California Rapid Assessment Method for Wetlands

Riverine Wetlands Field Book

ver. 6.0

March 2012

Basic Information Sheet: Riverine Wetlands

CRAM Site ID:	
Project Site ID:	
Assessment Area Name:	

Project Name:		**Date (m/d/y)**			

Assessment Team Members for This AA:

Average Bankfull Width:

Approximate Length of AA (10 times bankfull width, min 100 m, max 200 m)**:**

Upstream Point Latitude: **Longitude:**

Downstream Point Latitude: **Longitude:**

Wetland Sub-type:

            Confined   Non-confined

AA Category:

Restoration   Mitigation   Impacted   Ambient   Reference   Training

Other:

Did the river/stream have flowing water at the time of the assessment?   yes   no

What is the apparent hydrologic flow regime of the reach you are assessing?

The hydrologic flow regime of a stream describes the frequency with which the channel conducts water. *Perennial* streams conduct water all year long, whereas *ephemeral* streams conduct water only during and immediately following precipitation events. *Intermittent* streams are dry for part of the year, but conduct water for periods longer than ephemeral streams, as a function of watershed size and water source.

            perennial   intermittent   ephemeral

Photo Identification Numbers and Description:

	Photo ID No.	Description	Latitude	Longitude	Datum
1		Upstream			
2		Middle Left			
3		Middle Right			
4		Downstream			
5					
6					
7					
8					
9					
10					

Site Location Description:

Comments:

Scoring Sheet: Riverine Wetlands

AA Name:				(m/d/y)			
Attribute 1: Buffer and Landscape Context				**Comments**			

	Alpha.	Numeric			
Aquatic Area Abundance Score (D)					
Buffer:					
Buffer submetric A: Percent of AA with Buffer	Alpha.	Numeric			
Buffer submetric B: Average Buffer Width					
Buffer submetric C: Buffer Condition					
Raw Attribute Score = D+[C x (A x B)½]½ (use numerical value to nearest whole integer)				**Final Attribute Score = (Raw Score/24) x 100**	

Attribute 2: Hydrology					
	Alpha.	Numeric			
Water Source					
Channel Stability					
Hydrologic Connectivity					
Raw Attribute Score = sum of numeric scores				**Final Attribute Score = (Raw Score/36) x 100**	

Attribute 3: Physical Structure					
	Alpha.	Numeric			
Structural Patch Richness					
Topographic Complexity					
Raw Attribute Score = sum of numeric scores				**Final Attribute Score = (Raw Score/24) x 100**	

Attribute 4: Biotic Structure					
Plant Community Composition (based on sub-metrics A-C)					
	Alpha.	Numeric			
Plant Community submetric A: Number of plant layers					
Plant Community submetric B: Number of Co-dominant species					
Plant Community submetric C: Percent Invasion					
Plant Community Composition (*average of submetrics A-C rounded to nearest whole integer*)					
Horizontal Interspersion					
Vertical Biotic Structure					
Raw Attribute Score = sum of numeric scores				**Final Attribute Score = (Raw Score/36) x 100**	

Overall AA Score (average of four final Attribute Scores)	

Identify Wetland Type
Figure 1: Flowchart to determine wetland type and sub-type.
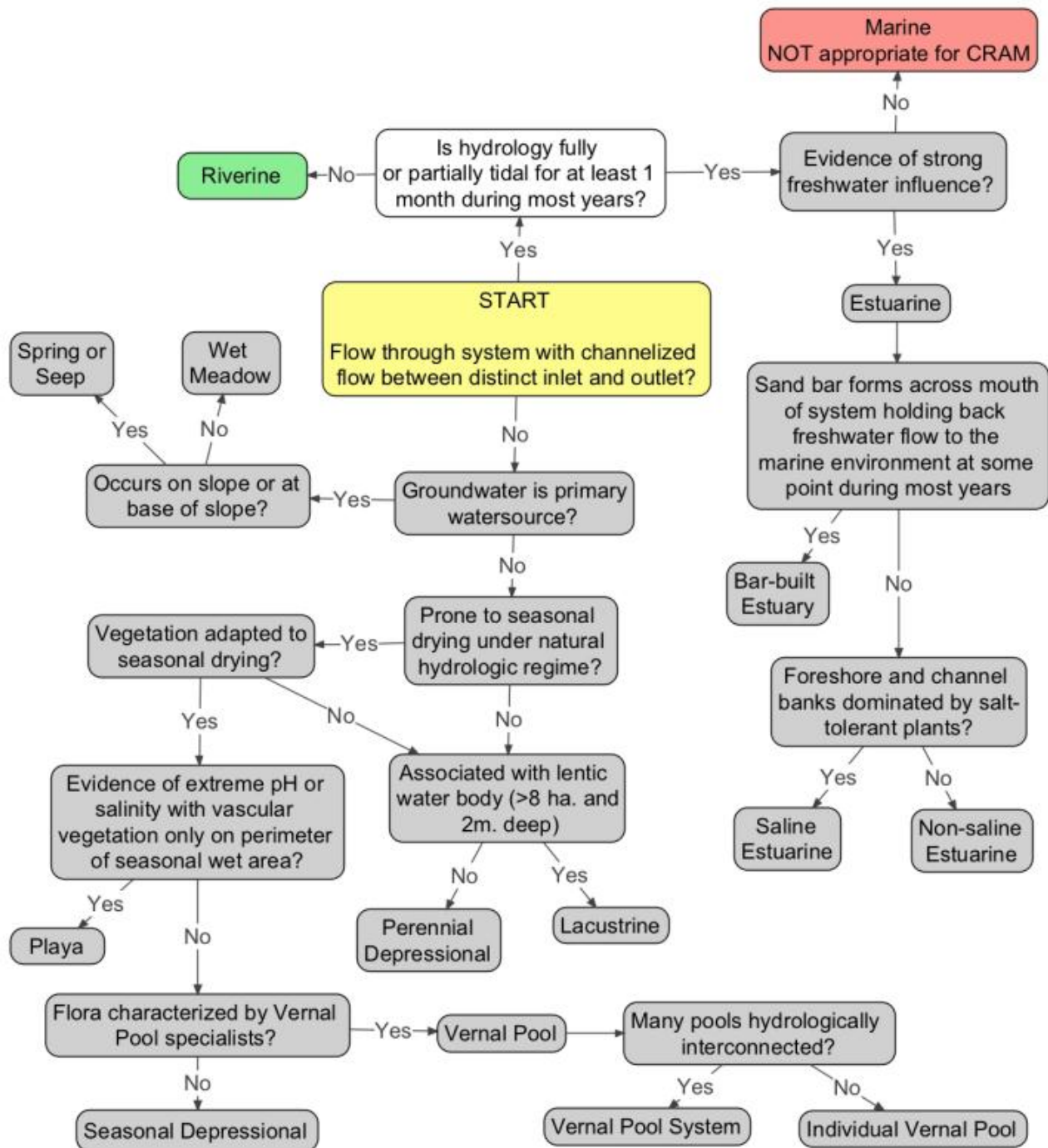
Riverine Wetlands (Including Closely Associated Riparian Areas)

