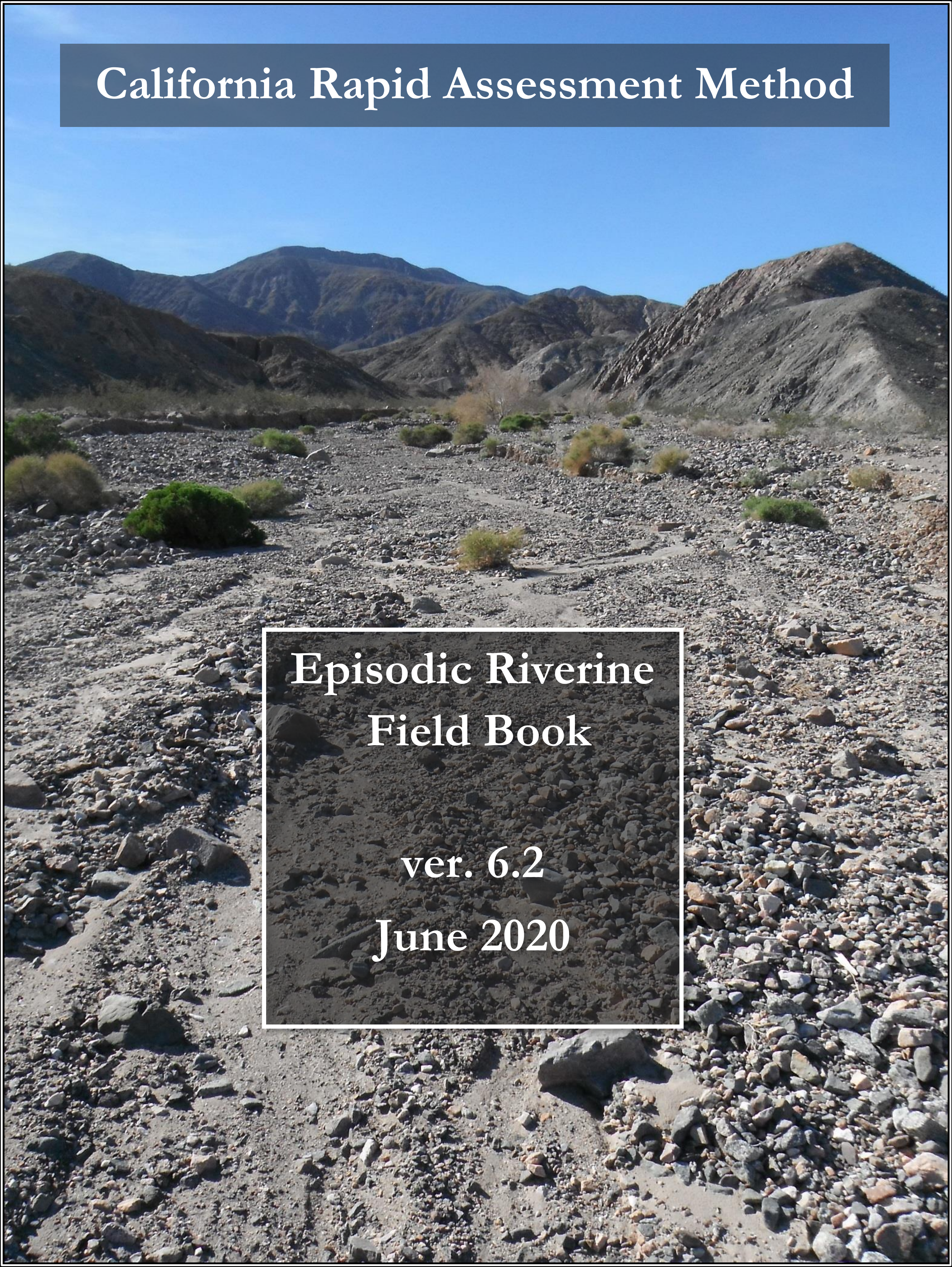

California Rapid Assessment Method

Episodic Riverine Field Book

ver. 6.2

June 2020

FOREWORD

This module of the California Rapid Assessment Method (CRAM) has been developed to assess dryland episodic streams, herein termed the **episodic riverine CRAM module (ver 6.2).** Episodic streams are those that flow only in response to rainfall events and experience long periods of no measurable surface flow. This field book is intended to be used in context with the User's Manual of CRAM (ver. 6.1; CWMW 2013). It was developed as a modification of the field book for riverine wetlands (ver. 6.1), herein termed the **standard riverine CRAM module**. This module was designated version 6.2 to bring it into alignment with the version numbers of other CRAM modules that were recently updated.

The episodic riverine CRAM module is based on the fundamental assumptions and relationships between condition and function shared between all CRAM modules. Four universal attributes of condition are recognized: (1) Buffer and landscape context; (2) Hydrology; (3) Physical structure; and (4) Biotic structure. However, the metrics comprising these attributes have been adapted to account for the unique characteristics of predominantly dry episodic waterways.

This field book provides the standard operating procedures for using CRAM to assess episodic waterways. The general procedure for applying the episodic module of CRAM consists of the same series of steps as described in the CRAM User's Manual. Users should refer to the CRAM User's Manual for overarching key concepts, assumptions, and the developmental process of the CRAM method.

The data produced from appropriate application and use of this module results could be integrated into existing regulatory programs to provide improved evaluation of and compensation for impacts to episodic stream types, an underrepresented aquatic resource type in current state and federal monitoring programs. Appropriate application of this module by trained practitioners will help to facilitate a process for regulatory agencies and other entities to coordinate and share data, formulate best management practices, and agree upon mitigation and restoration priorities for episodic streams in California.

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF WORKSHEETS

CHAPTER 1: WHERE TO USE THE EPISODIC MODULE

Episodic waterways are streams and rivers that exhibit short-duration, highly localized, and extremely variable (flashy) flow in response to rainfall events or other sources of flow such as dam releases. The physical features and biological communities of these systems reflect the fact that surface water occurs at low frequency and typically does not persist, and that substrates are often dry (i.e., not saturated). More than half the total stream miles in California, and more than two thirds in the drier Southern California region, are comprised of streams that do not flow continuously throughout the year (NHD 2020, Levick 2010).

The episodic riverine CRAM module should be applied where a stream shows indicators of flow primarily for short durations during and immediately following rain events (although flows of longer duration may be observed in extremely wet years). Episodic flow events may also be due to dam releases upstream rather than directly from rainfall. In contrast, perennial streams in which flowing water is present for the entire annual cycle are assessed using the standard riverine module of CRAM. Intermittent streams should generally be assessed with the standard riverine module if they exhibit biological, hydrological, or physical characteristics commonly associated with conveyance of surface water or near-surface water for extended duration (i.e. several weeks to months). However, intermittent streams on the dry end of the spectrum may be best assessed with the episodic module. This should be determined based on local site characteristics. Ephemeral streams that don't exhibit the indicators characteristic of episodic channels may not be appropriate for this module. However, most ephemeral streams in arid regions are likely to be best characterized by the episodic module.

Some streams may require the episodic module in some reaches, while the standard riverine module is more appropriate in other reaches. For example, many alluvial fans exhibit episodic characteristics, while lower in the watershed streams may develop distinct bed and banks with perennial riparian corridors. There may be reaches up in the mountainous part of the streams that support perennial flow, but as the stream reaches the valley floor and forms an alluvial fan most of the flow may sink into the sub-surface, resulting in flow only during episodic events. Another example where the stream type differs along different reaches is when the system has been highly modified by anthropogenic inputs. One portion of the stream may be episodic, while further downstream additions from human sources have converted it to perennial or intermittent. There are many different potential scenarios where disparate parts of the stream have different flow regimes, these are just a couple of examples.

Some streams are so highly modified that it can be difficult to detect their characteristics. In that situation the practitioner can look upstream and downstream to other parts of the stream to determine the appropriate classification for that system. Since different reaches can have different flow regimes, the investigation into reaches upstream and downstream should look to nearby reaches within a kilometer or two.

Determining which module to use should be done based on site-specific field indicators as well as desktop screening variables such as climate information. Rainfall and temperature can be used as an initial screening tool, but the final designation should be based on conditions in the field. Biotic and physical characteristics that would lead to selecting the episodic module are listed below in Table 1.1.

In some cases it may not be clear which module to use. In that situation, a practitioner can implement both the standard Riverine CRAM and the Episodic Riverine CRAM modules and take the one with the higher score.

Table 1.1. Indicators in the channel and floodplain for selecting the Episodic CRAM module

Biotic Indicators
• Vegetation dominated by sage scrub, chaparral, or desert plants (cactus and low shrubs) • Sparse vegetation coverage overall • Typically no trees taller than 3-4 m (taller for Joshua trees, ironwood, palo verde, pine species, oak species, saguaros, etc.) • If tall trees are present they are sparsely distributed • Xeric perennial shrubs growing inside main channel(s) • Typical species may include: Ambrosia salsola (Burrobrush), Artemisia tridentata (Sagebrush), Atriplex canescens (Fourwing Saltbush), Atriplex polycarpa (Allscale Saltbush), Larrea tridentata (Creosote), Lepidospartum squamatum (Scalebroom) • Not dominated by plants such as sycamore and willow that tolerate prolonged inundation • Little or no evidence of prolonged stream inundation, such as dried algal mats found in-situ or aquatic invertebrate shells in dried pools
Physical Indicators
• Braided or multi-thread systems (for lower watershed stream reaches not significantly altered by hydromodification and channelization: see Sediment Transport Metric) • Single-thread systems with high sediment transport and at least some vegetation indicators • Evidence of massive sediment movement (sandy substrate, angular cobbles, large unvegetated bars) • No apparent seeps/springs that contribute directly to the AA • Poorly defined banks (for lower watershed stream reaches) • No evidence of prolonged stream inundation, such as rock staining throughout the active channel, persistent residual pools, or flowing water during dry periods • Lack of pool/riffle sequences • Evidence of flash flooding (wrack and scour in dry channels) • Sand fans in bed • Interior desert areas with <5 in annual rainfall (in combination with site-specific indicators) • Arid regions with 5 to 15 inches annual rainfall (in combination with site-specific indicators)

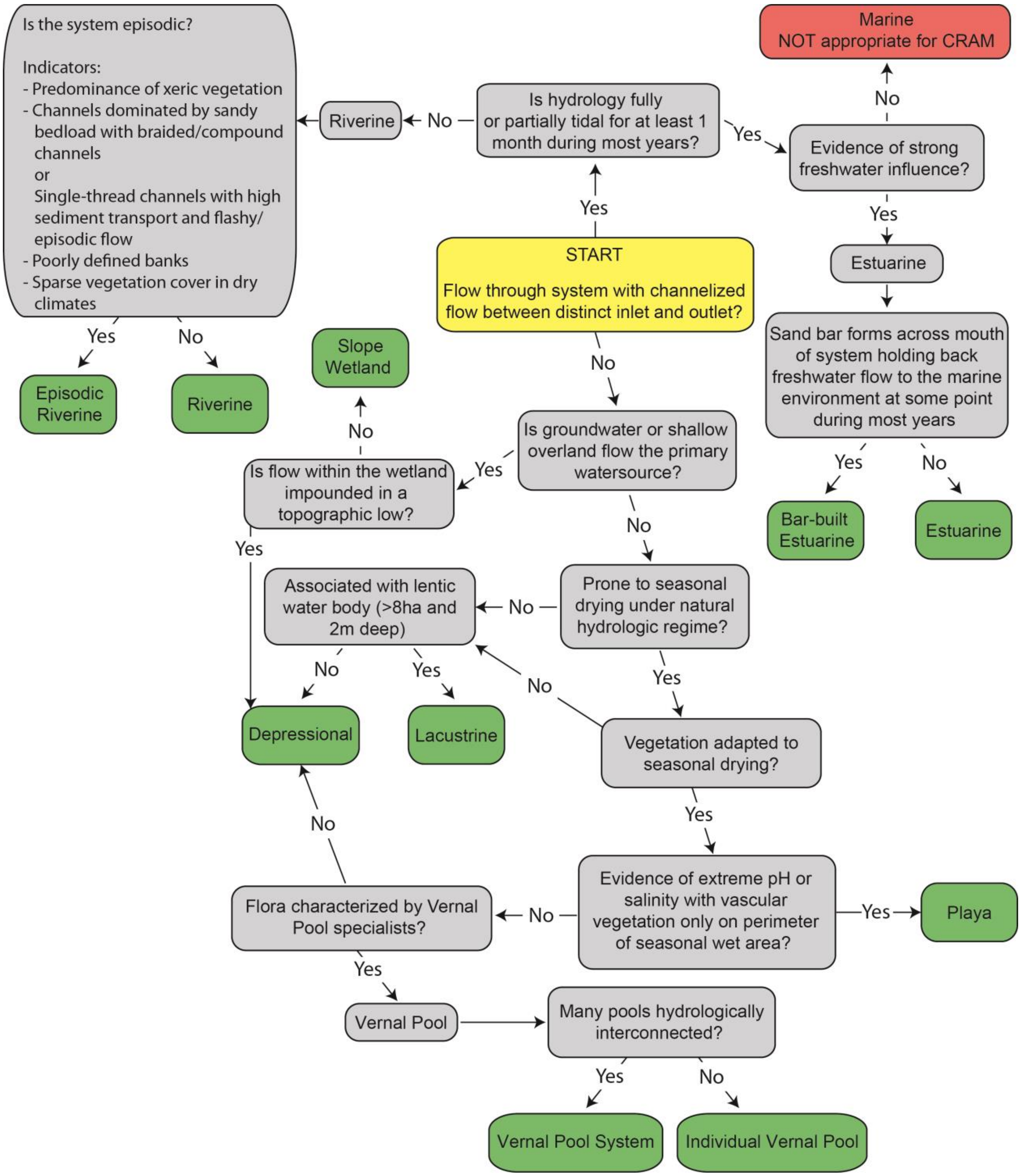


Figure 1.1: Flowchart to determine wetland type

Episodic streams are common throughout the dryland (arid and semi-arid) regions of California (USDA 2006) where annual evapotranspiration exceeds precipitation (Bailey 1995; Bull and Kirkby 2002). For these regions, annual average precipitation is typically less than 15 inches (380 mm). Drylands constitute over 60% of the State's landscape and broadly include the Mediterranean regions of the state, including the associated coastal zone of southern California, as well as the interior desert portions (Figure 1.2). Episodic streams are especially well-represented in the inland deserts of California (e.g., Mojave, Great Basin, Sonoran-Colorado), but are not exclusive to these regions. Not all streams in areas with less than 15 inches annual average precipitation are characterized by episodic flow, so individual reaches should be evaluated based on local site conditions.

