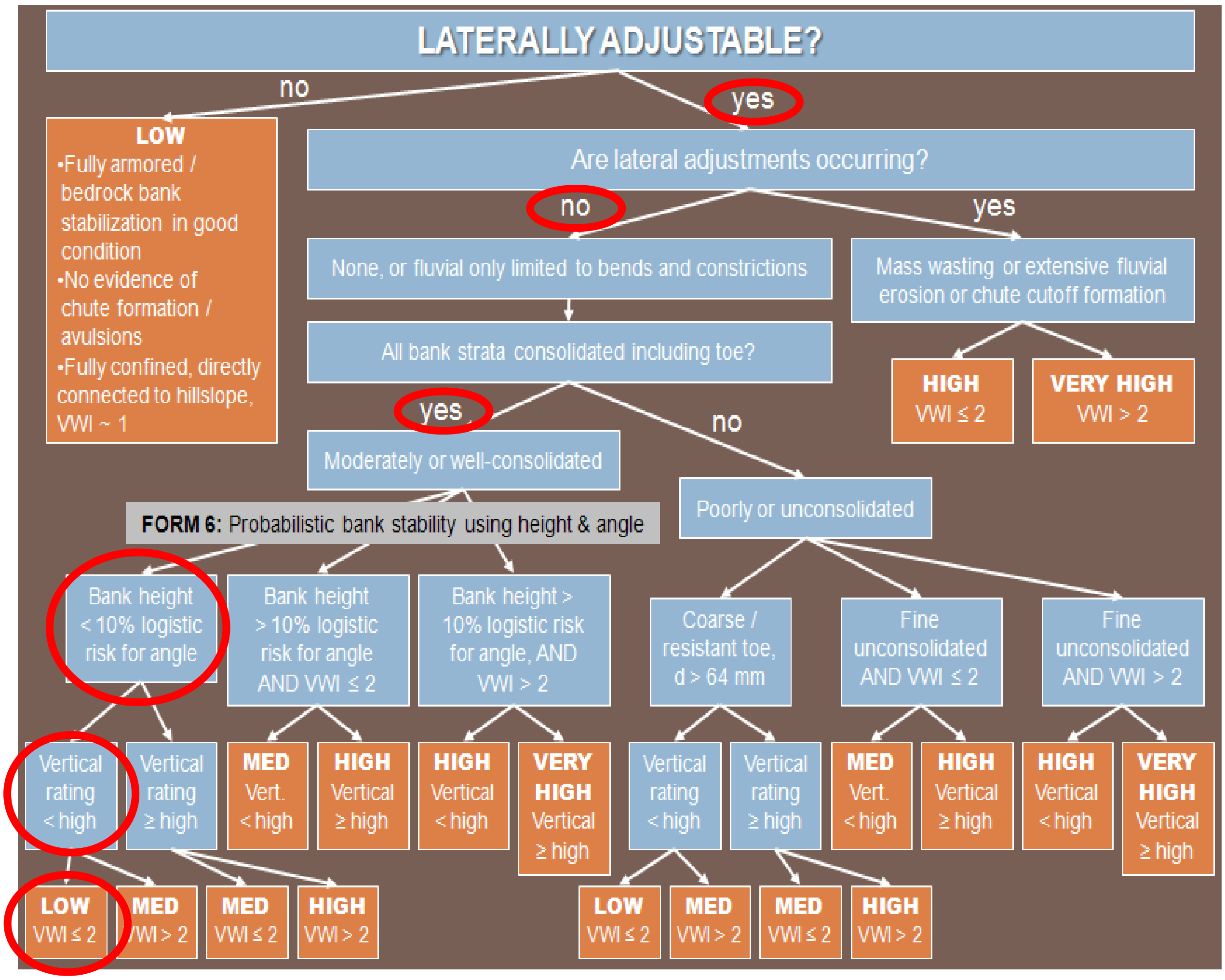
Vertical Susceptibility based on Vertical Rating: <4.5 = LOW; 4.5 to 7 = MEDIUM; and >7 = HIGH.