A riverine wetland consists of the riverine channel and its active floodplain, plus any portions of the adjacent riparian areas that are likely to be strongly linked to the channel and immediate floodplain through bank stabilization and allochthonous organic material (productivity) inputs. An active floodplain is defined as the relatively level area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc. The water level that corresponds to incipient flooding can vary depending on flow regulation and whether the channel is in equilibrium with water and sediment supplies. Under equilibrium conditions, the usual high water contour that marks the inboard margin of the floodplain (i.e., the margin nearest the thalweg of the channel) corresponds to the height of bankfull flow, which typically has a recurrence interval of about 1.5 to 2.0 years under mesic climate conditions. The active floodplain can include broad areas of vegetated and non-vegetated bars and low benches among the distributaries of deltas and braided channel systems. The active floodplain does not include terraces that are geomorphologically disconnected from channel-forming processes, although riparian areas along terrace margins may be included as part of the floodplain. Vegetated wetlands can develop along the channel bottoms of intermittent and ephemeral streams during the dry season. Dry season assessment in these systems therefore includes the channel beds. However, the channel bed is excluded from the assessment when it contains non-wadeable flow. To help standardize the assessment of riverine wetlands, the assessments should be restricted to the dry season.

There may be a limit to the applicability of this module in low order (i.e., headwater) streams, in very arid environments, and in desert streams that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple riverine systems. In addition, this module is has limited application in river reaches with extremely broad floodplains, such as those which occur where large rivers occupy valleys with very low channel slopes, or near coastal embayments or the ocean, unless the extent of the floodplain included in the Assessment Area is limited to an area less than about two times bankfull width on each side of the channel (see below).

Riverine wetlands are further classified as confined or non-confined, based on the ratio of valley width to channel bankfull width (see Figure 2 below). Channels can also be entrenched, based on the ratio of flood prone width to bankfull width (Figure 2 below). Entrenchment affects hydrologic connectivity. A channel can also be considered confined by artificial levees and urban development if the average distance across the channel at bankfull is more than half the distance between the levees or more than half the width of the non-urbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development, or that levee breaches will be repaired.
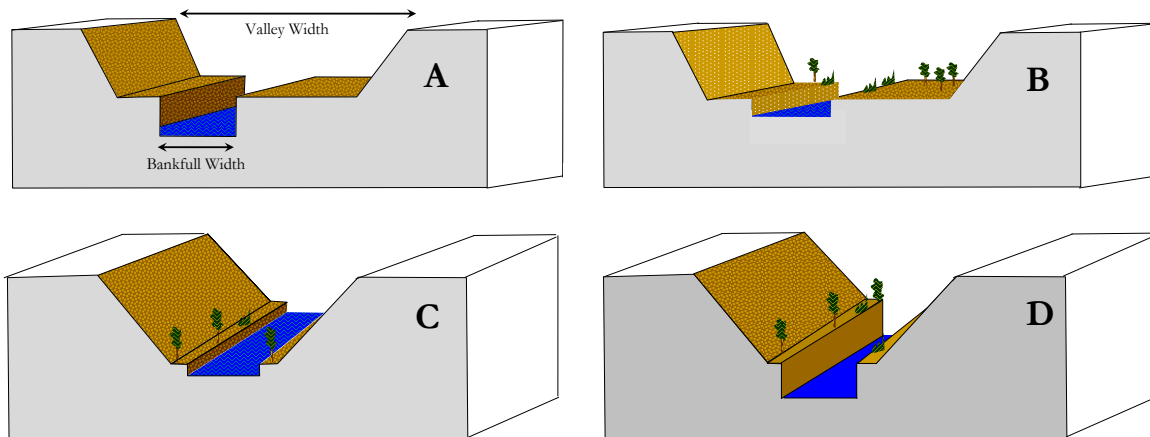
Figure 2: Illustrations of alternative conditions of riverine confinement and entrenchment. (A) non-confined, entrenched, (B) non-confined, not entrenched, (C) confined, not entrenched, and (D) confined, entrenched riverine.

Non-confined Riverine Sub-type:

In non-confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, or other feature that is likely to prevent further migration is **at least twice** the average bankfull width of the channel. Non-confined riverine systems typically occur on alluvial fans and plains, deltas in lakes, and along broad valleys.

Confined Riverine Sub-type:

In confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, man-made levee, or urban development is **less than twice** the average bankfull width of the channel.

Special Note:

Entrenchment varies naturally with channel confinement. Channels in steep canyons naturally tend to be confined, and tend to have small entrenchment ratios indicating less hydrologic connectivity. Assessments of hydrologic connectivity based on entrenchment must therefore be adjusted for channel confinement. It is essential that the riverine AA be further classified as confined or unconfined, based on the definitions provided

Establish the Assessment Area (AA)

For a riverine wetland, the AA should begin at a hydrological or geomorphic break in form or structure of the channel that corresponds to a significant change in flow regime or sediment regime, as guided by Tables 1 and 2. If no such break exists, then the AA can begin at any point near the middle of the wetland. For ambient surveys, the AA should begin at the point drawn at random from the sample frame. From this beginning, the AA should extend upstream or downstream for a distance ten times (10x) the average bankfull width of the channel, but at least 100 m, and for a distance no longer than 200 m. In any case, the AA should not extend upstream of any confluence that obviously increases the downstream sediment supply or flow, or if the channel in the AA is obviously larger below the confluence than above it. The AAs should include both sides of wadeable channels, but only one side of channels that cannot be safely crossed by wading.

All types of wetlands can have adjacent riparian areas that benefit the wetlands. Riparian areas play a particularly important role in the overall form and function of riverine wetlands. Riverine wetlands are generally highly influenced by the allochthonous organic material input from riparian areas that support aquatic food webs. Also, the large woody debris provided by riparian areas can be essential to maintaining riverine geomorphology, such as pools and riffles, as well as the associated ecological services, such as the support of anadromous fishes. Conservation policies and practices commonly associate riparian functions with riverine wetlands more than other wetland types.