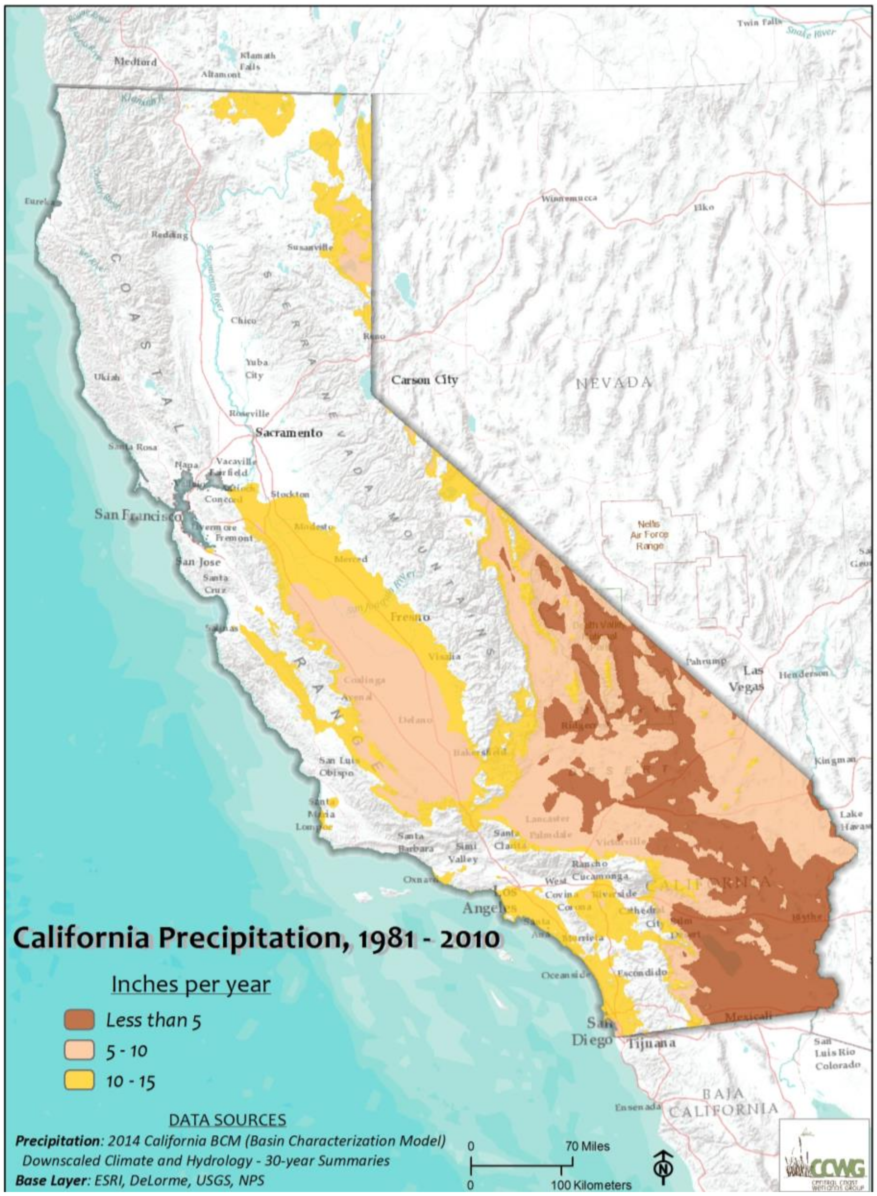


Figure 1.2: Rainfall in California showing areas with less than 15 inches (38 cm) of average annual precipitation

CHAPTER 2: CHARACTERIZING THE SITE

2.1 Episodic Stream Sub-types

Some CRAM metrics for episodic streams are tailored for different types of channel forms. The various sub-types are grouped into two overall channel types: single-thread and multi-thread. Because these types exhibit very different morphology and flow characteristics, they are assessed in different ways for certain metrics. In general, single-thread channels tend to be found higher in the watershed at steeper gradients, while multi-thread channels are usually found lower in the watershed, where the valleys are wider and gradients are more gradual. However, this can be altered by channelization and hydromodification, which may constrain lower gradient systems to a single channel.

Multi-thread Episodic Riverine Sub-type

In multi-thread episodic riverine systems, there are two or more channels that convey flow. They consist of one or more low-flow channel(s) nested within a braided network of secondary channels within the active floodplain, separated by exposed islands or channel bars. Multi-thread episodic riverine systems typically occur lower in the watershed on alluvial fans and plains, and along broad valleys. Some lower watershed systems have been constrained and narrowed by anthropogenic features, but still retain two or more channels that convey flow. These can be topographically low relief and indistinct, especially in sandy washes, but still have multiple flow pathways within the active floodplain. Lower watershed systems that have been completely restricted to one channel due to anthropogenic features are not included in this category.

Single-thread Episodic Riverine Sub-type

In single-thread episodic riverine systems, streamflow is restricted to a discrete, meandering channel form. There is one main channel that conveys flow, and typically no secondary channels. The channel gradient is often steep and the floodplain is relatively small or discontinuous. They may have secondary channels that appear intermittently, but the majority of flow is in one main channel. Single-thread channels are usually found higher in the watershed, in steep canyons or narrow valley. However, some lower watershed systems may be constrained to a single-thread form by development, channel hardening, or other hydromodification. The episodic channel sub-type should be determined in the field based on specific site characteristics.

In the standard Riverine CRAM module streams are classified based on degree of confinement. While episodic streams do exhibit a range of confinement, as shown in Figure 2.1, the difference between confined and non-confined systems doesn't substantially affect the scoring criteria for these systems. In the standard Riverine CRAM assessments one of the metrics measures the degree of entrenchment based on field data on the bankfull and floodprone widths, and the resulting scores are adjusted by the confinement category. However, in episodic systems there is often not a clear bankfull channel form and this metric was replaced with an assessment of anthropogenic alterations through levees or other hard structures.

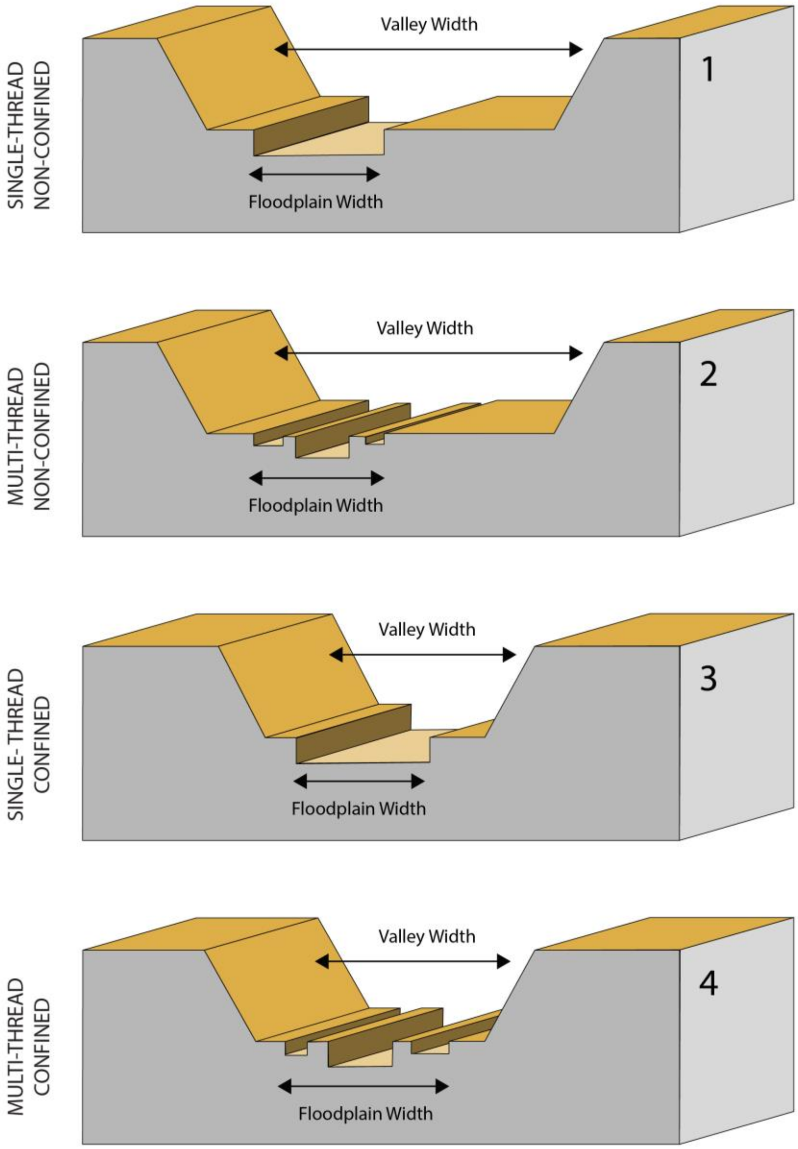


Figure 2.1: Illustrations of riverine confinement and sub-type for episodic channels. (1) single-thread non-confined, (2) multi-thread non-confined, (3) single-thread confined, and (D) multi-thread confined

2.2 Verify the Appropriate Assessment Window

The assessment window is the period of time each year when CRAM assessments should be conducted. In general, the CRAM assessment window falls within the growing season for the characteristic plant community of the system to be assessed. Drylands in California span vast and topographically diverse regions, and variations in growing season will be related to seasonal changes in precipitation and evapotranspiration, as well as altitude and latitude. The best cues will be the early evidence of new growth of plants, and the subsequent senescence of the plants.

Regardless of the optimal assessment window, rivers and streams should not be assessed during high water and flood periods, not only because some important indicators of channel condition might be concealed, but also because of the dangers presented by high flows.

2.3 Establish the Assessment Area

The assessment area (AA) is the portion of the stream that is assessed using CRAM. Examples of features that should be used to **establish AA boundaries,** and other features that should not be used, are listed in Table 2.1 below. Although an AA boundary can be drafted in the office with aerial imagery, this must be verified in the field. The AA should be bounded by obvious physical changes in topography, hydrology, or infrastructure that significantly control the sources, volumes, rates, or general composition of sediment supplies or water supplies within the AA.

Table 2.1: Guidelines for identifying features that should be used to establish episodic riverine AA boundaries

Examples of features that <u>should</u> be used to establish riverine AA boundaries	**Examples of features that should <u>not</u> be used to establish riverine AA boundaries**
• major changes in channel entrenchment, confinement, degradation, aggradation, slope, or bed form • major tributary or channel confluences • abrupt vertical drops in channel course (where waterfalls would be present if water was present) • transitions between stream or wetland types • diversion ditches • end-of-pipe large discharges • weirs, culverts, dams, drop- structures, levees, and other flow control, grade control, or water height control structures	• **at-grade**, unpaved, single-lane, infrequently-used roadways or crossings • **at-grade** bike paths and jogging trails • equestrian trails • bare ground within what would otherwise be the AA boundary • fences (unless designed to obstruct the movement of wildlife) • property boundaries, unless access is not allowed • transitions in channel bed substrate (e.g., sand bed to gravel bed) • spatial changes in land cover or land use along the stream border • state and federal jurisdictional boundaries

Table 2.2: Major features of episodic streams

Delineating Feature	Description of Features
Low-flow Channel(s)	The topographically lowest stream channel, or the dominant sub-channel within a compound channel watercourse, occupied by recurring flow events.
Active Floodplain Area	An area encompassing all contemporary stream channels and the interfluvial areas. These areas have evidence of episodic flow, including sediment deposits, wrack, and vegetation communities that are distinct from surrounding uplands.
Upland	Well-drained areas of higher ground that are dominated by terrestrial processes.

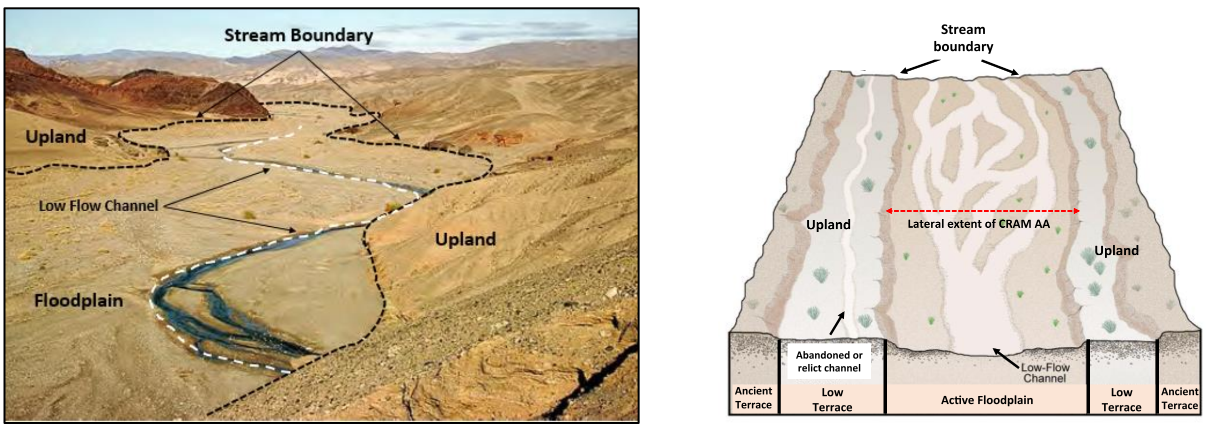


Figure 2.2: Identifying channels, floodplain, and upland terraces for a compound channel form (photo courtesy of Marli Bryant Miller, diagram courtesy of Kris Vyverberg).

Table 2.3: Steps to establish episodic AAs

Step	AA Establishment Task
1	On the site imagery, identify the low-flow channel or channels and active floodplain.
2	Extend the AA out from the low-flow channel to include the active floodplain and any overhanging vegetation.
3	Extend the AA upstream for 10x the floodplain width, but not less than 100 m and no more than 200 m length.

Establish the Lateral Extent of the AA

To determine the lateral extent of the AA, first identify the low-flow channel. The low-flow channel has the lowest elevation in the active floodplain, contains flowing water the most frequently, and often has recent indicators of flow (such as linear bands of concentrated sediment, wrack piles, mud cracks, or a general lower density of vegetation than surrounding uplands). In general, the AA should extend from the center of the low-flow channel to the outer extent (upland terrace edge) of the active floodplain. Any vegetation that directly contributes organic material to the active floodplain, if present, should be included in the AA in its entirety. If there is no vegetation present at the edge of the floodplain, the minimum width of the AA should extend 2 m from the edge of the floodplain into the adjacent uplands. The AA can include topographic floodplain benches, bars, islands, secondary channels, meander cutoffs, and other features that are at least **semi-regularly** influenced by fluvial processes and are associated with the AA.

The AA should not extend beyond the limits of the active floodplain, as indicated by transitions to fluvially inactive uplands, terraces with abandoned or relict (paleo) channels, or other surfaces that are geomorphically disconnected from the floodplain and channel-forming processes or are only inundated by infrequent extreme events under current flow conditions. Note that the AA extends to the outside edge of any vegetation overhanging the active floodplain.

In some regions, changes in the density of certain plant species, such as cacti (*Opuntia* sp.), Joshua trees (*Yucca brevifolia*), and creosote bush (*Larrea tridentata*) are useful indicators of the limits of the active floodplain and transitions to upland areas. These species may occur with the active flow areas, but typically at substantially lower densities than in the adjacent upland areas.

Establish the Longitudinal Extent of the AA

The AA should begin at a hydrologic or geomorphic break in form or structure of the channel, as guided by Table 2.1, or at a specific targeted point based on probabilistic sampling or project evaluation. From this beginning, the AA should extend upstream or downstream for a distance ten times (10x) the average width of the AA, but at least 100 m, and for a distance no longer than 200 m. The AA should not extend beyond any confluence that obviously changes the sediment supply or flow, or that changes the width of the stream channel.

General Size Considerations for Episodic Riverine AAs

CRAM requires AAs to fall within a narrow range of size to maintain consistency and reduce any size bias in assessment results. In the case of large episodic riverine systems, overall size may be the dominant criterion for delineating the AA.

Table 2.4 General size guidelines for AAs in episodic streams

Parameter	Size Guidelines
AA width	**Recommended**: entire active floodplain, plus overhanging vegetation or no less than 2 m. **Minimum:** No less than 2 m from the lateral boundary of the active floodplain **Maximum:** 200 m
AA length	**Recommended**: Ten times the average AA width **Minimum**: 100 m **Maximum**: 200 m

Special Considerations for Episodic Channel Forms

Single-thread Channels: Among single-thread forms, streamflow is restricted to a discrete, meandering channel form (Figure 2.3). The AA includes the active floodplain (if present) and any overhanging vegetation, but does not include upper terraces that are beyond the active floodplain and inundated only by extreme events. Floodplains can be contiguous or non-contiguous along the course of the channel, and may be entirely absent in steep and/or constrained landscapes.