(Sheet 4 of 4)

REACH 1, 2, AND 3 RESULTS

FORM 4: LATERAL SUSCEPTIBILTY FIELD SHEET

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



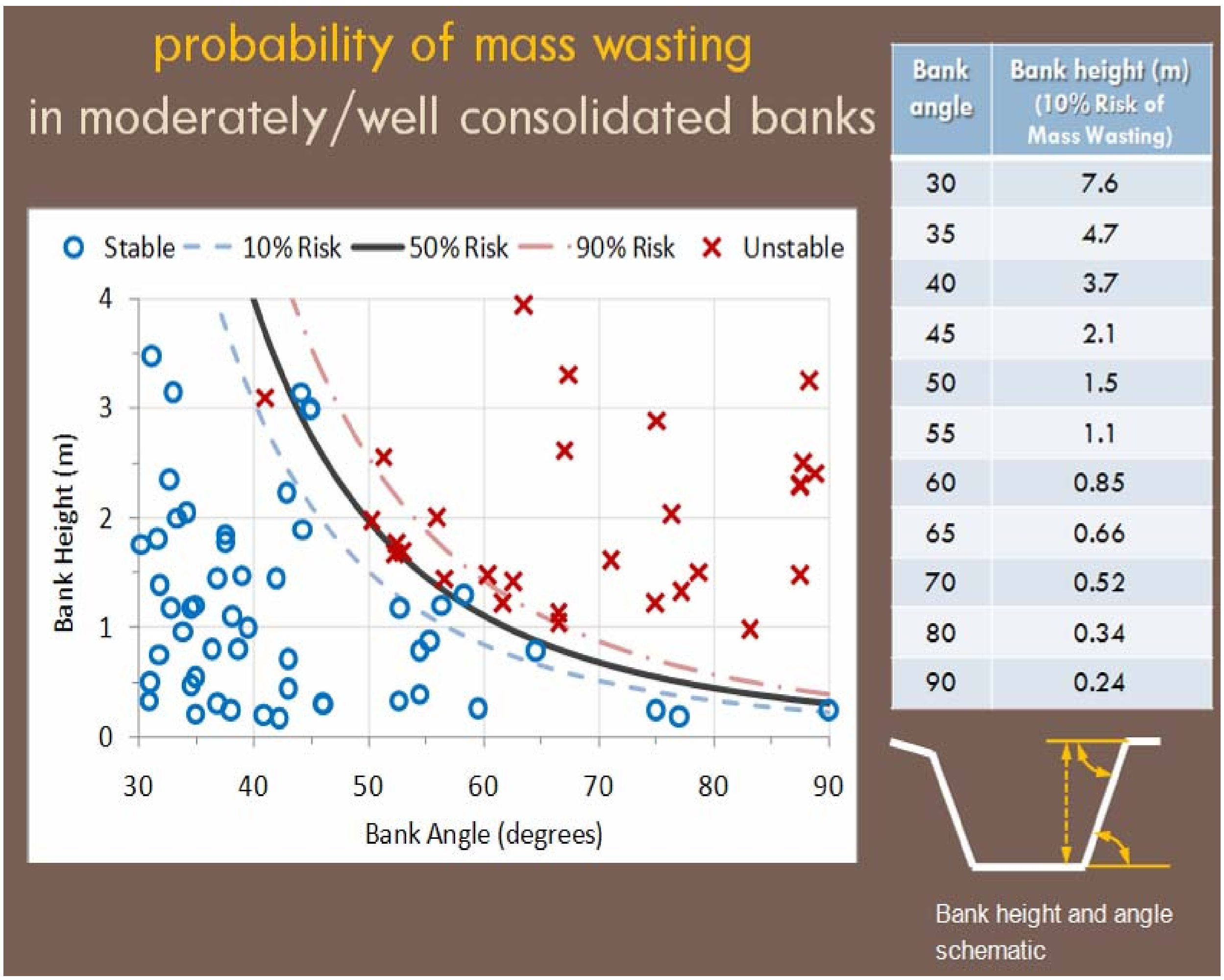
(Sheet 1 of 1)

REACH 1, 2, AND 3 RESULTS

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	1.5:1 (33.7 deg)	varies	---	<10%
Right Bank	1.5:1 (33.7 deg)	varies	---	<10%



Bank angle	Bank height (m) (10% Risk of Mass Wasting)
30	7.6
35	4.7
40	3.7
45	2.1
50	1.5
55	1.1
60	0.85
65	0.66
70	0.52
80	0.34
90	0.24

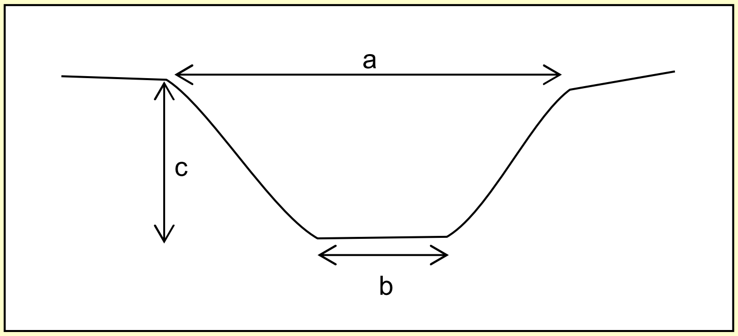
Form 6 Figure 1. Probability Mass Wasting diagram, Bank Angle:Height/% Risk table, and Band Height:Angle schematic.