Therefore, the riverine AA should extend landward from the foreshore of the floodplain (located at the bankfull width) to include the adjacent riparian area that probably accounts for bank stabilization and most of the direct allochthonous inputs of leaves, limbs, insects, etc., into the channel, and its immediate floodplain. Any trees or shrubs that directly contribute allochthonous material to the channel and its immediate floodplain should be included in the AA in their entirety (Figure 3). The AA can include topographic floodplain benches, interfluves, paleo-channels, meander cutoffs, and other features that are at least **semi-regularly** influenced by fluvial processes associated with the main channel of the AA. It can also include adjacent areas such as terrace margins that support vegetation that is likely to directly provide allochthonous inputs.

Special Note:
The opposing sides (different banks) of a riverine AA can have different riparian widths, based on differences in plant architecture and topography.

*The minimum width of the AA should extend **no less than** two meters (2 m) from the bankfull channel margin.*

Where the module is applied to riverine wetlands that occupy very broad floodplains (for example, where floodplains are > 10X or 20X the average channel width), CRAM does not adequately address the multiple dynamic processes that occur on the extensive floodplains, and the riverine AA must be limited to the area that directly influences the channel. While it is clear that during floods the entire floodplain may contribute allochthonous material to the wetland ecosystem, and while it is also clear that very broad floodplains may significantly influence the hydrological dynamics of large rivers in flood, these factors were not incorporated into the development of the Riverine module. In order to allow the module to be applied to these wetlands, the AA should be limited to the floodplain area that immediately affects the channel, which is defined for the purposes of CRAM as the area no more than two times the bankfull width on each side of the channel. However, within that distance, if a topographic feature is encountered, use this feature along with standard CRAM guidance to define the edge of the AA.

In systems located in a steep valley which lack an obvious active floodplain, set the lateral extent of the AA a distance of no more than two times the bankfull width on each side of the channel to include the adjacent riparian area that probably accounts for bank stabilization and most of the direct allochthonous inputs of leaves, limbs, insects, etc., into the channel.
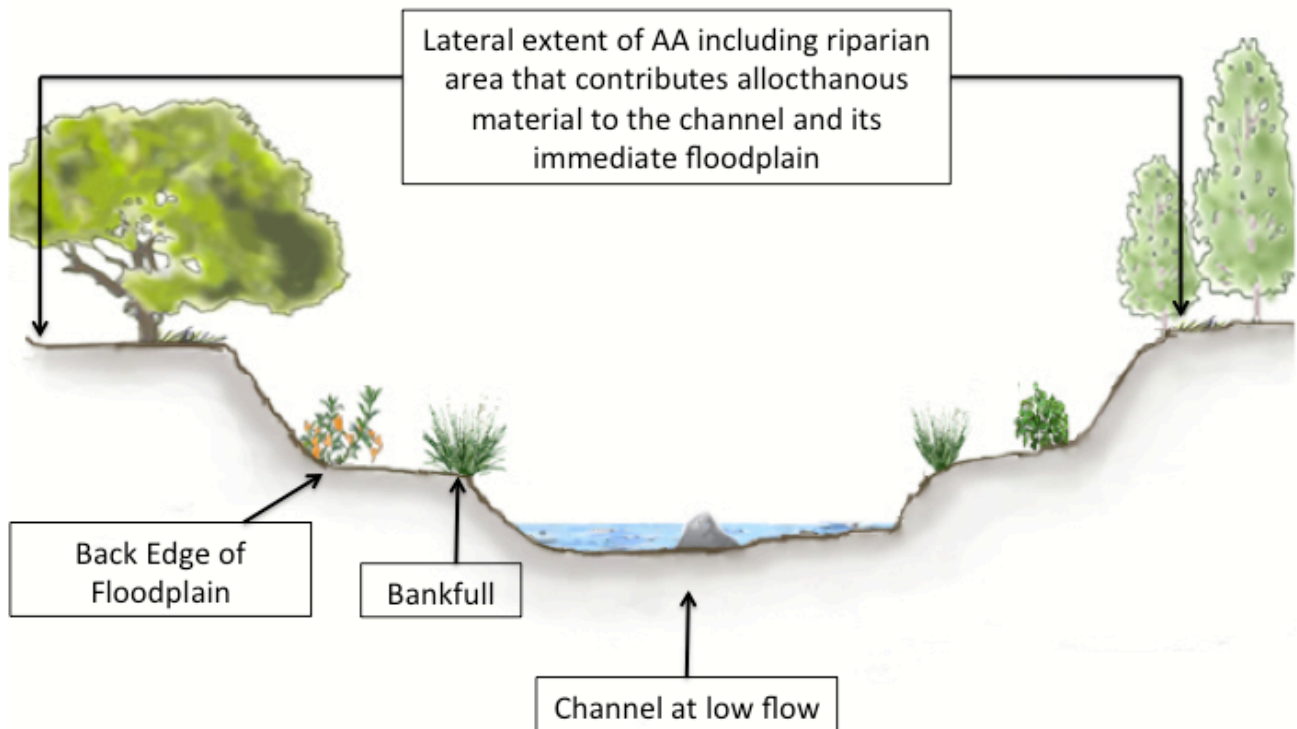
Figure 3: Diagram of the lateral extent of a riverine AA that includes the portion of the riparian area that can help stabilize the channel banks and that can readily provide allochthonous inputs of plant matter, insects, etc. to the channel and its immediate floodplain.

Table 1: Examples of features that *should* be used to delineate AA boundaries for Riverine wetlands.

- major changes in riverine entrenchment, confinement, degradation, aggradation, slope, or bed form
- major channel confluences
- diversion ditches
- end-of-pipe large discharges
- water falls
- open water areas more than 30 m wide on average or broader than the wetland
- transitions between wetland types
- weirs, culverts, dams, drop- structures, levees, and other flow control, grade control, or water height control structures

Table 2: Examples of features that *should not* be used to delineate AAs.

- **at-grade**, unpaved, single-lane, infrequently used roadways or crossings
- bike paths and jogging trails **at grade**
- bare ground within what would otherwise be the AA boundary
- equestrian trails
- fences (unless designed to obstruct the movement of wildlife)
- property boundaries, unless access is not allowed
- riffle (or rapid) – glide – pool transitions in a riverine wetland
- spatial changes in land cover or land use along the wetland border
- state and federal jurisdictional boundaries

Table 3: Recommended maximum and minimum AA sizes for the Riverine wetland type.
Note: Wetlands smaller than the recommended AA sizes <u>can</u> be assessed in their entirety.

Wetland Type	Recommended AA Size
Confined and Non-confined Riverine	Recommended length is 10x average bankfull channel width; maximum length is 200 m; minimum length is 100 m.

Attribute 1: Buffer and Landscape Context

Metric 1: Riparian Continuity (Aquatic Area Abundance)

Definition: The Riparian Continuity metric for a riverine Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources. Wetlands close to each other have a greater potential to interact ecologically and hydrologically, and such interactions are generally beneficial.