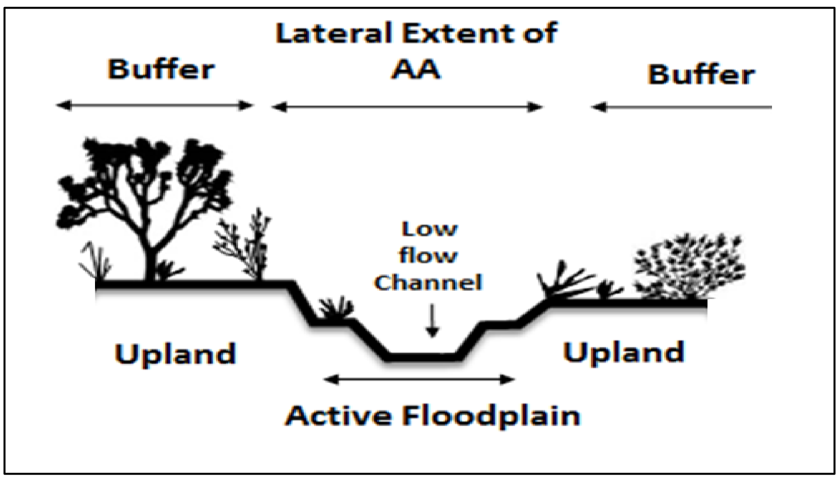


Figure 2.3: Cross-section diagram of a typical single-thread channel form showing the lateral extent of the AA in relation to its hydrogeomorphic units

Compound and Braided Channels: Compound channel forms consist of one or more low-flow channel(s) nested within a braided network of secondary channels within the active floodplain, separated by exposed islands or channel bars. For these channel forms, the outer extent of the active floodplain is the most stable and reliable landform that can be used to determine the lateral extent of the AA (Figure 2.4). Flooded by low-to-moderate events, vegetation on the active floodplain is frequently dominated by young plant growth, and the sediment texture is often coarser than in the low-flow channel.

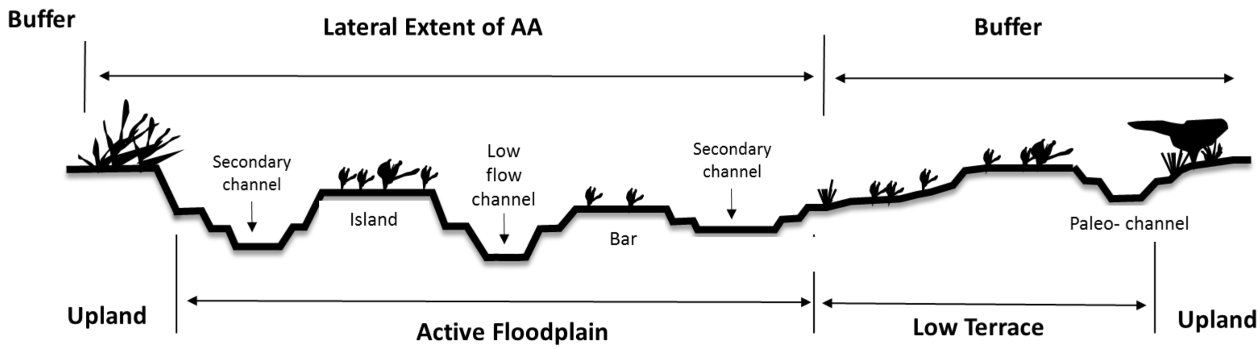


Figure 2.4: Cross-section diagram of a typical compound channel form showing the lateral extent of the AA in relation to its hydrogeomorphic units (diagram adapted from Lichvar and McColley 2008)

<u>Discontinuous Channels:</u> Discontinuous channels have alternating well-defined erosional channel segments and depositional reaches having poorly defined channel form and unconstrained or subsurface flow. The limits of erosional and depositional reaches are important in defining AA longitudinal extent, as these can constitute major changes in channel entrenchment, confinement, degradation, aggradation, or bed form. For depositional reaches with poorly defined channel form, refer to the procedures for establishing AAs in compound and braided channels (above).

<u>Very Wide Channels</u>: Some compound and braided systems extend across very wide valleys and may be so large that assessing the entire system would be impractical. The AA should not be wider than 200 m. First identify the main low-flow channel or channel of interest (e.g. an impact or restoration site). If there are multiple low-flow channels, select the one that appears to have the most active flow and has the lowest elevation in the valley. If there is an upland boundary of the active floodplain within 100 m of the low-flow channel, that will form one edge of the AA. The AA will then extend for a total of 200 m width to the other side of the low-flow channel. If there is not a distinct upland boundary within 100 m of the low-flow channel, extend the AA 100 m in each direction laterally from the centerline of the low-flow channel.

Figure 2.5. Diagram of episodic system with very wide floodplain. The light blue line represents the dominant low-flow channel. The dark blue line represents the active floodplain width (675 m). The orange box shows an appropriate AA with dimensions 200m x 200m.

Alluvial Fans

Alluvial fans can extend for many kilometers across the landscape and form vast, complex networks of shallow and more defined incised channel and swales, bounded laterally by adjacent fans, bedrock outcrops, and relict fan surfaces. Across a fan surface, stream channels tend to diverge and diminish in width, depth, and discharge due to the diversion of water by sediment and debris blockages, seepage losses, and declining sediment transport capabilities. It is important to distinguish indicators of fluvial activity and inactivity, as areas of activity are most likely to be included as part of the active floodplain within the watercourse boundary. Look for the presence of upland surfaces to define distinct AAs. In general, the AA should not extend across any well-defined upland area. For floodout zones where channels can no longer be defined and overland flow is the dominant process occurring, CRAM is no longer appropriate as an assessment method and should not be used.

Table 2.5: Steps to establish AAs on alluvial fans

Step	AA Establishment Task
1	On the site imagery, identify the system of channels that are probably interconnected by surface flow and fluvial activity. To the extent possible, the boundary should follow the drainage divide of the basin encompassing the selected channel system, without extending across an interfluve or desert pavement and without extending into non-buffer land cover.
2	Identify and number all well-defined channels within the system delineated from Step 1. These channels comprise the AA sample universe for the fan surface.
3	If there are three or fewer channels in the area, assess all of them as one AA using the episodic riverine module. However, if any channel looks substantially different than the others in the system (in terms of its vegetation, entrenchment, etc.), then it should be assessed independently as a separate AA. If there are more than three channels within the AA universe, they can be assessed as separate AAs, with each AA including up to three channels. Each AA should be no wider than 200 m.

CHAPTER 3: PROCEDURES TO CONDUCT CRAM ATTRIBUTES AND METRICS

3.0 Summary

This chapter contains procedures for implementation of each metric of CRAM for episodic streams. Each metric is supported by a definition, rationale, and an indication of the metric's sensitivity to seasonal variability in stream condition.

Attribute 1: Buffer and Landscape Context

CRAM includes two metrics to assess the Buffer and Landscape Context attribute: the Stream Corridor Continuity metric and the Buffer metric. The position of the AA in its watershed and the qualities of the buffer surrounding the AA provide important insight on how local land use influences stream condition. Both of these metrics are best assessed with the aid of GIS, satellite imagery, or aerial photography, but must be verified in the field during the assessment.

Metric 1: Stream Corridor Continuity

Definition: Stream Corridor Continuity refers to the physical, ecological and hydrological continuity of the stream corridor and the habitat it provides to wildlife, either in the form of vegetation or intact soils. In general, good corridor continuity exists when a stream does not contain intervening land use types or obstructions that could inhibit the movements of wildlife along the stream corridor or disrupt sediment and flow processes.

This metric addresses the continuity of the AA with its stream corridor upstream and downstream in terms of the expected vegetation cover and "naturalness" of the channel. The "non-buffer land cover" types in Table 3.3 are considered land use conditions that break this continuity. While the stream corridor upstream and downstream generally reflects the overall health of the riverine system, of special concern for this metric is the ability of wildlife to enter the stream corridor from outside of it at any place within 500 m of the AA and to move easily through adequate cover along the stream corridor through the AA from upstream and downstream.

Rationale. Ephemeral and intermittent episodic channels provide important wildlife movement corridors because they tend to contain continuous chains of vegetation that wildlife can utilize for cover and food (Levick et al. 2008). Most species of snakes and lizards preferentially utilize xeroriparian habitat because of the dense cover provided (Jones 1988; Rosen and Lowe 1996). Channel bank material provides shelter for numerous species of wildlife, including reptiles, amphibians, birds, mammals and terrestrial invertebrates.

Seasonality. This metric is not sensitive to seasonality.

Office and Field Indicators. The Stream Corridor Continuity metric is assessed as the total length of anthropogenic land cover segments (defined by the "non-buffer land cover" types in Table 3.3) that break or disrupt the physical, ecological and/or hydrological continuity of the stream corridor over a distance of 500 m upstream and 500 m downstream of the AA (Table 3.1). "Non-buffer land covers" occupying less than 10 m of stream length are disregarded in this metric. Although the term “non-buffer land cover” is used in the context of this metric to indicate the presence of unnatural breaks in corridor continuity, it is important to remember that the Stream Corridor Continuity metric does not assess the buffer surrounding the AA or stream corridor upstream and downstream. The segments that break continuity must encroach into the average width of the AA extended upstream and downstream, not into buffer areas adjacent to those corridors.

Scoring Instructions. Using satellite imagery or aerial photography, identify the presence of unfavorable land uses (non-buffer types), anthropogenic features (e.g. road crossings), and existing infrastructure (see Table 3.3) that encroach into the average width of the AA extended over a distance of 500 m upstream and 500 m downstream of the AA, and if necessary verify the results in the field while conducting the assessment. Use the steps outlined in Table 3.1 and Worksheet 3.1 to calculate the metric score. Printed aerial images, specifically within 500 m of the AA, should be brought to the field.

Table 3.1: Steps to assess Corridor Continuity

Step 1	Extend the average width of the AA 500 m upstream and downstream from the ends of the AA, regardless of the land cover types that are encountered (see Figure 3.1).
Step 2	Using aerial imagery, identify all the places where “non-buffer land covers” (see Table 3.3) at least 10 m long (measured parallel to the stream channel) interrupt the stream corridor within the average width of your AA on **either side of the channel** in the extended AA. Disregard interruptions of the stream corridor that are less than 10 m wide. Do not consider any open water areas as an interruption. It is possible for a non-buffer segment to cross one or both sides of a two-sided AA (see Figure 3.1). If a non-buffer segment crosses both sides it must be counted twice (one time for each side of the stream corridor).
Step 3	Estimate the length (measured parallel to the stream corridor) of each “non-buffer” segment identified in Step 2, and enter the estimates in the Worksheet 3.1.

Special Notes:
** For compound, braided channel forms, use the established lateral extent boundary of the AA (where the transition from active floodplain to upland occurs) to define the width of the expected stream corridor.*

**Assume the stream corridor width is the same upstream and downstream as it is for the AA, unless a substantial change in width is obvious for a distance of at least 100 m.*

Worksheet 3.1: Stream Corridor Continuity Metric for Riverine Systems

Lengths of Non-buffer Segments For Distance of 500 m Upstream of AA		Lengths of Non-buffer Segments For Distance of 500 m Downstream of AA	
Segment No.	Length (m)	Segment No.	Length (m)
1		1	
2		2	
3		3	
4		4	
5		5	
Upstream Total Length		Downstream Total Length	

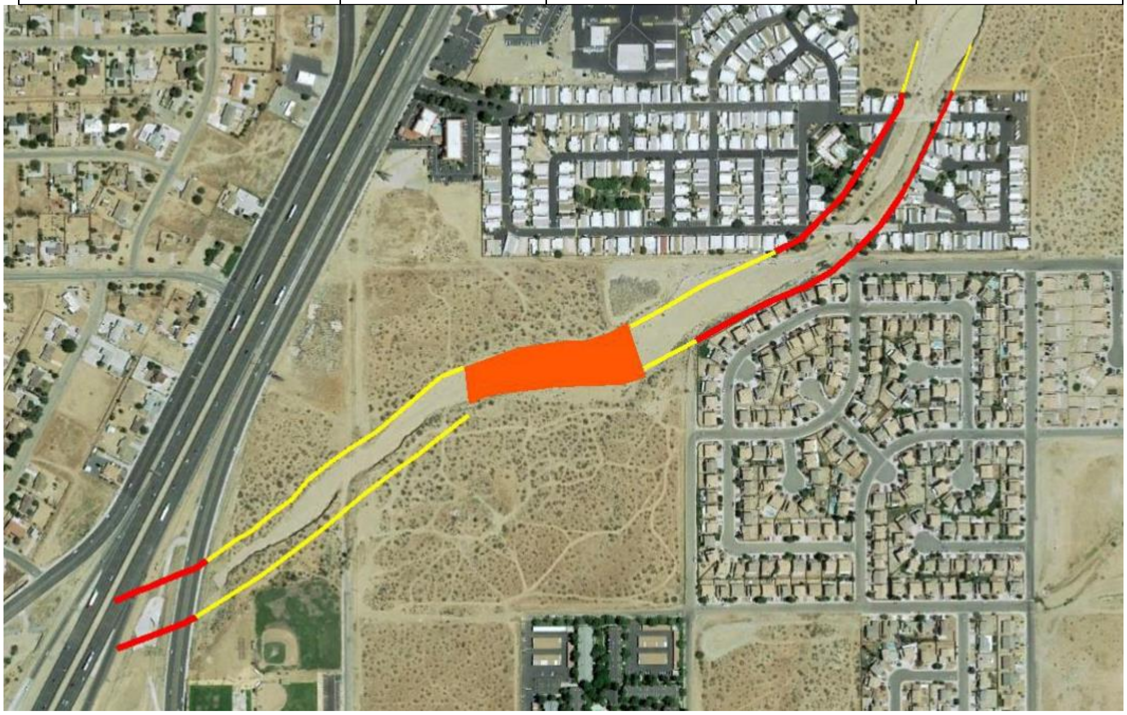


Figure 3.1: Stream Corridor Continuity diagram.

Using aerial imagery, the stream corridor is extended the average width of the AA 500 m upstream and 500 m downstream of the AA (yellow lines extending from orange polygon). In Figure 3.1 the red lines indicate the location of "non-buffer land covers" along the extended AA that break the stream corridor within this distance. A combination of housing developments and rip-rap walls lining the channel on the south and north side of the stream break the corridor continuity downstream, while a road culvert breaks the continuity upstream. The remainder of the yellow line does not have any breaks.

Table 3.2: Rating for Stream Corridor Continuity.

Rating	**For Distance of 500 m Upstream of AA:**	**For Distance of 500 m Downstream of AA:**
A	The combined total length of all non-buffer segments is less than 100 m.	The combined total length of all non-buffer segments is less than 100 m.
B	The combined total length of all non-buffer segments is less than 100 m.	The combined total length of all non-buffer segments is between 100 m and 200 m.
	OR	
	The combined total length of all non-buffer segments is between 100 m and 200 m.	The combined total length of all non-buffer segments is less than 100 m.
C	The combined total length of all non-buffer segments is between 100 m and 200 m.	The combined total length of all non-buffer segments is between 100 m and 200 m.
D	The combined total length of non-buffer segments is greater than 200 m.	any condition
	OR	
	any condition	The combined total length of non-buffer segments is greater than 200 m.

Metric 2: Buffer

Definition: The buffer is the area between the AA and its surrounding environment that helps protect it from anthropogenic stress (see Figure 3.2). The buffer is the area adjoining the AA that is in a natural or semi-natural state and is currently not dedicated to anthropogenic uses that would severely detract from its ability to entrap contaminants, discourage forays into the AA by people and non-native predators, or otherwise protect the AA from stress and disturbance. Areas adjoining the AA that probably do not provide protection are not considered buffers.

To be considered as buffer, a suitable land cover type (Table 3.3) must be at least 5 m wide starting at the edge of the AA extending perpendicular from the channel and extend along the perimeter of the AA (measured parallel to the channel) for at least 5 m. The maximum width of the buffer is 250 m. At distances beyond 250 m from the AA, the buffer becomes part of the landscape context.