(Sheet 1 of 1)

Critical Flow Calculator

Reach 1

enter all values in green cells
and drop down boxes



Inputs

a) Receiving channel width at top of bank (ft) - see figure on right	35.0
b) Channel width at bed (ft)	10.0
c) Bank height at top of bank (ft)	5.0
Channel gradient (ft/ft)	0.0195
Receiving channel roughness	Light brush and trees, leaves not present n=0.06

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)	10.13	Receiving water watershed area at PoC (sq mi)	1.7764
Project watershed annual precipitation (inches)	10.13	Project watershed area draining to PoC (sq mi)	1.7764

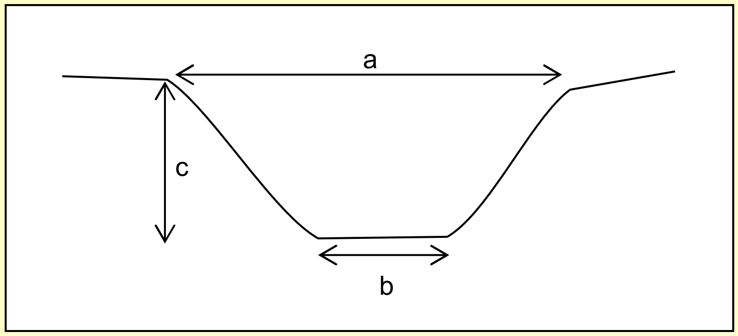
Outputs - Flow control range

Receiving water Q2	9.0	**Point of Compliance low flow rate (cfs)**	**4.5**
Project site Q2	9.0	**Low flow class**	**0.5Q2**
		Channel vulnerability	**Low**

Critical Flow Calculator

Reach 2

enter all values in green cells
and drop down boxes



Inputs

a) Receiving channel width at top of bank (ft) - see figure on right	30.0
b) Channel width at bed (ft)	8.0
c) Bank height at top of bank (ft)	5.0
Channel gradient (ft/ft)	0.0138
Receiving channel roughness	Light brush and trees, leaves not present n=0.06

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)	10.13	Receiving water watershed area at PoC (sq mi)	1.7764
Project watershed annual precipitation (inches)	10.13	Project watershed area draining to PoC (sq mi)	1.7764

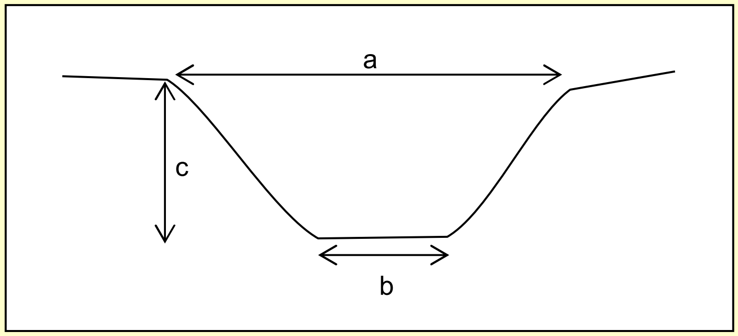
Outputs - Flow control range

Receiving water Q2	9.0	**Point of Compliance low flow rate (cfs)**	**4.5**
Project site Q2	9.0	**Low flow class**	**0.5Q2**
		Channel vulnerability	**Low**

Critical Flow Calculator

Reach 3

enter all values in green cells
and drop down boxes



Inputs

a) Receiving channel width at top of bank (ft) - see figure on right	23.0
b) Channel width at bed (ft)	8.0
c) Bank height at top of bank (ft)	5.0
Channel gradient (ft/ft)	0.0922
Receiving channel roughness	Light brush and trees, leaves not present n=0.06

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)	10.13	Receiving water watershed area at PoC (sq mi)	0.0656
Project watershed annual precipitation (inches)	10.13	Project watershed area draining to PoC (sq mi)	0.0656

Outputs - Flow control range

Receiving water Q2	0.8	**Point of Compliance low flow rate (cfs)**	**0.4**
Project site Q2	0.8	**Low flow class**	**0.5Q2**
		Channel vulnerability	**Low**

STUDY AREA EXHIBIT