For riverine wetlands, aquatic area abundance is assessed as the continuity of the riparian corridor over a distance of 500 m upstream and 500 m downstream of the AA. While riparian areas upstream and downstream generally reflect the overall health of the riverine system, of special concern for this metric is the ability of wildlife to enter the riparian area from outside of it at any place within 500 m of the AA, and to move easily through adequate cover along the riparian corridor through the AA from upstream and downstream. This metric is assessed as the total length of unfavorable habitat (defined by the "non-buffer land covers" in Table 6) that interrupts the riparian corridor within 500 m upstream or downstream of the AA. "Non-buffer land covers" occupying less than 10 m of stream length are disregarded in this metric.

It should be noted that this metric adopts the "non-buffer land cover" types in Table 6 as indications of habitat conditions that break or disrupt ecological and hydrological continuity. This metric explicitly addresses the connectivity of the AA with the riparian areas upstream and downstream, and the "non-buffer land covers" are considered as indicators of conditions that break this continuity. This metric does *not* address the AA buffer condition, which is addressed in the following metric.

Special Note:

Assume the riparian 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.

To be a concern, a "non-buffer land cover" segment must break or sever the continuity of the riparian area for a length of at least 10 meters on at least one side of the channel upstream or downstream from the AA.

*For the purpose of assessing aquatic area abundance for riverine wetlands, open water **is** considered part of the riparian corridor. This acknowledges the role the riparian corridors have in linking together aquatic habitats and in providing habitat for anadromous fish and other wildlife.*

A bridge crossing the stream that is at least 10 m wide will typically interrupt the riparian corridor on both sides of the stream, thus the crossing width is counted twice, once for the right bank and once for the left bank.

For wadeable systems, assess both sides of the channel upstream and downstream from the AA.

For systems that cannot be waded, only assess the side of the channel that has the AA, upstream and downstream from the AA.

Table 4: Steps to assess Riparian Continuity for riverine wetlands.

Step 1	Extend the average width of the AA 500 m upstream and downstream, regardless of the land cover types that are encountered (see Figure 4).
Step 2	Using the site imagery, identify all the places where "non-buffer land covers" (see Table 6) at least 10 m wide interrupt the riparian area within the average width of your AA on **either side of the channel** in the extended AA. Disregard interruptions of the riparian corridor that are less than 10 m wide (measured parallel to the stream). Do not consider open water as an interruption. For one-sided riverine AAs, assess only one side of the system
Step 3	Estimate the length of each "non-buffer" segment identified in Step 2, and enter the estimates in the worksheet for this metric.

Figure 4: Diagram of method to assess Riparian Continuity of riverine wetlands. This example shows that about 400 m of "non-buffer land cover" crosses about half of the riparian corridor within 500 m downstream of the AA. This is due to the large parking lot on the south side of the stream in addition to two bridge crossings. There is a 20 m break in the riparian corridor upstream of the AA due to a bridge crossing (10 m for each side of the stream).

Worksheet for Riparian Continuity Metric for Riverine Wetlands

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	

Table 5: Rating for Riparian Continuity for Riverine wetlands.

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 for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).	The combined total length of all non-buffer segments is less than 100 m for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).
B	The combined total length of all non-buffer segments is less than 100 m for "2-sided" AAs; 50 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.
B	OR	
B	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is less than 100 m for "2-sided" AAs; is less than 50 m for "1-sided" AAs.
C	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.
D	The combined total length of non-buffer segments is greater than 200 m for "2-sided" AAs; greater than 100 m for "1-sided" AAs.	any condition
D	OR	
D	any condition	The combined total length of non-buffer segments is greater than 200 m for "2-sided" AAs; greater than 100 m for "1-sided" AAs.

Metric 2: Buffer

Definition: The buffer is the area adjoining the AA that is in a natural or semi-natural state and 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.

To be considered as buffer, a suitable land cover type must be at least 5 m wide starting at the edge of the AA extending perpendicular to 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 of the AA.

Special Note:

Any area of open water at least 30 m wide that is adjoining the AA, such as a lake, large river, or large slough, is not considered in the assessment of the buffer. Such open water is considered to be neutral, and is neither part of the wetland nor part of the buffer. There are three reasons for excluding large areas of open water (i.e., more than 30 m wide) from Assessment Areas and their buffers.

> *1) Assessments of buffer extent and buffer width are inflated by including open water as a part of the buffer.*

> *2) While there may be positive correlations between wetland stressors and the quality of open water, quantifying water quality generally requires laboratory analyses beyond the scope of rapid assessment.*

> *3) Open water can be a direct source of stress (i.e., water pollution, waves, boat wakes) or an indirect source of stress (i.e., promotes human visitation, encourages intensive use by livestock looking for water, provides dispersal for non-native plant species), or it can be a source of benefits to a wetland (e.g., nutrients, propagules of native plant species, water that is essential to maintain wetland hydroperiod, etc.).*

However, any area of open water that is within 250 m of the AA but is not directly adjoining the AA **is considered part of the buffer.*

Submetric A: Percent of AA with Buffer

Definition: This submetric is based on the relationship between the extent of buffer and the functions provided by aquatic areas. Areas with more buffer typically provide more habitat values, better water quality and other valuable functions. 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 5). The upstream and downstream edges of the AA are not included in this metric, only the edges parallel to the stream.
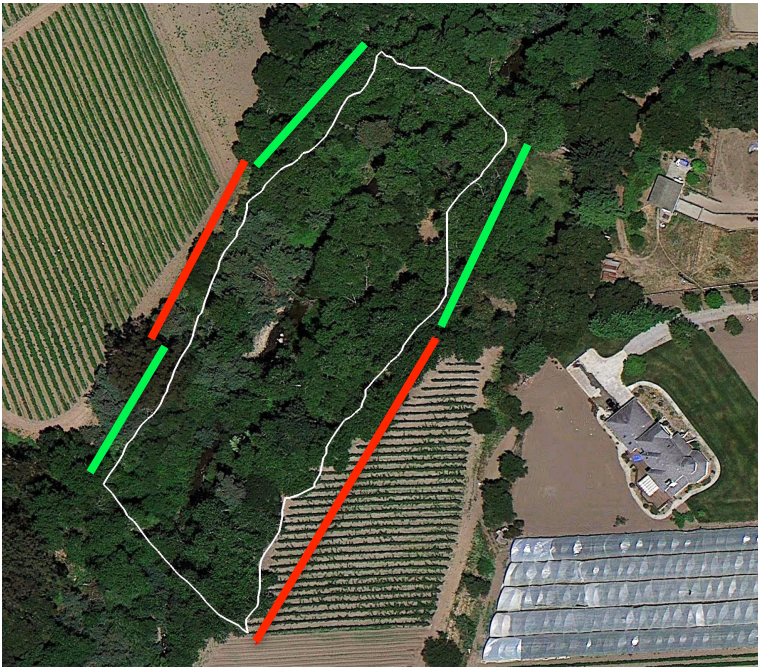
Figure 5: Diagram of approach to estimate Percent of AA with Buffer for Riverine AAs. The white line is the edge of the AA, the red line indicates where there is **less** than 5 meters of buffer land cover adjacent to the AA, while the green line indicates where buffer is present. In this example 55% of the AA has buffer.