Rationale. Buffers provide important benefits and services, including water quality improvement, stream bank stabilization, flood control, wildlife habitat, and groundwater recharge (USDA, 2006; Castelle et al., 1994; Wenger, 1999; Correll, 1996). Buffers can protect streams and wetlands by filtering pollutants, providing refuge for wildlife during times of high water levels, and acting as barriers to disruptive incursions by people and pets. Buffers can also reduce the risk of invasion by non-native plants and animals. Because regulation and protection of streams historically did not extend to adjacent uplands, these areas, in some cases, have been converted to recreational, agricultural, or other human land uses and might no longer provide their critical buffering functions.

Submetric A: Percent of AA with Buffer

Definition: This submetric is based on the positive relationship between the extent of buffer present and the functions provided, including habitat, water quality and other valuable functions.

B. Rationale. The ability of buffers to protect a stream increases with buffer extent along its perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions.

C. Seasonality. This metric is not sensitive to seasonality.

D. Office and Field Indicators. This submetric is scored by visually estimating from aerial imagery (with field verification) the percent of the AA that is surrounded by at least 5 meters of buffer land cover (Figure 3.2). The upstream and downstream edges of the AA are not included in this metric, only the edges parallel to the stream.

Figure 3.2: Percent of AA with Buffer for Episodic Riverine AAs

The blue line is the edge of the AA, the red lines indicate where there is no buffer or less than 5 meters of buffer adjacent to the AA, while the green line indicates where buffer is present. The north side of the AA directly adjoins a non-buffer development, and on the southwest side of the AA there is a fence less than 5 meters from the AA. In this example 48% of the AA has buffer.

Table 3.3: Guidelines for identifying buffers and breaks in buffers.

Examples of Land Covers Included in Buffers* Buffers can cross these land covers	**Examples of Land Covers Excluded from Buffers** Buffers do not cross these land covers
• at-grade bike and foot trails with light traffic • horse trails • natural upland habitats • nature or wildland parks • range land and pastures • railroads (with infrequent use: 2 trains per day or less) • roads not hazardous to wildlife, such as seldom used rural roads, forestry roads or private roads • swales and ditches • vegetated levees	• commercial developments • fences that interfere with the movements of wildlife (i.e. food safety fences that prevent the movement of deer, rabbits frogs, etc.) • intensive agriculture (row crops, orchards and vineyards) • golf courses • paved roads (two lanes or larger) • active railroads (more than 2 trains per day) • lawns • parking lots • horse paddocks, feedlots, turkey ranches, etc. • residential areas • sound walls • sports fields • urbanized parks with active recreation • pedestrian/bike trails (with heavy traffic)

Worksheet 3.2: Percent of AA with Buffer

In the space provided below, make a quick sketch of the AA, or perform the assessment directly on the aerial imagery; indicate where buffer is present, estimate the percentage of the AA perimeter providing buffer functions, and record the estimate amount in the space provided.

Percent with buffer ________________

Table 3.4: Rating for Percent of AA with Buffer.

Rating	Alternative States
A	Buffer is 75 - 100% of AA perimeter.
B	Buffer is 50 – 74% of AA perimeter.
C	Buffer is 25 – 49% of AA perimeter.
D	Buffer is 0 – 24% of AA perimeter.

Submetric B: Average Buffer Width

Definition: CRAM uses a fixed buffer maximum width of 250 m and fixed minimum width of 5 m. Average buffer width is assessed as the average length of eight straight lines that are drawn at regular intervals perpendicular to the AA from its perimeter outward to the nearest non-buffer land cover (see Figure 3.3), or 250 m (the maximum buffer width), whichever is first encountered. CRAM assumes that the functions of the buffer do not increase significantly beyond 250 mm, thus the maximum buffer width is set at 250 m. The minimum length of buffer along the perimeter of the AA is also set at 5 m. Any area that is less than 5 m wide and 5 m long is considered too small to be a buffer. See Table 3.3 above for more guidance regarding the identification of buffers for CRAM AAs.

Rationale. A substantial body of research exists that correlates buffer widths with stream function. A wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species, to reduce the inputs of non-point source contaminants, to control erosion, and to generally protect the wetland from human activities. Recommended widths for different stream functions range from as small as 3 m for bank stabilization and stream shading to 500 m or more for protection of certain types of wildlife habitat. CRAM errs on the conservative side by prescribing a maximum buffer width of 250 m to provide ample leeway for the buffer to accommodate multiple buffer functions.

Seasonality. This metric is not sensitive to seasonality.

Office and Field Indicators. See Table 3.3 for more guidance regarding the identification of buffer and non-buffer land cover types for CRAM AAs. The procedure has five steps as presented in Table 3.5 below.

Table 3.5: Steps to estimate Buffer Width for episodic riverine systems

Step 1	Identify areas in which open water is directly adjacent to the AA, with <5 m between the edge of the AA and the open water. **These areas are excluded from buffer calculations.**
Step 2	From the previous sub-metric, identify the areas that have buffer adjacent to the AA.
Step 3	For the area that has been identified as having buffer, draw straight lines 250 m in length perpendicular to the axis of the stream channel at regularly spaced intervals starting at the AA boundary. For one-sided riverine AAs, draw **four** lines; for AAs that include both sides of the stream draw **eight** lines (see Figure 6 below).
Step 4	Estimate the length of each of the lines as they extend away from the AA. Record these lengths on the Worksheet 3.2 in the accompanying document.
Step 5	Calculate the average buffer width. Record this width on the Worksheet 3.2.

Figure 3.3: Diagram of Average Buffer Width for Episodic Riverine AAs
Continuing with the example from above, draw 8 lines evenly distributed within the buffer (red lines indicate where no buffer is present). The lines end in this example when they encounter the road to the south.

Worksheet 3.3: Calculating average buffer width of AA

Line	Buffer Width (m)
A	
B	
C	
D	
E	
F	
G	
H	
Average Buffer Width *Round to the nearest integer*	

Table 3.6: Rating for average buffer width.

Rating	Alternative States
A	Average buffer width is 190 – 250 m.
B	Average buffer width 130 – 189 m.
C	Average buffer width is 65 – 129 m.
D	Average buffer width is 0 – 64 m.

Submetric C: Buffer Condition

Definition: CRAM assesses the condition of a buffer using three parameters: 1) the overall condition of its substrate, 2) the amount of human visitation, and 3) the quality of vegetation, if present. Buffer conditions are assessed only for the portion of the landscape that has **already been identified as having at least 5 m of buffer** (i.e., as in Figure 3.4). Thus, evidence of direct impacts (parking lots, buildings, etc.) by people are excluded from this metric, because these features are not included as buffer land covers; instead these impacts are included in the Stressor Checklist.

Rationale. The condition or composition of the buffer, in addition to its width and extent, determines the overall capacity of the buffer to perform its critical functions. Maintenance of buffers in their natural condition has been identified as one of the most effective means of protecting multiple outstanding resource values, including water quality, hydrology, unique species and natural communities, and watershed ecosystem function (Hawes and Smith 2005). For episodic systems, and intact buffer also provides continuity of hillslope derived sediment sources and the active floodplain. This promotes maintenance of geomorphic functions along the stream reach.

Seasonality. This metric is not sensitive to seasonality.

Office and Field Indicators. Buffer condition must be assessed in the field. Absence of recent substrate disturbance and absence of trash or debris are assumed to indicate good buffer conditions. For the purpose of assessing substrate condition in the buffer, no evidence of problems more than 3 years old should be considered. Narratives for Buffer Condition ratings are provided in Table 3.7. If there is no buffer present, assign a score of D.

Figure 3.4: Diagram of method to assess Buffer Condition for Riverine AAs

Continuing with the example from above, this submetric assesses the condition of the buffer only where it was found to be present in the two previous steps (the shaded area shown to the south of the AA).

Table 3.7: Rating for Buffer Condition

Rating	Alternative States
A	Buffer for AA has > 75% undisturbed substrate, is apparently subject to little or no human visitation, and if vegetation is present it is dominated by native species.
B	Buffer for AA is characterized by between 25% and 75% cover of mostly undisturbed substrate, is apparently subject to little or low impact human visitation, and if vegetation is present it is an intermediate mix of native and non-native species (25-75%).
C	Buffer for AA is characterized by substantial (>75%) cover of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation, and/or if vegetation is present it is characterized by substantial amounts of non-native species (>75%).
D	Buffer for AA is characterized by barren ground and/or highly compacted or otherwise disturbed soils, and/or there is evidence of very intense human visitation, or there is no buffer present.

Attribute 2: Hydrology

Hydrology is the most important direct determinant of stream and wetland function (Mitch and Gosselink 1993). It includes the sources, quantities, and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load. The physical structure of a stream is largely determined by the magnitude, duration, and intensity of water movement. Hydrology affects many other physical processes, including nutrient cycling, sediment entrapment, and pollution filtration, and constitutes a dynamic habitat template for associated plants and animals.

Metric 1: Water Source

Definition: Water sources directly affect the extent, duration, and frequency of the hydrological dynamics within an Assessment Area, and include direct inputs of water into the AA as well as any diversions of water from the immediate upstream watershed. Diversions influence water source because they directly affect the hydrologic regime of the AA. Inputs of water affecting conditions outside of episodic high flow events are especially important because they strongly influence the structure and composition of stream and wetland plant and animal communities. For example, urban and agricultural runoff that occurs outside of normal precipitation patterns can facilitate invasion by non-native animals and plants. The water source metric looks beyond the scale of the AA to the upstream watershed within about 2 km.

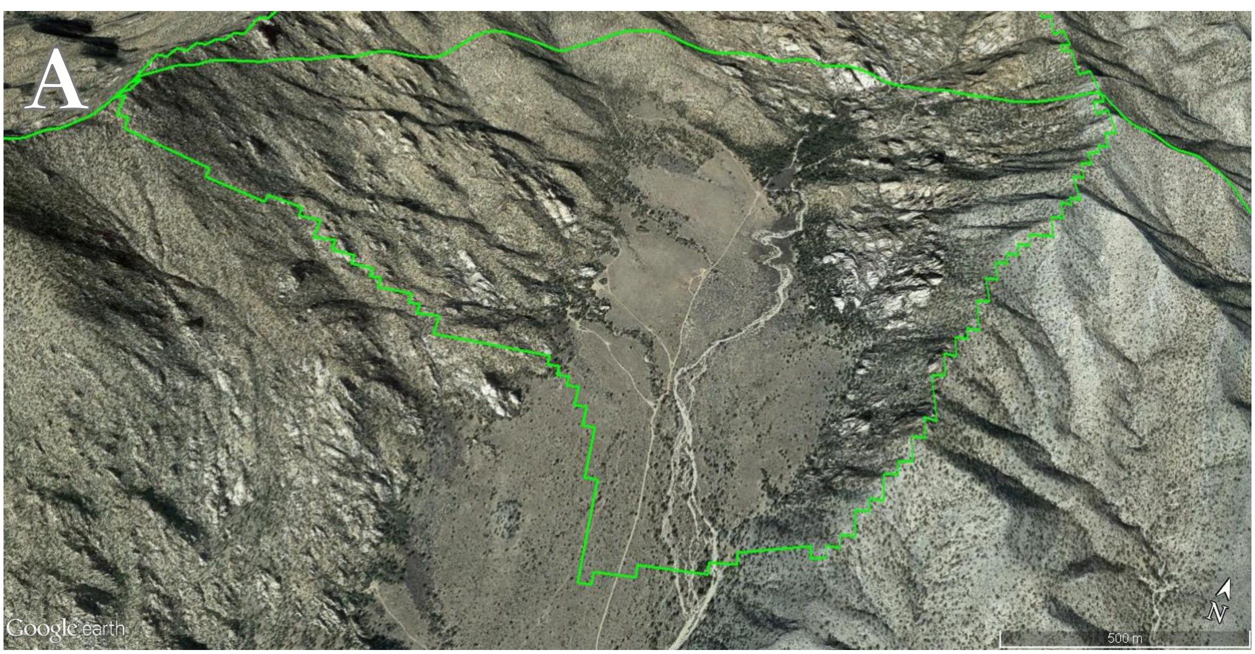
Rationale: Periodic inflows of water and sediment to streams are important to their ability to perform and maintain their intrinsic ecological, hydrological, and societal functions and services. The flow of water to a stream channel also affects its sedimentary processes, geo-chemistry, and basic physical structure. Although episodic streams do not flow continuously, they perform the same critical hydrologic functions as perennial streams: they move water, sediment, nutrients, and debris through the stream network and provide connectivity within the watershed (Levick et al. 2008).

Seasonality: This metric is not sensitive to seasonality.

Office and Field Indicators: The Water Source metric is concerned with *direct* sources of water and sediment to the AA and emphasizes the identification of the unnatural inputs or diversions of water and sediment that directly affect conditions of the AA. Direct, natural sources of water include precipitation, snow melt, groundwater, and seasonal stream flows. Examples of direct, unnatural inputs include urban storm drains that empty into the AA or into the watershed upstream, or irrigation runoff from agriculture. Landscape indicators of unnatural water inputs include adjacent intensive development, irrigated agriculture, and wastewater treatment discharge.

Scoring Instructions: To score this metric, use the aerial site imagery and any other information collected about the watershed to assess the water source to the AA within a 2 km area upstream (Figure 3.5). Topo maps or detailed watershed maps can be useful to determine the watershed area for a specific AA.

Engineered hydrological controls such as weirs, flashboards, grade control structures, check dams, etc., can serve to demarcate the boundary of an AA, but they don't affect the sources of water supplied to the AA. These features may temporarily impound water, but they are not the source of the water, and should not be considered in the assessment of this metric. In addition, large dams greater than 2 km upstream from the AA are not considered in this metric as these will have ubiquitous effects on broad geographic areas of the watershed of which the AA is a small part. However, the effects of land use, such as urbanization, on hydrologic dynamics in the immediate watershed containing the AA are considered in this metric because these can both increase the volume and intensity of runoff and reduce infiltration.



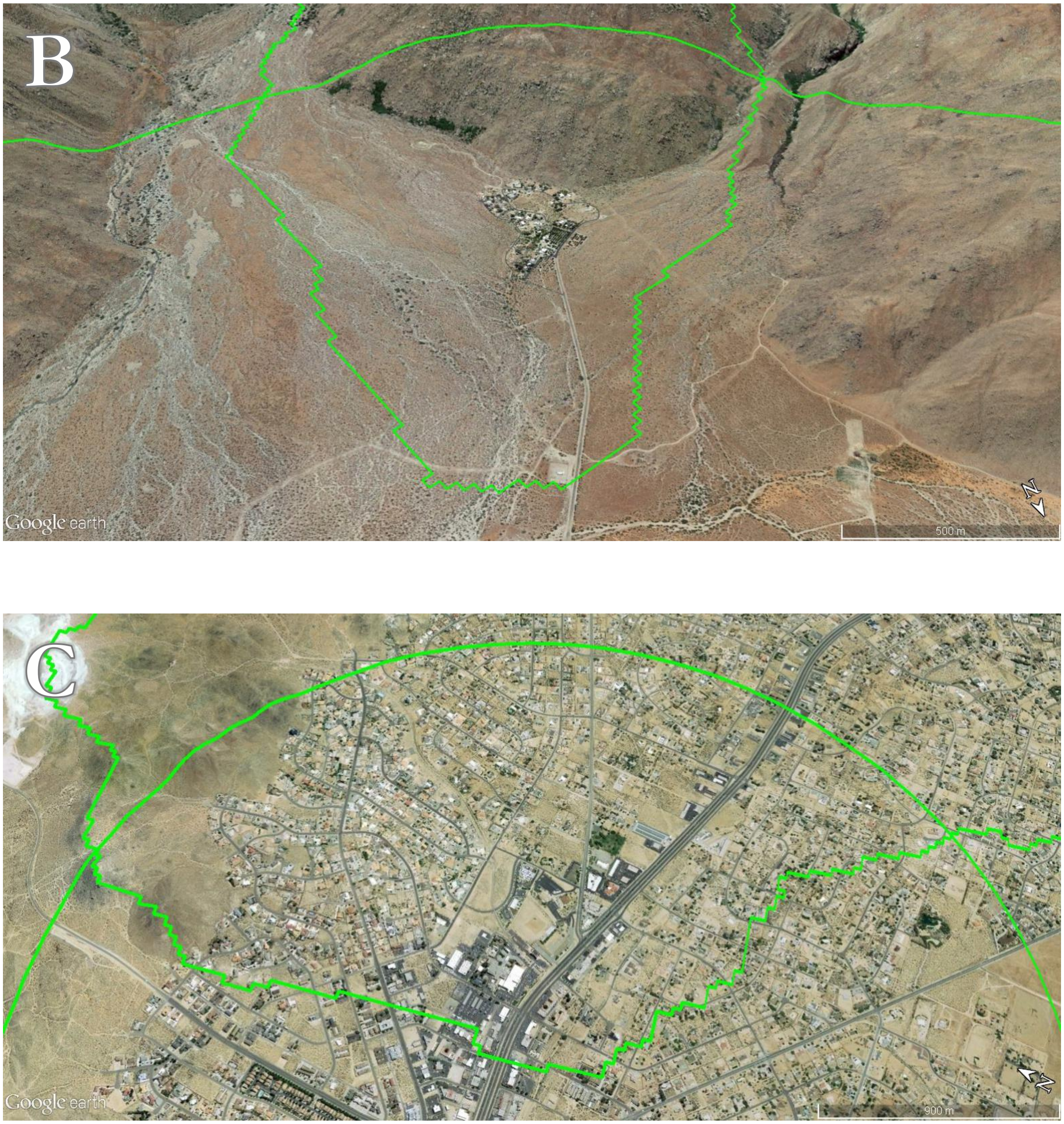


Figure 3.5: Water Source diagrams showing oblique views of the watersheds

The upstream watershed within 2 km is delineated by the green lines. Parts A, B, and C represent A, B, and C scores for this metric.