Table 6: Guidelines for identifying wetland buffers and breaks in buffers.

Examples of Land Covers Included in Buffers	Examples of Land Covers Excluded from Buffers Notes: buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.
- at-grade bike and foot trails, or 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 and frogs) - 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)

Percent of AA with Buffer Worksheet.
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 of AA with Buffer: _____ %

Table 7: Rating for Percent of AA with Buffer.

Rating	Alternative States (not including open-water areas)
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: The average width of the buffer adjoining the AA is estimated by averaging the lengths of eight straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover or 250 m, which ever is first encountered. It is assumed that the functions of the buffer do not increase significantly beyond an average width of about 250 m. The maximum buffer width is therefore 250 m. The minimum buffer width is 5 m, and the minimum length of buffer along the perimeter of the AA is also 5 m. Any area that is less than 5 m wide and 5 m long is too small to be a buffer. See Table 6 above for more guidance regarding the identification of AA buffers.

Table 8:   Steps to estimate Buffer Width for riverine wetlands

|	
Step 1	Identify areas in which open water is directly adjacent to the AA, with <5 m of vegetated wetland or upland area in between. **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 buffer width of each of the lines as they extend away from the AA. Record these lengths on the worksheet below.
Step 5	Calculate the average buffer width. Record this width on the worksheet below.

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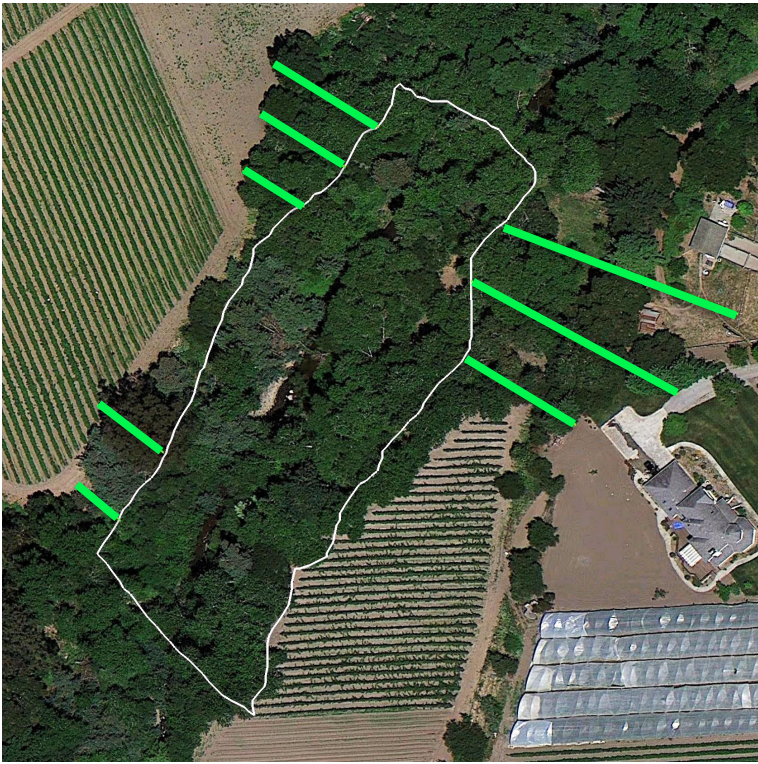
Figure 6: Diagram of approach to estimate Average Buffer Width for Riverine AAs. Continuing with the example from above, draw 8 lines evenly distributed within the buffer. The lines end in this example when they encounter active row crop agriculture, a lawn, and some fencing that restricts wildlife movement.

Worksheet for calculating average buffer width of AA

Line	Buffer Width (m)
A	
B	
C	
D	
E	
F	
G	
H	
Average Buffer Width	

Table 9: 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: The condition of a buffer is assessed according to the extent and quality of its vegetation cover, the overall condition of its substrate, and the amount of human visitation. Buffer conditions are assessed only for the portion of the wetland border that has **already been identified as buffer** (i.e., as in Figure 7). 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. If there is no buffer, assign a score of D.

Figure 7: 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 areas shown).

Table 10: Rating for Buffer Condition.

Rating	Alternative States
A	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
B	Buffer for AA is characterized by an intermediate mix of native and non-native vegetation (25% to 75% non-native), but mostly undisturbed soils and is apparently subject to little or low impact human visitation.
	OR
	Buffer for AA is dominated by native vegetation, but shows some soil disturbance and is apparently subject to little or low impact human visitation.
C	Buffer for AA is characterized by substantial (>75%) amounts of non-native vegetation AND there is at least a moderate degree of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation.
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.

Attribute 2: Hydrology

Metric 1: Water Source

Definition: Water sources directly affect the extent, duration, and frequency of the hydrological dynamics within an Assessment Area. Water sources include direct inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrologic regime of the AA.

A water source is direct if it supplies water mainly to the AA, rather than to areas through which the water must flow to reach the AA. Natural, direct sources include rainfall, ground water discharge, and flooding of the AA due to naturally high riverine flows. Examples of unnatural, direct sources include stormdrains that empty directly into the AA or into an immediately adjacent area. Indirect sources that should not be considered in this metric include large regional dams that have ubiquitous effects on broad geographic areas of which the AA is a small part. However, the effects of urbanization on hydrological dynamics in the immediate watershed containing the AA ("hydromodification") *are* considered in this metric; because hydromodification both increases the volume and intensity of runoff during and immediately after rainy season storm events and reduces infiltration that supports base flow discharges during the drier seasons later in the year.

Engineered hydrological controls such as weirs, flashboards, grade control structures, check dams, etc., can serve to demarcate the boundary of an AA but they are not considered water sources.

Natural sources of water for riverine wetlands include precipitation, snow melt, groundwater, and riverine flows. Whether the wetlands are perennial or seasonal, alterations in the water sources result in changes in either the high water or low water levels. Such changes can be assessed based on the patterns of plant growth along the wetland margins or across the bottom of the wetlands.

To score this metric use site aerial imagery and any other information collected about the region or watershed surrounding the AA to assess the water source in a 2 km area upstream of the AA (Table 11).
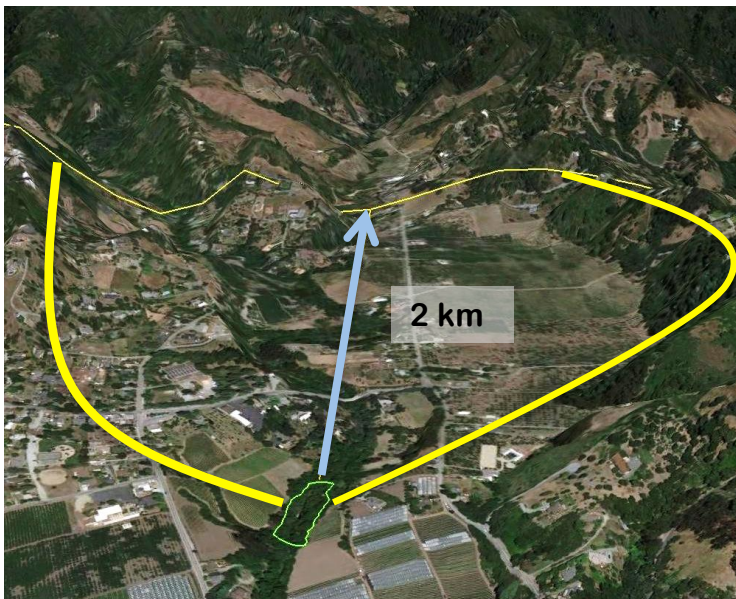

Figure 8: Diagram of approach to assess water sources affecting a CRAM AA showing an oblique view of the watershed. After identifying the portion of the aerial imagery that constitutes the contributing watershed region for the AA, assess the condition of the water source in a 2 km region (represented by yellow lines) upstream of the AA (represented with green box).

Table 11: Rating for Water Source.

Rating	Alternative States
A	Freshwater sources that affect the dry season condition of the AA, such as its flow characteristics, hydroperiod, or salinity regime, are precipitation, snow melt, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the dry season. There is **no indication** that dry season conditions are substantially controlled by artificial water sources.
B	Freshwater sources that affect the dry season 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 sources that affect the dry season conditions 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 dry season conditions of the AA are **substantially controlled** by known diversions of water or other withdrawals directly from the AA, its encompassing wetland, or from its drainage basin.
D	Natural, freshwater sources that affect the dry season conditions of the AA have **been eliminated** based on the following indicators: impoundment of all possible wet season inflows, diversion of all dry-season inflow, predominance of xeric vegetation, etc.

Metric 2: Channel Stability

Definition: For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are very important. The patterns of flow, in conjunction with the kinds and amounts of sediment that the flow carries or deposits, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel in cross-section, plan view, and longitudinal profile remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes can be associated with upstream land use changes, alterations of the drainage network of which the channel of interest is a part, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations among flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any of these factors will be countered by adjustments in the others.

Channel stability is assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e., net loss of sediment from the bed causing it to be lower over time). The degree of channel stability can be assessed based on field indicators. There is much interest in channel entrenchment (i.e., the inability of flows in a channel to exceed the channel banks) however, this is addressed later in the Hydrologic Connectivity metric.

There are many well-known field indicators of equilibrium conditions for assessing the degree to which a channel is stable enough to sustain existing wetlands. To score this metric, visually survey the AA for field indicators of aggradation or degradation (listed in the worksheet). After reviewing the entire AA and comparing the conditions to those described in the worksheet, decide whether the AA is in equilibrium, aggrading, or degrading, then assign a rating score using the alternative state descriptions in Table 12.

Special Note:

The hydroperiod of a riverine wetland can be assessed based on a variety of statistical parameters, including the frequency and duration of flooding (as indicated by the local relationship between stream depth and time spent at depth over a prescribed period), and flood frequency (i.e., how often a flood of a certain height is likely to occur). These characteristics plus channel form in cross-section and plan view, steepness of the channel bed, material composition of the bed, sediment loads, vegetation on the banks, and the amount of woody material entering the channel all interact to create the physical structure and form of the channel at any given time. However, the data needed to calculate hydroperiod are not available for most riverine systems in California. Rapid assessment must therefore rely on field indicators of hydroperiod. For a broad spectral diagnosis of overall riverine wetland condition, the physical stability or instability of the system is especially important. Whether a riverine system is stable (i.e., sediment supplies and water supplies are in dynamic equilibrium with each other and with the stabilizing qualities of riparian vegetation), or if it is degrading (i.e., subject to chronic incision of the channel bed), or aggrading (i.e., the bed is being elevated due to in-channel storage of sediment) can have large effects on downstream flooding, contaminant transport, riparian vegetation structure and composition, and wildlife support. CRAM therefore translates the concept of riverine wetland hydroperiod into riverine system physical stability.

Every stable riverine channel tends to have a particular form in cross section, profile, and plan view that is in dynamic equilibrium with the inputs of water and sediment. If these supplies change enough, the channel will tend to adjust toward a new equilibrium form. An increase in the supply of sediment can cause a channel to aggrade. Aggradation might simply increase the duration of inundation for existing wetlands, or might cause complex changes in channel location and morphology through braiding, avulsion, burial of wetlands, creation of new wetlands, splay and fan development, etc. An increase in discharge or modification of the timing of discharge might cause a channel to incise (i.e., cut-down), leading to bank erosion, headward erosion of the channel bed, floodplain abandonment, and dewatering of riparian areas.

Worksheet for Assessing Channel Stability for Riverine Wetlands.

Condition	Field Indicators (check all existing conditions)
Indicators of Channel Equilibrium	☐ The channel (or multiple channels in braided systems) has a well-defined bankfull contour that clearly demarcates an obvious active floodplain in the cross-sectional profile of the channel throughout most of the AA. ☐ Perennial riparian vegetation is abundant and well established along the bankfull contour, but not below it. ☐ There is leaf litter, thatch, or wrack in most pools. ☐ The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area. ☐ There is little or no active undercutting or burial of riparian vegetation. ☐ There are no densely vegetated mid-channel bars and/or point bars that support perennial vegetation. ☐ Channel bars consist of well-sorted bed material. ☐ There are channel pools, the spacing between pools tends to be regular and the bed is not planar through out the AA ☐ The larger bed material supports abundant mosses or periphyton.
Indicators of Active Degradation	☐ The channel is characterized by deeply undercut banks with exposed living roots of trees or shrubs. ☐ There are abundant bank slides or slumps. ☐ The lower banks are uniformly scoured and not vegetated. ☐ Riparian vegetation is declining in stature or vigor, or many riparian trees and shrubs along the banks are leaning or falling into the channel. ☐ 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. ☐ Recently active flow pathways appear to have coalesced into one channel (i.e. a previously braided system is no longer braided). ☐ The channel has one or more knickpoints indicating headward erosion of the bed.
Indicators of Active Aggradation	☐ There is an active floodplain with fresh splays of coarse sediment (sand and larger that is not vegetated) deposited in the current or previous year. ☐ There are partially buried living tree trunks or shrubs along the banks. ☐ The bed is planar overall; it lacks well-defined channel pools, or they are uncommon and irregularly spaced. ☐ There are partially buried, or sediment-choked, culverts. ☐ Perennial terrestrial or riparian vegetation is encroaching into the channel or onto channel bars below the bankfull contour. ☐ There are avulsion channels on the floodplain or adjacent valley floor.
Overall	Equilibrium Degradation Aggradation

Table 12: Rating for Riverine Channel Stability.