Table 3.8: Rating for Water Source.

Rating	Alternative States
A	Freshwater and sediment sources **that affect the condition of the AA,** by influencing flow characteristics or hydroperiod in the AA, are precipitation, snow melt, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body. There is **no indication** that conditions are substantially controlled by artificial water sources.
B	Freshwater and sediment sources that affect the condition of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology. Indications of such anthropogenic inputs include developed land or irrigated agricultural land that comprises **less than 20%** of the immediate drainage basin within about 2 km upstream of the AA, or that is characterized by the presence of a few small stormdrains or scattered homes with septic systems. No large point sources or dams control the overall hydrology of the AA.
C	Freshwater and sediment sources that affect the condition of the AA are primarily urban runoff, direct irrigation, pumped water, artificially-impounded water, water remaining after diversions, regulated releases of water through a dam, or other artificial hydrology. Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises **more than 20%** of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major point source discharges that obviously control the hydrology of the AA. OR Freshwater sources that affect the condition of the AA are **substantially controlled** by known diversions of water or other withdrawals directly from the AA or from its drainage basin.
D	Natural, freshwater and sediment sources that affect the condition of the AA have **been eliminated** based on the impoundment of all possible wet season inflows and diversion of all dry-season inflows.

Special Notes:

*To assist in determining a 2 km watershed area upstream from the AA, StreamStats (available at https://water.usgs.gov/osw/streamstats or www.ecoatlas.org) can be used to delineate an upstream catchment from a user-defined point on the stream network.

Metric 2: Sediment Transport

Definition: Sediment transport is the dominant process in episodic systems. Sediment behavior in response to water flow determines the channel form of an episodic stream and affects the potential for that channel to provide other ecosystem services.

Rationale: The pattern and balance of inflows and outflows of water and sediment is a major determinant of stream and wetland functions. The patterns of import, storage, and export of sediment and other water-borne materials can be altered by human actions or other perturbations to the system. In most systems, plant recruitment and maintenance are dependent on water and sediment flow. The interactions of sediment, geology, and topography are major determinants of the distribution and abundance of native plants and animals found within a system.

Special Considerations for Episodic Channels: The *effectiveness* (i.e., the relative capacity of flows to alter or "rework" a channel) of large, episodic floods in dryland climates is substantial. Channel features are frequently reworked. Episodic systems exhibit a rapid response to rainfall and tend to be shaped by high-magnitude flow events. The transitory nature of morphological features in these climates is further enhanced by generally less cohesive soils and poorly vegetated banks. These processes create a fabric of highly-varied, transient channel forms.

Hydrological modifications to episodic channels can concentrate flows, increase flood intensities, and increase sediment transport and erosion, although the effects of such modifications may not manifest for years or even decades until the next flash flood (Stein et al. 2011).

Natural sediment dynamics at high-quality reference sites vary depending on their position in the watershed. This metric measures the deviation from natural conditions and therefore must take into account the unique nature of episodic streams in different sections of their watersheds. In general, streams in the upper watershed are often single thread channels with steep gradients and extremely flashy flows. These streams are characterized by erosional processes and, under natural conditions, will perform much of the work of extracting sediment and moving it downstream. Anthropogenic alterations can disrupt these processes and cause aggradation in reaches that would otherwise be erosional. In other cases, streams in the upper watershed can respond to stress with incision, often leading to accelerated erosion and disconnecting streams from their past floodplains. Streams in the lower watershed are characterized by depositional processes. These streams are lower gradient, often braided, compound channels where continual aggradation and dynamic sediment processes are the norm. These systems can respond to impacts by widening and deepening the primary low-flow channel, up to the point where all secondary channels are subsumed into one wide main channel. This process is often termed *planform simplification*. Examples of features that impact episodic systems include impervious surfaces in the upstream watershed, channel hardening, artificial downstream grade changes, and general hydromodification.

Seasonality: Hydroperiod should be evaluated during the dry season.

Office and Field Indicators: This metric evaluates deviation from "least-disturbed" or reference condition. To evaluate departure from the reference condition, the practitioner looks at indicators of intact or altered sediment processes. These indicators are different for different types of episodic streams. To score this metric, visually survey the AA for field indicators of sediment transport, then assign a rating score using the alternative state descriptions in Table 3.10.

Table 3.9a: Field Indicators of Altered Sediment Transport for Multi-thread (typically lower watershed) Streams

Condition	Field Indicators (check all existing conditions)
Indicators of Natural Processes in Multi-thread Reaches	☐ There are distinct soil texture and grain size differences between different parts of the AA (e.g. the low-flow channel, floodplain, upper terrace, or other geomorphic surfaces) ☐ Braided compound channels ☐ High density of channels (3 or more low-flow and secondary channels within AA) ☐ The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area ☐ Channel bars consist of well-sorted bed material (smaller grain size on the top and downstream end of the bar, larger grain size along the margins and upstream end of the bar)
Indicators of Altered Sediment Transport in Multi-thread Reaches	☐ Planform simplification (previously braided channels appear to have coalesced into fewer channels or into one single channel) ☐ Low channel density (2 or less primary flow channels per AA) ☐ Soil texture and grain size differences between the low-flow channel and floodplain are not evident or distinctive ☐ An obvious historical floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation ☐ The channel bed appears scoured to bedrock or dense clay ☐ The channel has one or more knickpoints indicating headward erosion of the bed ☐ Channel bed and bars (if present) are not well-sorted, rather a homogenized mix of grain sizes or uniform grain size ☐ There is cement or rip-rap hardening the banks or bed of the channel(s)

Table 3.9b: Field Indicators of Altered Sediment Transport for Single-thread (typically upper watershed) Streams

Condition	Field Indicators (check all existing conditions)
Indicators of Natural Processes in Single-thread Reaches	☐ There are distinct soil texture and grain size differences between different parts of the AA (e.g. the low-flow channel, floodplain, upper terrace, or other geomorphic surfaces) ☐ The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area ☐ Channel bars consist of well-sorted bed material (smaller grain size on the top and downstream end of the bar, larger grain size along the margins and upstream end of the bar) ☐ Well-defined channel ☐ Regulated changes in stream gradient with natural grade control features (boulder steps, cobble rapids, etc.)
Indicators of Altered Sediment Transport in Single-thread Reaches	☐ The channel is characterized by steep or deeply undercut banks ☐ An obvious historical floodplain has recently been abandoned ☐ The channel bed appears scoured to bedrock or dense clay ☐ The channel has one or more knickpoints indicating headward erosion of the bed ☐ Soil texture and grain size differences between the low-flow channel and floodplain are not evident or distinctive ☐ The channel is nebulous or ill-defined ☐ Planform simplification (previously braided channels appear to have coalesced into fewer channels or into one single channel) ☐ There is cement or rip-rap hardening the banks or bed of the channel

Table 3.10: Rating table for Sediment Transport

Rating	Alternative State (based on the field indicators listed in the worksheet above)
A	Most of the channel through the AA is characterized by natural sediment processes, with little evidence of altered sediment transport. Based on the indicators of condition, typical sediment transport processes are occurring.
B	Most of the channel through the AA is characterized by some evidence of altered sediment transport, none of which is severe. Based on the indicators of condition, typical sediment transport processes are occurring, but the reach shows a trend toward excess transport or deposition due to moderate disequilibrium conditions.
C	There is evidence of severely altered sediment transport of most of the channel through the AA or the channel bed (and/or banks) is artificially hardened through less than half of the AA. Based on the indicators of condition, typical sediment transport processes are severely altered.
D	The channel bed and banks are concrete or otherwise artificially hardened through most of AA.

Metric 3: Hydrologic Connectivity

Definition: Hydrologic connectivity refers to the maintenance of natural hydrologic connections and sediment transfer routes. In dryland streams, this hydrologic connection may only occur episodically during flood pulses, yet it still provides important physical and biotic functions.

This metric assesses the maintenance of natural hydrologic connections of surface (and subsurface) flows and sediment movement between the hydrogeomorphic units (i.e., channels, floodplain, and upland terraces) of a stream system. This includes the ability of flows in channels to exceed the channel banks and flood adjacent areas. In addition, under natural conditions sediment transfer routes from adjacent hill slopes to the stream are not interrupted.

Rationale: Hydrologic connectivity between a channel and its adjacent areas promotes the exchange of water, sediment, nutrients, and organic carbon. Inputs of organic carbon are of great importance to ecosystem function. Litter and allochthonous input from adjacent uplands provides energy that subsidizes the aquatic food web (Roth et al. 1996). Connection between the channel and its floodplain promotes the import and export of water-borne materials, including nutrients. Linkages between aquatic and terrestrial habitats allow wetland-dependent species to move between habitats to complete life cycle requirements.

Seasonality: This metric is not sensitive to seasonality.

Field Indicators: This metric measures the degree to which the lateral movement of floodwaters or sediment delivery to the floodplain is artificially obstructed or restricted by anthropogenic features, such as engineered levees, armored or unnaturally steep banks, or other human-induced perturbations. This includes systems that appear to be severely entrenched or incised due to anthropogenic hydromodification upstream or downstream. This metric is assessed based on the potential for anthropogenic features to restrict or impede water, sediment, and debris mobilized on the hillslope from entering the stream, or water in the channel or channels from exceeding the banks and flooding adjacent areas. This metric is scored as the percent of the AA's lateral boundary (as determined at the time the AA was established) that is artificially obstructed or restricted by unnatural features such as levees, road grades, other infrastructure, or unnaturally steep banks. Use Table 3.11 to rate the hydrologic connectivity.

Table 3.11 Rating of Hydrologic Connectivity for Episodic Channels

Rating	Alternative States
A	Floodwaters from the low-flow channel have mostly unrestricted access to the floodplain and adjacent transition zones. Less than 10% of the boundary of the stream reach that contains the AA is artificially hardened or obstructed by features such as rip-rap, concrete banks, levees, unnaturally steep banks, or other anthropogenic structures.
B	The lateral movement of floodwaters from the low-flow channel to the floodplain and adjacent transition zones is restricted (e.g., artificially hardened or obstructed by features such as rip-rap, concrete banks, unnaturally steep banks, or levees) for 10-49% of the AA. These restrictions also impede sediment delivery from hillslope areas to the floodplain. Restrictions may be intermittent along margins of the stream that contains the AA, or they may occur only along one bank.
C	The lateral movement of floodwaters from the low-flow channel to the floodplain and adjacent transition zones is restricted (e.g., artificially hardened or obstructed by features such as rip-rap, concrete banks, unnaturally steep banks, or levees) for 50-90% of the AA. Restrictions may be intermittent as described above.
D	The lateral movement of floodwaters from the low-flow channel to the floodplain and adjacent transition zones (and sediment movement from hillslopes to the floodplain) is severely restricted (e.g., artificially hardened or obstructed by features such as rip-rap, concrete banks, unnaturally steep banks, or levees), for more than 90% of the AA.

Attribute 3: Physical Structure

Physical structure is defined as the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock 1999). The distribution and abundance of organisms in riverine systems are largely controlled by physical processes and the resulting physical characteristics of habitats.

Metric 1: Structural Patch Richness

Definition: Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, riparian, or terrestrial species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersion of the types.

Rationale: The richness of physical, structural surfaces and features in a stream reflects the diversity of physical processes, such as energy dissipation, water storage, and groundwater exchange, which strongly affect the potential ecological complexity of the system. Natural, physical complexity promotes natural, ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition.

Seasonality: This metric should be assessed in the dry season so that the stream bed is accessible, conditions are safe, and physical features are readily observable.

Field Indicators: Episodic flow and sediment movement produce transient channel forms that expand/contract laterally/longitudinally. This creates diverse and spatially variable physical habitats (Vyverberg 2010).

Scoring Instructions: This metric is scored using the Structural Patch Type Worksheet 3.4 for episodic channels, with the rating based on the total number of patch types relative to reference condition for these systems. Structural Patch Worksheet 3.4 is filled out by noting each of the patch types present in the AA. Table 3.12 is used to score the Structural Patch Richness Metric.

Patch Type Definitions for Episodic Channels:

Abundant wrack or organic debris in channel or on floodplain. Wrack is an accumulation of natural debris carried by wind or water. Organic debris includes loose fallen leaves, twigs, and seeds not yet transported by stream processes. This patch type does not include standing dead vegetation. The organic debris must be free of its original growth position. Senesced plant material that is still attached to the parent plant does not count as a patch type (for example, an annual grass thatch from the previous growing season).

Animal mounds and burrows. Many vertebrates make mounds or holes as a consequence of their foraging, denning, predation, or other behaviors. Animal mounds can include those made by invertebrates (ants, termites, etc.). The resulting soil disturbance (bioturbation) helps to redistribute soil nutrients and influence plant species composition and abundance. To be considered a patch type there should be evidence that a population of burrowing animals has occupied the Assessment Area. A single burrow or mound does not constitute a patch.

Bank slumps or undercut banks in channels. A bank slump is a portion of a bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank that have been excavated by flowing water. Undercut banks are created through the action of water, wind, and gravity, independent of whether the stream contains water year-round. Crevices and bank slumps can be especially prevalent along ephemeral stream banks and provide desert wildlife refuge from predators as well as critical protection from extreme heat and aridity.

Biotic or algal soil crusts. Biological crusts are soil communities of mosses, lichens, alga, fungi or cyanobacteria. They are typically found on fluvially-undisturbed surfaces and appear as soft, puffy, dark-colored growths (resembling popcorn). Biological soil crusts play a significant role in the process of formation, stability and fertility of soil, prevention of soil erosion caused by water or wind, augmentation of vascular plant colonization, and stabilization of sand dunes, especially in desert ecosystems.

Cobbles and boulders. Cobbles and boulders are rocks of different size categories. The intermediate axis of cobble ranges from about 6 cm to about 25 cm. A boulder is any rock having an intermediate axis greater than 25 cm. Exposed cobbles and boulders provide roosting habitat for birds and shelter for amphibians. They contribute to patterns of shade and light and air movement near the ground surface that affect local soil moisture gradients, deposition of seeds and debris, and overall substrate complexity.

Debris jams. A debris jam is an accumulation of driftwood and other flotage across a channel that partially or completely obstructs surface water flow and sediment transport, causing a change in the course of flow.

Coarse woody debris. A single piece of woody material, greater than 10cm in diameter and greater than 1 m long.