Rating	Alternative State (based on the field indicators listed in the worksheet above)
A	Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation.
B	Most of the channel through the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form.
C	There is evidence of severe aggradation or degradation of most of the channel through the AA or the channel bed is artificially hardened through less than half of the AA.
D	The channel bed is concrete or otherwise artificially hardened through most of AA.

Metric 3: Hydrologic Connectivity

Definition: Hydrologic connectivity describes the ability of water to flow into or out of the wetland, or to accommodate rising floodwaters without persistent changes in water level that can result in stress to wetland plants and animals.

This metric is scored by assessing the degree to which the lateral movement of floodwaters or the associated upland transition zone of the AA and/or its encompassing wetland is restricted. For riverine wetlands, the Hydrologic Connectivity metric is assessed based on the degree of channel entrenchment (Leopold et al. 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment is a field measurement calculated as the flood-prone width divided by the bankfull width. Bankfull depth is the channel depth measured between the thalweg and the projected water surface at the level of bankfull flow. The flood-prone channel width is measured at the elevation equal to twice the maximum bankfull depth. The process for estimating entrenchment is outlined below. A long meter tape and a stadia rod are required.

For non-wadeable streams (i.e., one-sided Assessment Areas) this metric cannot be measured directly and must be approximated using the following procedure. (a) First, identify indicators of bankfull condition on the side of the stream being assessed. Then, using binoculars to visualize the opposite bank, identify the corresponding bankfull location there. (b) Using appropriate tools (e.g., a portable electronic distance-measuring device) estimate the bankfull width. (c) Estimate, using the best information available, the depth of the thalweg in the stream at the selected cross-section location, with reference to the estimated bankfull elevation. (d) As with the procedure for wadeable streams, double the estimated bankfull depth to yield an estimated flood-prone depth. (e) Estimate the flood-prone width as with the procedure for wadeable streams. If the flood-prone width is obscured from view in the field, use aerial imagery to estimate flood-prone width. (f) Divide the estimated flood-prone width by the estimate bankfull width to provide an estimated entrenchment ratio for use in scoring this metric in non-wadeable streams.

Riverine Wetland Entrenchment Ratio Calculation Worksheet

The following 5 steps should be conducted for each of 3 cross-sections located in the AA at the approximate midpoints along straight riffles or glides, away from deep pools or meander bends. An attempt should be made to place them at the top, middle, and bottom of the AA.

Steps	Replicate Cross-sections ⟶	TOP	MID	BOT
1 Estimate bankfull width.	This is a critical step requiring familiarity with field indicators of the bankfull contour. Estimate or measure the distance between the right and left bankfull contours.			
2: Estimate max. bankfull depth.	Imagine a level line between the right and left bankfull contours; estimate or measure the height of the line above the thalweg (the deepest part of the channel).			
3: Estimate flood prone depth.	Double the estimate of maximum bankfull depth from Step 2.			
4: Estimate flood prone width.	Imagine a level line having a height equal to the flood prone depth from Step 3; note where the line intercepts the right and left banks; estimate or measure the length of this line.			
5: Calculate entrenchment ratio.	Divide the flood prone width (Step 4) by the bankfull width (Step 1).			
6: Calculate average entrenchment ratio.	Calculate the average results for Step 5 for all 3 replicate cross-sections. Enter the average result here and use it in Table 13a or 13b.			
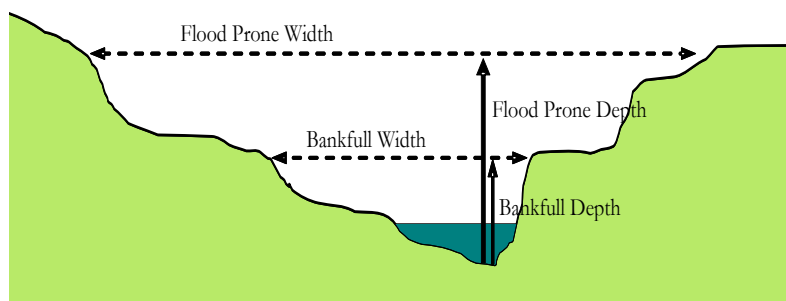
Figure 9: Diagram of channel entrenchment elements. Flood prone depth is twice maximum bankfull depth. Entrenchment is measured as flood prone width divided by bankfull width.

Special Note:

Definitions:

- *Bankfull: stage when water just begins to flow over the floodplain*
  - *There is a 50-66% chance to observe bankfull in a single year*
  - *Supplemental indicators of bankfull:*
    - *Break in slope of bank from vertical to horizontal depositional surface making up the edge of the channel*
    - *Lower limit of woody perennial species*
    - *In some cases, the presence and height of certain depositional features-especially point bars can define lowest possible level for bankfull stage. However, point bar surfaces are usually below the bankfull height and are not reliable indicators of bankfull stage.*
- *Floodplain: relatively flat depositional surface adjacent to the river/stream that is formed by the river/stream under current climatic and hydrologic conditions.*

It may be necessary to conduct a short test on how uncertainty about the location of the bankfull contour affects the metric score. To conduct the sensitivity analysis, assume two alternative bankfull contours, one 10% above the original estimate and one 10% below the original estimate. Re-calculate the metric based on these alternative bankfull heights. If either alternative changes the metric score, then add three additional cross-sections to finalize the estimates of bankfull height.

* *In altered systems (e.g. urban systems affected by hydromodification, reaches downstream from dams) the physical indicators of bankfull are often obscured.*

For a video describing bankfull, please go to the tips page of the CRAM website to see "A Guide for Field Identification of Bankfull Stage in the Western United States"

Table 13a: Rating of Hydrologic Connectivity for Non-confined Riverine wetlands.

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 2.2.
B	Entrenchment ratio is 1.9 to 2.2.
C	Entrenchment ratio is 1.5 to 1.8.
D	Entrenchment ratio is <1.5.

Table 13b: Rating of Hydrologic Connectivity for Confined Riverine wetlands.