Pannes or pools on floodplain. A panne is a shallow topographic basin lacking vegetation. Pannes fill with water at least seasonally due to overland flow to form pools. In episodic systems these can be highly transient, but still provide temporary habitat.

Plant hummocks/sediment mounds/coppice dunes. Hummocks are mounds along the banks and floodplains of fluvial systems created by the collection of sediment and biotic material around plants. Sediment mounds are depositional features that lack plant cover and are formed from repeated flood flows depositing sediment on the floodplain. Coppice dunes are formed by the accumulation of wind-blown sand around and beneath vegetation. Hummocks, sediment mounds, and coppice dunes are typically less than 1m high.

Point bars and in-channel bars. Bars are sedimentary features within fluvial channels. They are patches of transient bedload sediment that can form along the inside of meander bends or in the middle of straight channel reaches. They sometimes support vegetation. They are convex in profile and their surface material varies in size from finer on top to larger along their lower margins. They can consist of any mixture of silt, sand, gravel, cobble, and boulders.

Pools or depressions in channels. Pools are areas along fluvial channels that are much deeper than the average depths of their channels and that tend to retain water longer than other areas of the channel during periods of low or no surface flow. When the channel is dry depressions are found in deeper parts of the channel, sometimes with evidence of prolonged water retention such as mud cracks, dried algae residue, or water marks.

Sand ripples. Ripples are sedimentary features formed in fine-grained sediments from the interaction a moving fluid (air or water) with a mobile substrate (mostly sand-size sediment). As current velocity (or wind) increases over the fine-grained substrata, the streambed is molded into a predictable succession of ripple like bed forms (often associated with dunes). Ripples are relatively small sedimentary features within the channel or floodplain.

Secondary channels on floodplain. Channels confine riverine flow and consist of a bed and its opposing banks. The systems of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of a primary (low-flow) channel that contains flowing water the most frequently and one or more secondary channels of varying sizes. Secondary channels (also known as overflow or high-flow channels) are usually topographically higher channels.

Standing snags. Tall, woody vegetation, such as trees and tall shrubs, can take many years to fall to the ground after dying. These standing "snags" provide habitat for many species of birds, small mammals, and invertebrates. Any standing, dead woody vegetation within the AA that is at least 3 m tall is considered a snag. These include cacti such as saguaro and pseudo-trees such as Joshua trees and palms.

Swales. Swales are broad, elongated, sometimes vegetated, shallow depressions that can sometimes help to convey flood flows to and from floodplains to channels. However, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. Swales that yield channel flow are important sources of water, sediment, nutrients, and other materials during runoff events.

Variegated, convoluted, or crenulated channel margins. As viewed from above, a stream channel can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated channel margin resembles a meandering pathway. Variegated channel margins provide greater contact between water and land. This can also be viewed on a scale smaller than the whole AA (2-3 m). Large boulders, exposed tree roots, and fallen vegetation along the margins can contribute to variegation.

Vegetated islands (exposed at high-water stage). An island is an elevated body of land that is periodically surrounded by and isolated from the upland landscape by water. The unique habitats they provide are defined and generally formed by the water that surrounds shapes, and interacts with them. Islands differ from hummocks and other mounds by being large enough to support trees and large shrubs, and high enough to be exposed at the high water stage. Indicators of inundation such as wrack lines, water marks, and fresh sediment deposits should not be present.

Water-cuts along channels. Water cuts are fluvial features that form along the inside margins of channels in a stair-step configuration to indicate fluctuating water levels, stream energy, and differential erodibility in substrates.

Worksheet 3.4: Structural Patch Types for Episodic Streams

Circle each patch type that is observed in the AA and enter the total number of observed patches. Multi- or single-thread characterization will determine which patches are expected in the system (indicated by a "1" in the table below).

STRUCTURAL PATCH TYPES (circle for presence)	**Episodic Riverine (Multi-thread)**	**Episodic Riverine (Single-thread)**
Minimum Patch Size	**3 m²**	**3 m²**
Abundant wrack or organic debris in channel or on floodplain	**1**	**1**
Animal mounds and burrows	**1**	**1**
Bank slumps or undercut banks in channels	**1**	**1**
Biotic/algal soil crusts	**1**	**1**
Cobbles and/or boulders	**1**	**1**
Debris jams	**1**	**1**
Coarse woody debris	**1**	**1**
Pannes or pools on floodplain	**1**	**1**
Plant hummocks and/or sediment mounds	**1**	**1**
Point bars and in-channel bars	**1**	**1**
Pools or depressions in channels (wet or dry channels)	**1**	**1**
Sand ripples	**1**	**1**
Secondary channels on floodplains	**n/a**	**1**
Standing snag	**1**	**1**
Swales	**1**	**1**
Variegated, convoluted, or crenulated channel margins (instead of broadly arcuate or mostly straight)	**1**	**1**
Vegetated islands (*exposed at high-water stage*)	**1**	**n/a**
Water-cuts	**1**	**1**
Total Possible	**17**	**17**
No. Observed Patch Types (enter here and use in Table 14 below)		

Special Notes:
**Physical patches can be natural or unnatural (artificial) in origin.*
** Any feature within the AA should only be counted once as a patch type. If a feature appears to meet the definition of more than one patch type (i.e. swale and secondary channel) the practitioner should choose which patch type best illustrates the feature. Not all features at a site will be patch types.*

Table 3.12: Rating of Structural Patch Richness

Rating	Multi-thread Episodic Riverine	Single-thread Episodic Riverine
A	≥ 12	≥ 9
B	9 – 11	7 – 8
C	6 – 8	5 – 6
D	≤ 5	≤ 4

Metric 2: Topographic Complexity

Definition: Topographic complexity refers to the micro- and macro-topographic relief and variety of elevations within a stream that affect moisture gradients, influence the path of flowing water, and mediate habitat.

Rationale: Topographic complexity promotes variable hydroperiods and resulting moisture gradients that, in turn, promote ecological complexity by increasing the spatial and temporal variability in energy dissipation, surface water dynamics, particulate matter detention, cycling of elements and compounds, and habitat dynamics. In dryland ephemeral channels, topographic gradients can affect habitats that can be occupied by both ephemeral and perennial vegetation, although this vegetation can be sparse.

Seasonality: This metric is not sensitive to seasonality.

Field Indicators: Macro-topographic relief refers to the presence of major breaks in slope along stream margins and in the stream channel or channels. Micro-topography is the surface relief created by the presence of physical features such as boulders or cobbles, partially buried woody debris, undercut banks, etc. Examples of topographic features used to score this metric include in-channel depressions, soil pits, sediment mounds, bars, debris jams, cobbles, boulders, slump blocks, tree-fall holes, plant hummocks, and sediment mounds. In dryland ephemeral channels, topographic features may be more diffuse, tend to be distributed randomly within the various floodplain units, and are not associated with any specific flow-event levels as in perennial streams (Curtis and Lichvar

2010). Major breaks in slope may be accompanied by distinct shifts in vegetation and dominant sediment size.

Scoring Instructions: At three locations along the AA, sketch the cross-section profile of the AA (by convention, the cross-section is depicted looking downstream). Draw the cross-section from the AA boundary down to its deepest area then back out to the other AA boundary. Try to capture the macro-topography (e.g., breaks in slope) and intervening micro-topographic relief. Label the location of the low-flow channel and flood plain units. Based on these sketches and the profiles in Figure 3.6a or 3.6b, choose a description in Table 3.13a or 3.13b that best describes the overall topographic complexity of the AA.

Worksheet 3.5: AA Topographic Complexity

Profile 1
Profile 2
Profile 3

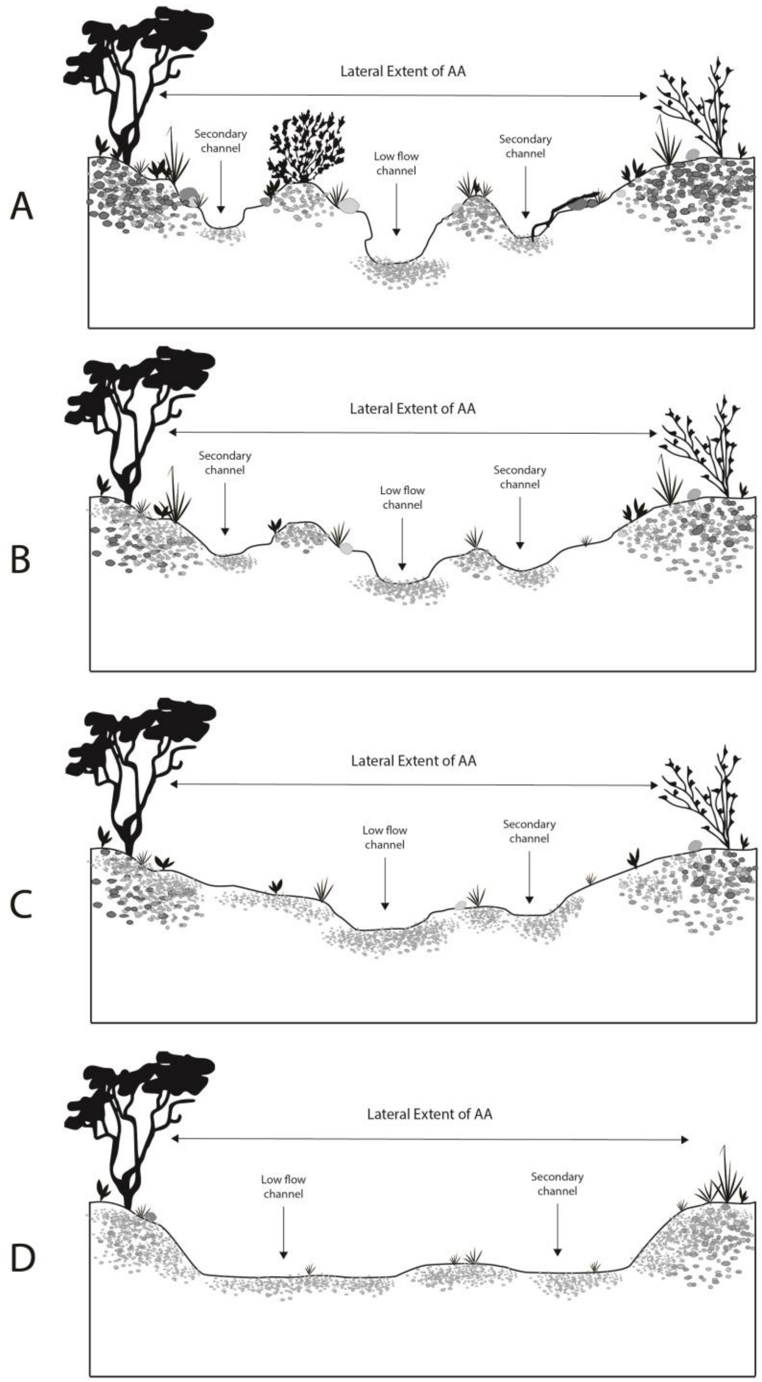


Figure 3.6a: MULTI-THREAD scale-independent schematic profiles of Topographic Complexity. Each profile A-D represents a characteristic cross-section through an AA. Use in conjunction with Table 3.13a to score this metric.

Table 3.13a: Rating of Topographic Complexity for MULTI-THREAD Episodic Channels

Rating	**Alternative States** (based on Worksheet 3.5 and diagrams in Figure 3.6 above)
A	AA, as viewed along a typical cross-section, has one or more distinct low-flow channel(s), and is nested within a braided network of numerous secondary channels. Macro-topographic relief is also found in a variety of slopes and gradients throughout the channels. There are a variety of sediment grain sizes, from silt and sand to larger cobbles and boulders. Surficial features such as islands, bars, boulders or cobbles, partially buried woody debris, undercut banks, secondary channels, debris jams, etc. contribute to abundant micro-topographic relief as illustrated in profile A.
B	AA, as viewed along a typical cross-section, has a distinct low-flow channel. The low-flow channel is still the dominant channel feature and secondary channels are present, but less numerous than as described for profile A. Macro-topographic relief such as a variety of slopes and gradients is present but less common than in the A profile. Surficial features are less distinct and varieties of surficial features are less numerous. Sediment grain size is still varied but less heterogenous. The AA resembles profile B.
C	AA, as viewed along a typical cross-section, has a very poorly defined low-flow channel and secondary channels are poorly developed. Macro-topographic relief such as a variety of slopes and gradients is uncommon or absent. Surficial features are generally absent (i.e., the channel surface is homogenous) and micro-topographic relief is limited. Sediment grain size is mostly homogenous. The AA resembles profile C.
D	AA, as viewed along a typical cross-section, is best characterized by uniform planar bed channels of homogenous substrate texture with no macro- or micro-topographic complexity (includes concrete channels). Sediment grain size is homogenous. The AA resembles profile D.

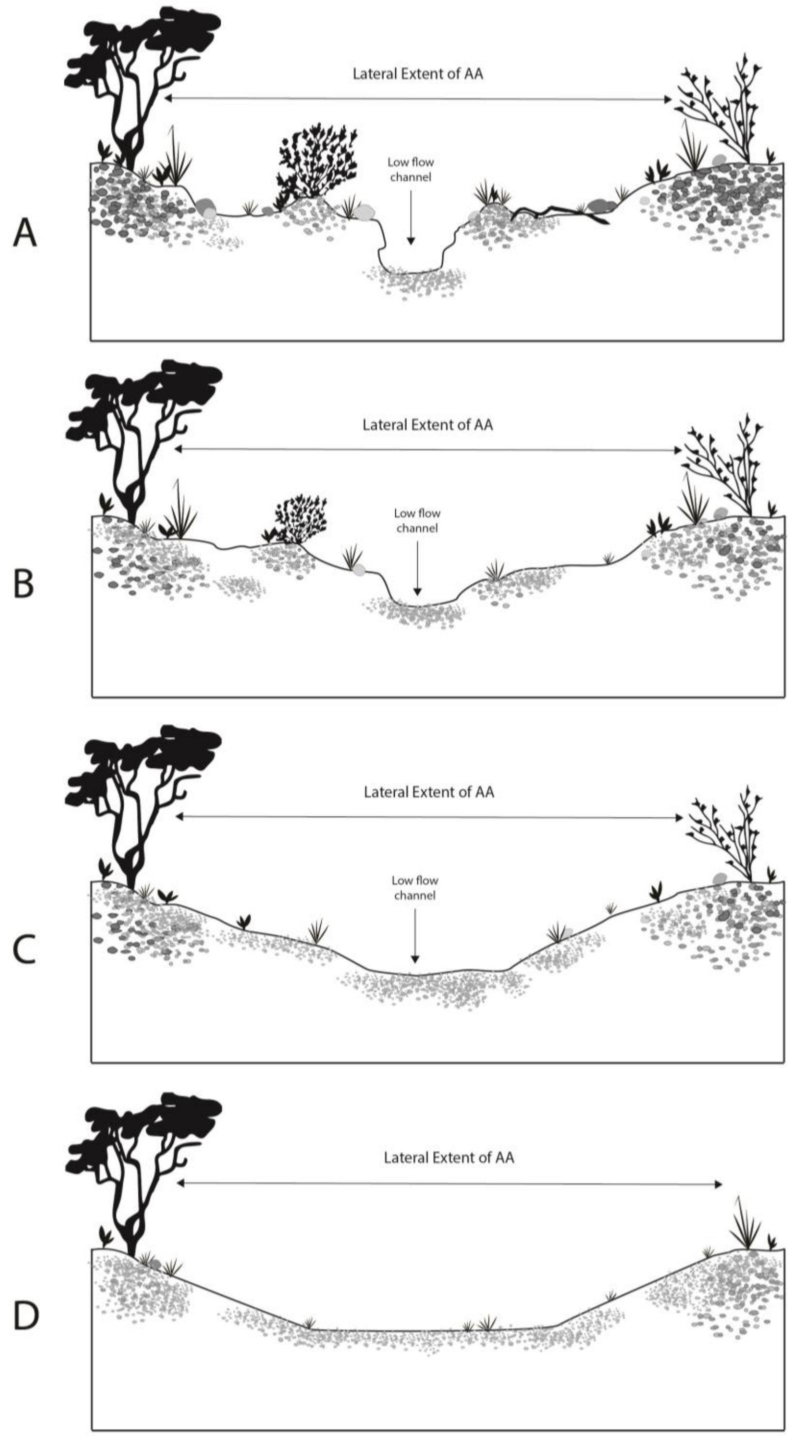


Figure 3.6b: SINGLE-THREAD scale-independent schematic profiles of Topographic Complexity. Each profile A-D represents a characteristic cross-section through an AA. Use in conjunction with Table 3.13b to score this metric.

Table 3.13b: Rating of Topographic Complexity for SINGLE-THREAD Episodic Channels

Rating	**Alternative States** (based on Worksheet 3.5 and diagrams in Figure 3.6 above)
A	Macro-topographic features such as floodplain surfaces, a variety of slopes, and changes in stream gradient are common throughout the AA. There are a variety of sediment grain sizes, from silt and sand to larger cobbles and boulders. Surficial features such as islands, bars, boulders or cobbles, partially buried woody debris, undercut banks, secondary channels, debris jams, etc. contribute to abundant micro-topographic relief as illustrated in profile A.
B	Macro-topographic features such as floodplain surfaces, a variety of slopes, and changes in stream gradient are present but are less common than in the A profile and may only be found in some parts of the AA. Sediment grain size is still varied but less heterogenous. Surficial micro-topographic features are less distinct and varieties of surficial features are less numerous compared to the A condition. The AA resembles profile B.
C	Macro-topographic features such as floodplain surfaces, a variety of slopes, and changes in stream gradient are uncommon or absent. Surficial features are generally absent (i.e., the channel surface is homogenous) and micro-topographic relief is limited. Sediment grain size is mostly homogenous. The AA resembles profile C.
D	AA, as viewed along a typical cross-section, is best characterized by a uniform planar bed channel of homogenous soil texture with no micro-topographic complexity (includes concrete channels). Sediment grain size is homogenous. The AA resembles profile D.

Attribute 4: Biotic Structure

Biotic Structure assesses plant communities that contribute to a stream's material structure and architecture. CRAM assesses Biotic Structure based on three metrics: 1) Plant Community, 2) Horizontal Interspersion, and 3) Vertical Biotic Structure.

Metric 1: Plant Community Metric

Definition: The Plant Community Metric is composed of three submetrics: Number of Plant Layers, Number of Co-dominant Plant Species, and Percent Invasion. For the purposes of CRAM, a "plant" is defined as an individual of any vascular macrophyte species of tree, shrub, herb, forb, grass, or fern, including non-native (exotic) plant species. Mosses and algae are <u>not</u> considered in the plant community metric.

Rationale: Vegetation strongly influences the quantity, quality, and spatial distribution of water and sediment within streams. Vascular plants associated with streams entrap suspended sediment, decrease water velocity, and function as habitat. Plant detritus is a main source of essential nutrients.

Although species-rich riparian plant communities and classic wetland zones may be absent, the vegetation associated with ephemeral episodic streams still provides important structural elements of food, cover, nesting and breeding habitat, and movement-migration corridors for wildlife that are not as available in adjacent uplands (Levick et al. 2008).

Seasonality: This metric should be assessed during the growing season, which varies geographically and depending on local site conditions.

Field Indicators: This metric requires the ability to identify the most common and abundant plant species present at a site. When a CRAM field team lacks the necessary botanical expertise, voucher specimens will need to be collected using standard plant presses and site documentation. A thorough reconnaissance of an AA is required to assess the Plant Community Metric.

<u>*Plant Community Submetric A: Number of Plant Layers Present*</u>

The first submetric of the Plant Community Metric is the Number of Plant Layers Present in the AA. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a specified height class. Layers are distinguished from one another by the differences in maximum heights of their associated plant species. To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer*. Although the layers might be found throughout all portions of the AA, they are not expected to occur in areas of exposed bedrock, active point bars, low-flow channels, etc.

It is essential that the layers be identified by the actual heights of plant species in the AA (i.e., the approximate maximum heights at the time of the assessment), regardless of the growth potential of the species. For example, a young desert willow sapling between 0.5 m and 1.5 m tall would belong to the "medium" layer, even though in the future the same individual tree might belong to the "Very Tall" layer. Some species might belong to multiple plant layers. For example, thickets of creosote bush (*Larrea tridentata*) of different age classes might be found in multiple height layers. The height of any individual vining plant, such as desert wild grape *(Vitis girdiana),* is determined by its current maximum growth. In the case of parasitic plants, such as desert mistletoe (*Phoradendron californicum*), its associated layer is determined by the height at which they are growing in their host tree or shrub, not the height of the plant itself.

Layer definitions:

Very Short Vegetation. This layer includes all vegetation that is less than 10 cm. in height. It can include young forms of species that grow taller. Vegetation that is naturally short in its mature stage includes very short annual grasses and species such as *Cryptantha* spp.*, Aristrida* spp.*,* and *Euphorbia* spp. (sandmat).

Short Vegetation. This layer ranges from 10 cm to 50 cm in height. It includes small plants that are naturally short in their mature stage, such as *Bromus madritensis ssp rubens* (red brome) and *Encelia farinosa* (brittlebush). It can also include young forms of species that grow taller.

Medium Vegetation. This layer ranges from 50 cm to 1.5 m in height. Examples of plants in this layer include *Ambrosia salsola* (cheeseweed)*, Ephedra* spp. (desert tea)*,* and *Larrea tridentata* (creosote bush).

Tall Vegetation. This layer ranges from 1.5 m to 2.5 m in height. It includes taller emergent plants and shrubs, and small trees. Examples include *Rhus ovata* (sugar bush), and *Senegalia gregii* (catclaw).

Very Tall Vegetation. This layer includes trees and shrubs (or any plants) that are greater than 2.5 m in height. Examples include *Chilopsis linearis* (desert willow), *Olneya tesota* (ironwood), and *Prosopis glandulosa.* (mesquite). Non-woody species that may occur in this layer may include *Fouquieria splendens* (ocotillo) and *Opuntia sp.* (prickly pear).

Scoring Instructions: Using the established plant layer heights for episodic CRAM, determine the layers that comprise at least 5% absolute cover of the portion of the AA that is suitable for supporting that plant layer. Assign scores as listed in Table 3.15.

Figure 3.7: Flow Chart to Determine Plant Community Submetrics

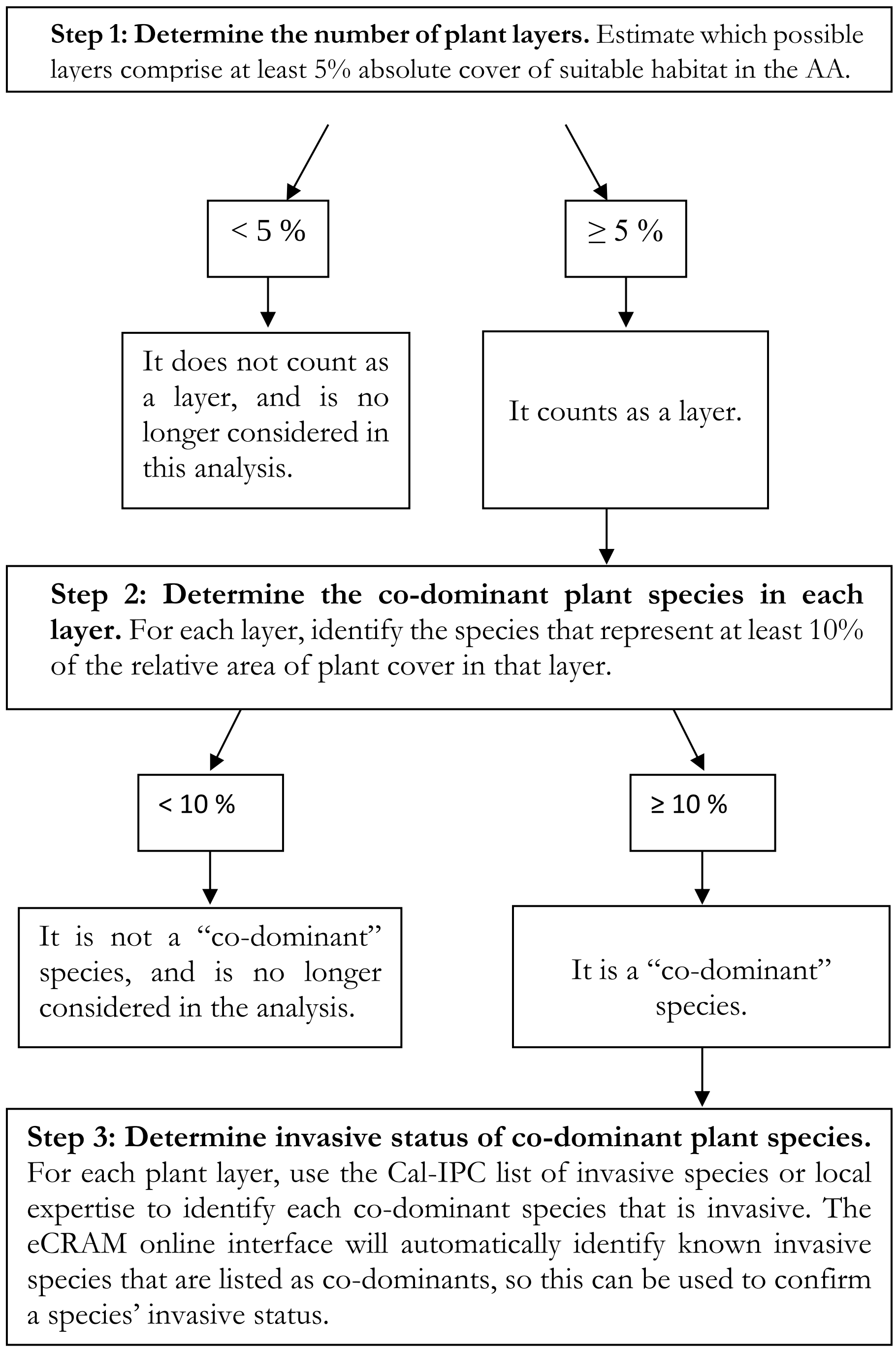


Table 3.14: Plant layer heights for all episodic riverine systems.

Channel Type	Plant Layers				
	Very Short	Short	Medium	Tall	Very Tall
Multi- and Single-thread Episodic Riverine	<0.1 m	0.1-0.5 m	0.5 – 1.5 m	1.5 – 2.5 m	> 2.5 m

Special Notes*:*

** Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present.*

**If the AA supports less than 5% plant cover and/or no plant layers are present (e.g. some concrete channels or agricultural ditches), automatically assign a score of "D" to the plant community metric.*

Plant Community Submetric B: Number of Co-dominant Species

For each plant layer identified in the AA, every species that comprises at least 10% relative cover within the layer is considered to be co-dominant in that layer, and should be recorded in the appropriate part of the Plant Community Metric Worksheet.

Scoring Instructions: List the names of all co-dominant plant species in each layer. Use this list to determine the total number of co-dominant species for all the layers that are represented in the AA. When identifying the total number of dominant species in an AA, count each species only once; do not count a species multiple times if it is found in more than one layer. Dead or senescent vegetation is disregarded in the scoring of this metric; only count living vegetation as a co-dominant. Assign scores as listed in Table 3.15.

Plant Community Submetric C: Percent Invasion

For the purposes of this sub-metric, "invasive" plants are defined as species that are non-native to the wildland ecosystems of California and have the potential to spread into these ecosystems. Invasive, non-native species can displace native species, hybridize with native species, alter biological communities, and alter ecosystem processes.

Non-native plant species are those that have been introduced to native wildland ecosystems after European contact as a direct or indirect result of human activity (Warner et al. 2003). Many of these non-native species are now "naturalized" in California, and may be widespread in occurrence. Naturalized plant species (if not considered invasive) can provide valuable buffering services for stream and wetland areas.

CRAM uses the California Invasive Plant Council (Cal-IPC, a non-regulatory advisory group) inventory to determine the invasive status of plants. While CRAM recommends use of the Cal-IPC inventory, it permits its *augmentation by regional experts*. If a co-dominant plant species is recognized to regionally pose an invasive threat, but is not included in the Cal-IPC list, it can still be considered invasive for the purposes of scoring this metric. If this is done, it should be noted in the Comments section of the Basic Information sheet.

Scoring Instructions. The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants; i.e., the number of invasive co-dominant invasive species in the AA divided by the number of all co-dominant species in the AA. Scoring is as shown in Table 3.15.

Worksheet 3.6: Plant Community Metric

A co-dominant species represents ≥10% relative cover.

Very Short (<0.1 m)	**Invasive?**	**Short (0.1-0.5 m)**	**Invasive?**
Medium (0.5-1.5 m)	**Invasive?**	**Tall (1.5 -2.5 m)**	**Invasive?**
Very Tall (>2.5 m)		**Total number of co-dominant species for all layers combined (enter here and use in Table 3.15)**	
		Percent Invasion *Round to the nearest integer* (enter here and use in Table 3.15)	

Special Notes:

* *Each plant species is only counted once when calculating the Number of Co-dominant Species and Percent Invasion submetric scores, regardless of the number of layers in which it occurs.*

Table 3.15: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
Multi-thread Episodic Riverine Wetlands			
A	≥ 4	≥ 6	0 – 15%
B	3	4 – 5	16 – 30%
C	2	2 – 3	31 – 45%
D	0-1	0 – 1	46 – 100%
Single-thread Episodic Riverine Wetlands			
A	≥ 4	≥ 7	0 – 15%
B	3	5 – 6	16 – 30%
C	2	3 – 4	31 – 45%
D	0-1	0 – 2	46 – 100%

Metric 2: Horizontal Interspersion

Definition: Horizontal interspersion is a measure the plant community organization of the AA in a two-dimensional plan view. Plant zones can be comprised of a single species or obvious multi-species associations that remain relatively constant in makeup throughout the AA and are arrayed along gradients of elevation, moisture, or other environmental factors.

Rationale: The existence of multiple plant zones indicates a well-developed plant community that is reflective of fluvial, sedimentary and bio-chemical processes. The amount of interspersion among these plant zones is indicative of the spatial heterogeneity of these processes. Richer native communities of plants and animals tend to be associated with greater zonation and more interspersion of the plant zones.

The vegetation associated with streams in semi-arid and arid regions is typically spatially heterogeneous. Distinct vegetation patch types can be distinguished on the basis of species composition, species dominance, or vegetation structure. Zonation typically occurs between fluvial surfaces with spatial distributions reflecting an adaptation to flooding.

Many plant species, including some community dominants, can occur in both the stream and adjacent upland habitats (Bloss and Brotherson 1979, Warren and Anderson 1985, Leitner 1987, McArthur and Sanderson 1992). For example, upland plants such as *Ambrosia* spp. *(*bursage*)* and *Larrea tridentata* (creosote bush) can occur on lower, middle, and upper parts of banks, but less-xeric species, such as *Chilopsis linearis* (desert willow) and *Acacia greggii* (catclaw acacia) are only found in the lower parts of larger, wetter washes, with upland species on the upper banks (Hupp and Osterkamp 1996).

Scoring: This metric is scored by assessing the number of distinct plant "zones" and the amount of edge (interspersion) between these zones. Each zone should comprise at least 5% of the AA. An "A" condition means BOTH more zones AND a greater degree of interspersion, and the departure from the "A" condition is proportional to BOTH the reduction in the numbers of zones AND their interspersion. A zone may include groups of species of multiple height categories; however, this metric is not based on the layers established in the Plant Community Submetric A. Plant zones are defined by a relatively unvarying combination of growth form and species composition. Think of each plant zone as a vegetation complex of relatively non-varying composition extending from the top of the tallest vegetation present at the site down to ground level.

Seasonality: This metric should be assessed during the growing season.

Worksheet 3.7: Horizontal Interspersion

Use the spaces below to make a quick sketch of the AA in plain view. It is helpful to first label the major hydrogeomorphic units present, and then identify major plant zones (this should take no longer than 10 minutes). Label the zones and record them on the right. Each zone should comprise at least 5% of the AA. Based on the sketch, choose a single profile from Figure 3.8 that best represents the AA overall.

	Assigned zones: ***1)*** ***2)*** ***3)*** ***4)*** ***5)***

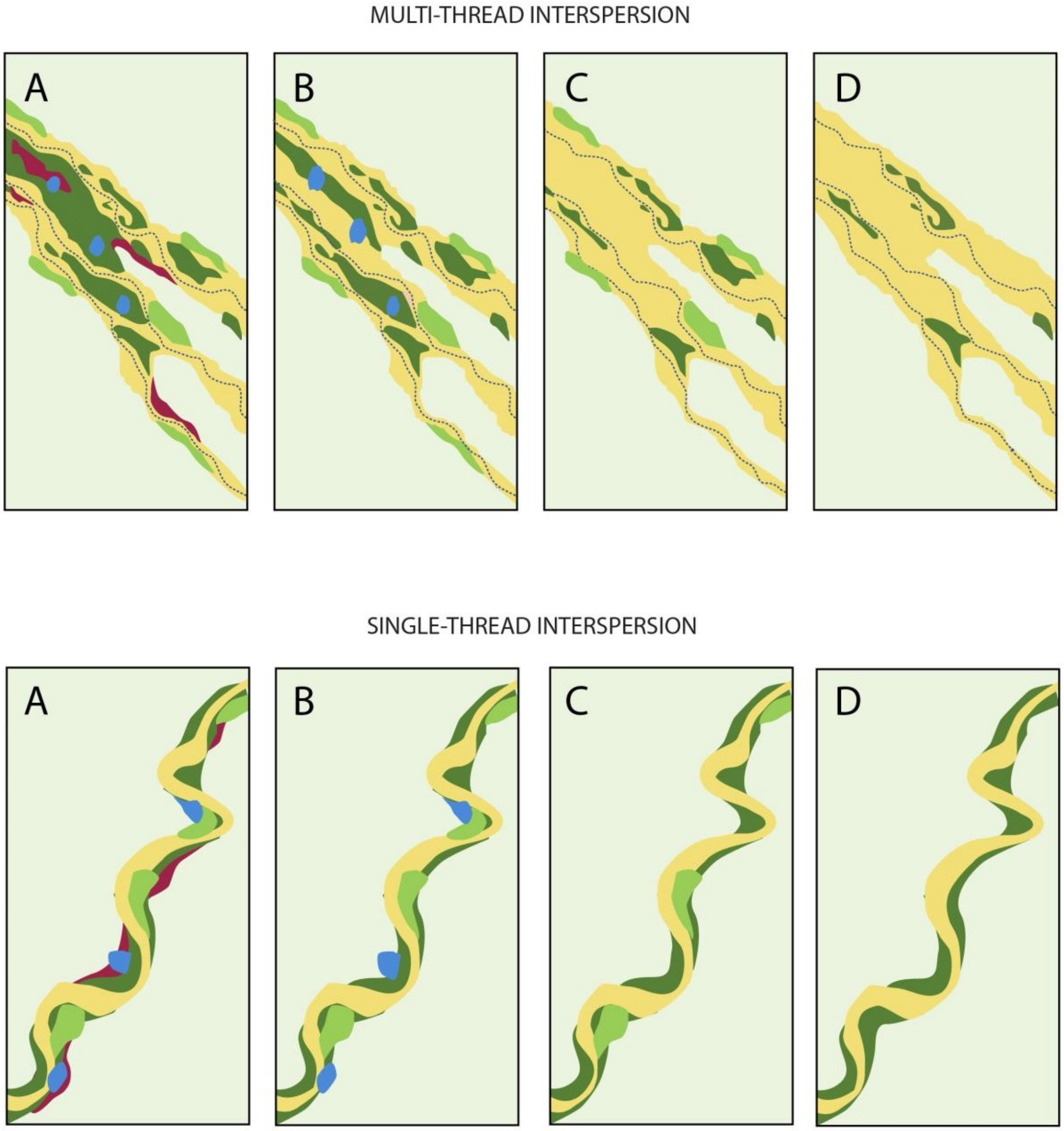


Figure 3.8: Horizontal Interspersion Diagrams.

Schematic diagrams illustrating varying degrees of interspersion of plant zones for compound episodic channels. Each plant zone must comprise at least 5% of the AA. The first row represents multi-thread channels, while the second row represents single-thread channels. Each color represents a unique plant zone or feature, and the beige background represents upland areas that are part of the buffer and not included in the AA. Dotted lines represent the locations of distinct low-flow and secondary channels within the AA.

Special Note:

**When assessing this metric, it is helpful to first map the hydrogeomorphic units (low-flow channel, active floodplain with secondary channels, and upper terrace), and then assign names of plant species or associations of species associated with these zones. Include the presence of terrace islands and other major geomorphic features as well as bare ground.*

Table 3.16: Rating of Horizontal Interspersion for Riverine AAs.

Rating	**Alternative States** (based on Worksheet 3.7 drawings and Figure 3.8)
A	AA has a high degree of plan-view interspersion.
B	AA has a moderate degree of plan-view interspersion.
C	AA has a low degree of plan-view interspersion.
D	AA has minimal plan-view interspersion.

Metric 3: Vertical Biotic Structure

Definition: The vertical component of biotic structure assesses the degree of overlap among plant layers. The same plant layers used to assess the Plant Community Composition Metrics are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer.

Rationale: The overall ecological diversity of a stream tends to correlate with the vertical complexity of the vegetation. Overlapping layers of vegetation contribute to vertical gradients in light and temperature that result in greater species diversity of macroinvertebrates, amphibians, and birds. In riparian areas, the species richness of birds and small mammals tends to increase with the density and number of well-developed, overlapping plant layers. Multiple layers of vegetation also enhance hydrological functions, including rainfall interception, reduced evaporation from soils, and enhanced filtration of floodwaters. Although structurally complex riparian canopies with intricately interdigitated plant layers are mostly lacking in dryland ephemeral streams, the vegetation associated with these systems still provides important structural elements of cover, nesting and breeding habitat, and movement-migration corridors for wildlife that are not as available in the adjacent uplands (Levick et al. 2008).

Seasonality: This metric should be assessed during the growing season.

Field Indicators: Plant layers for this metric are determined in the same way as defined in the Plant Community Metric. Only the maximum height of any vegetation should be used to determine the plant layer to which it belongs. For example, although a tall tree might span the entire range of all the layers, it can only represent one layer, based on its overall height. Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen plants are not lifted into a vertical position as evidence of plant height.

Scoring Instructions: Using the same plant layers identified from the Plant Community Composition metric, use the following worksheet and figures to assess the Vertical Biotic Structure metric.

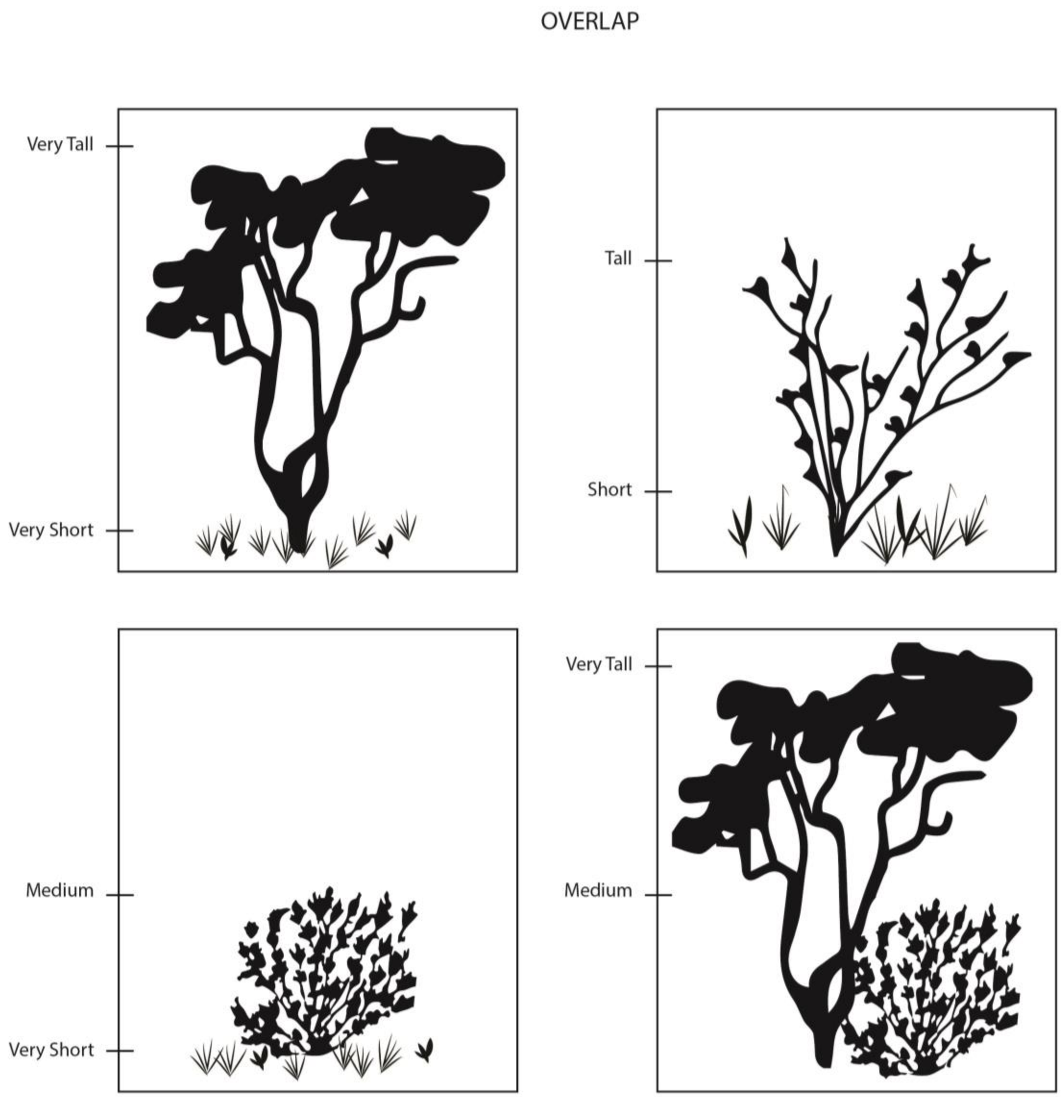


Figure 3.9: Vertical Structure plant overlap examples.

These are stylized diagrams of example scenarios that illustrate the concept of vertical overlap of plant layers for Episodic CRAM Riverine AAs. Many additional combinations of layer overlap exist.

Special Notes:

**This metric assesses the vegetated area of the AA, and disregards areas that are unvegetated*

Table 3.17: Rating of Vertical Biotic Structure for Episodic Riverine AAs

Rating	Alternative States
A	More than 25% of the vegetated area of the AA supports overlap of 2 or more plant layers.
B	10 – 25% of the vegetated AA supports overlap of 2 or more plant layers.
C	1 – 10% of the vegetated AA supports overlap of 2 or more plant layers.
D	There is less than 1% overlap and the AA is sparsely vegetated overall.

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APPENDIX A: GUIDELINES TO COMPLETE THE STRESSOR CHECKLIST

Definition: A stressor, as defined for the purposes of the CRAM, is an anthropogenic perturbation within a stream, wetland or their environmental setting that is likely to negatively impact the condition and function of the CRAM Assessment Area (AA). A disturbance is a natural phenomenon that affects the AA.

There are four underlying assumptions of the Stressor Checklist: (1) deviation from the best achievable condition can be explained by a single stressor or multiple stressors acting on the wetland; (2) increasing the number of stressors acting on the wetland causes a decline in its condition (there is no assumption as to whether this decline is additive (linear), multiplicative, or is best represented by some other non-linear mode); (3) increasing either the intensity or the proximity of the stressor results in a greater decline in condition; and (4) continuous or chronic stress increases the decline in condition.

Major episodic disturbances, such as very large storms, landslides, earthquakes, or anthropogenic stressor events, such as sudden reservoir drawdown and toxic spills, can significantly alter the form, structure, and even the location of a riverine system. Over time, the system will adjust both physically and ecologically to such episodic perturbations. Repeated use of CRAM at perturbed sites will help document their responses. The completed stressor checklist will also provide insight into the source of lower scores following episodic events.

The process to identify stressors is the same for all stream types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

Worksheet A.1: Wetland disturbances and conversions

Has a major disturbance or episodic event occurred at this site?	Yes	No		
If yes, was it a flood, fire, landslide, or other?	flood	fire	landslide	other
If yes, then how severe is the disturbance?	likely to affect site next 5 or more years	likely to affect site next 3-5 years	likely to affect site next 1-2 years	
Has this site been converted from another type? If yes, then what was the previous type?	Perennial non-confined riverine	Perennial confined riverine	Episodic ephemeral	

Worksheet A.2: Stressor Checklist

HYDROLOGY ATTRIBUTE (WITHIN 50 M OF AA)	Present	Significant negative effect on AA
Point Source (PS) discharges (POTW, other non-stormwater discharge)		
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)		
Flow diversions or unnatural inflows		
Dams (reservoirs, detention basins, recharge basins)		
Flow obstructions (culverts, paved stream crossings)		
Weir/drop structure, tide gates		
Dredged inlet/channel		
Engineered channel (riprap, armored channel bank, bed)		
Dike/levees		
Groundwater extraction		
Ditches (borrow, agricultural drainage, mosquito control, etc.)		
Actively managed hydrology		
Comments		

PHYSICAL STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present	Significant negative effect on AA
Filling or dumping of sediment or soils **(N/A for restoration areas)**		
Grading/ compaction **(N/A for restoration areas)**		
Plowing/Discing **(N/A for restoration areas)**		
Resource extraction (sediment, gravel, oil and/or gas)		
Vegetation management		
Excessive sediment or organic debris from watershed		
Excessive runoff from watershed		
Nutrient impaired (PS or Non-PS pollution)		
Heavy metal impaired (PS or Non-PS pollution)		
Pesticides or trace organics impaired (PS or Non-PS pollution)		
Bacteria and pathogens impaired (PS or Non-PS pollution)		
Trash or refuse		
Comments		

BIOTIC STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	**Present**	**Significant negative effect on AA**
Mowing, grazing, excessive herbivory (within AA)		
Excessive human visitation		
Predation and habitat destruction by non-native vertebrates (e.g., *Virginia opossum* and domestic predators, such as feral pets)		
Tree cutting/sapling removal		
Removal of woody debris		
Treatment of non-native and nuisance plant species		
Pesticide application or vector control		
Biological resource extraction or stocking (fisheries, aquaculture)		
Excessive organic debris in matrix (for vernal pools)		
Lack of vegetation management to conserve natural resources		
Lack of treatment of invasive plants adjacent to AA or buffer		
Comments		

BUFFER AND LANDSCAPE CONTEXT ATTRIBUTE (WITHIN 500 M OF AA)	**Present**	**Significant negative effect on AA**
Urban residential		
Industrial/commercial		
Military training/Air traffic		
Dams (or other major flow regulation or disruption)		
Dryland farming		
Intensive row-crop agriculture		
Orchards/nurseries		
Commercial feedlots		
Dairies		
Ranching (enclosed livestock grazing or horse paddock or feedlot)		
Transportation corridor		
Rangeland (livestock rangeland also managed for native vegetation)		
Sports fields and urban parklands (golf courses, soccer fields, etc.)		
Passive recreation (bird-watching, hiking, etc.)		
Active recreation (off-road vehicles, mountain biking, hunting, fishing)		
Physical resource extraction (rock, sediment, oil/gas)		
Biological resource extraction (aquaculture, commercial fisheries)		
Comments		