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 1.8.
B	Entrenchment ratio is 1.6 to 1.8
C	Entrenchment ratio is 1.2 to 1.5.
D	Entrenchment ratio is < 1.2.

Attribute 3: Physical Structure

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, or riparian 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.

Special Note:

Physical patches can be natural or unnatural.

Patch Type Definitions:

Abundant wrackline or organic debris in channel or on floodplain. Wrack is an accumulation of natural floating debris along the high water line of a wetland. Organic debris includes loose fallen leaves and twigs not yet transported by stream processes. This patch type does not include standing dead vegetation.

Bank slumps or undercut banks in channels or along shorelines. 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 or shoreline of a wetland that have been excavated by flowing water. These areas can provide habitat for fishes and invertebrates.

Cobble and boulders. Cobble 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 a long axis greater than 25 cm. Submerged cobbles and boulders provide habitat for aquatic macroinvertebrates and small fish. 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. Cobbles and boulders contribute to oxygenation of flowing water.

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.

Filamentous macroalgae and algal mats. Macroalgae occurs on benthic sediments and on the water surface of all types of wetlands. Macroalgae are important primary producers, representing the base of the food web in some wetlands. Algal mats can provide habitat for macro-invertebrates, amphibians, and small fishes.

Large (or coarse) woody debris. A single piece of woody material, greater than 30 cm in diameter and greater than 3 m long.

Pannes or pools on floodplain. A panne is a shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain. Pannes fill with water at least seasonally due to overland flow. They commonly serve as foraging sites for waterbirds and as breeding sites for amphibians.

Plant hummocks or sediment mounds. Hummocks are mounds along the banks and floodplains of fluvial systems created by the collection of sediment and biotic material around wetland plants such as sedges. Hummocks are typically less than 1m high. Sediment mounds are similar to hummocks

but lack plant cover. They are depositional features formed from repeated flood flows depositing sediment on the floodplain.

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.

Riffles or rapids. Riffles and rapids are areas of relatively rapid flow, standing waves and surface turbulence in fluvial channels. A steeper reach with coarse material (gravel or cobble) in a dry channel indicates presence. Riffles and rapids add oxygen to flowing water and provide habitat for fish and aquatic invertebrates.

Secondary channels on floodplains or along shorelines. Channels confine riverine flow. A channel consists of a bed and its opposing banks, plus its floodplain. Riverine wetlands can have a primary channel that conveys most flow, and one or more secondary channels of varying sizes that convey flood flows. The systems of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of one or more main channels plus secondary channels. Tributary channels that originate in the wetland and that only convey flow between the wetland and the primary channel are also regarded as secondary channels. For example, short tributaries that are entirely contained within the CRAM Assessment Area (AA) are regarded as secondary 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 and small mammals. Any standing, dead woody vegetation within the AA that is at least 3 m tall is considered a snag.

Submerged vegetation. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea) that are rooted in the sub-aqueous substrate but do not usually grow high enough in the overlying water column to intercept the water surface. Submerged vegetation can strongly influence nutrient cycling while providing food and shelter for fish and other organisms.

Swales on floodplain or along shoreline. Swales are broad, elongated, sometimes vegetated, shallow depressions that can sometimes help to convey flood flows to and from vegetated marsh plains or floodplains. However, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

Variegated or crenulated foreshore. As viewed from above, the foreshore of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated shoreline resembles a meandering pathway. Variegated shorelines provide greater contact between water and land. This can be viewed on a scale smaller than the whole AA (2-3 m). Large boulders and fallen trees along the shoreline can contribute to variegation.

Vegetated islands (exposed at high-water stage). An island is an area of land above the usual high water level and, at least at times, surrounded by water. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

Structural Patch Type Worksheet for Riverine wetlands

Circle each type of patch that is observed in the AA and enter the total number of observed patches in Table below. In the case of riverine wetlands, their status as confined or non-confined must first be determined (see page 6) to determine with patches are expected in the system (indicated by a "1" in the table below).

STRUCTURAL PATCH TYPE (circle for presence)	Riverine (Non-confined)	Riverine (Confined)
Minimum Patch Size	**3 m²**	**3 m²**
Abundant wrackline or organic debris in channel, on floodplain	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1
Cobble and/or Boulders	1	1
Debris jams	1	1
Filamentous macroalgae or algal mats	1	1
Pannes or pools on floodplain	1	N/A
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
Riffles or rapids (wet or dry channels)	1	1
Secondary channels on floodplains or along shorelines	1	N/A
Standing snags (at least 3 m tall)	1	1
Submerged vegetation	1	N/A
Swales on floodplain or along shoreline	1	N/A
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1
Vegetated islands (mostly above high-water)	1	N/A
Total Possible	16	11
No. Observed Patch Types (enter here and use in Table 14 below)		

Table 14: Rating of Structural Patch Richness (based on results from worksheet above).

Rating	Confined Riverine	Non-confined Riverine
A	≥ 8	≥ 12
B	6 – 7	9 – 11
C	4 – 5	6 – 8
D	≤ 3	≤ 5

Metric 2: Topographic Complexity

Definition: Topographic complexity refers to the micro- and macro-topographic relief and variety of elevations within a wetland due to physical and abiotic features and elevation gradients. Table 15 indicates the range of topographic features that occur in riverine wetlands.

Table 15: Typical indicators of Macro- and Micro-topographic Complexity for the Riverine wetlands.

Type	Examples of Topographic Features
Riverine	pools, runs, glides, pits, ponds, sediment mounds, bars, debris jams, cobble, boulders, slump blocks, tree-fall holes, plant hummocks

This metric is scored for wadeable streams using the alternative states described in Table 16, based on carefully drawing three bank-to-bank cross-sectional profiles across the AA, ideally associated with the three sets of measurements completed for the Hydrological Connectivity metric (by convention the cross-section is drawn looking downstream), then by comparing the cross-sections to the generalized conditions illustrated in Figure 10 below. For non-wadeable streams the drawings and the reference profile from Figure 10 may be one-sided.

Worksheet for AA Topographic Complexity

At three locations along the AA, make a sketch of the profile of the stream from the AA boundary down to its deepest area then back out to the other AA boundary. Try to capture the benches and the intervening micro-topographic relief. To maintain consistency, make drawings at each of the stream hydrologic connectivity measurements, always facing downstream. Include the water level, an arrow at the bankfull, and label the benches. Based on these sketches and the profiles in Figure 10, choose a description in Table 16 that best describes the overall topographic complexity of the AA.

Profile 1

Profile 2

Profile 3

Figure 10: Scale-independent schematic profiles of Topographic Complexity.
Each profile A-D represents a characteristic cross-section through an AA. Use in conjunction with Table 16 to score this metric.
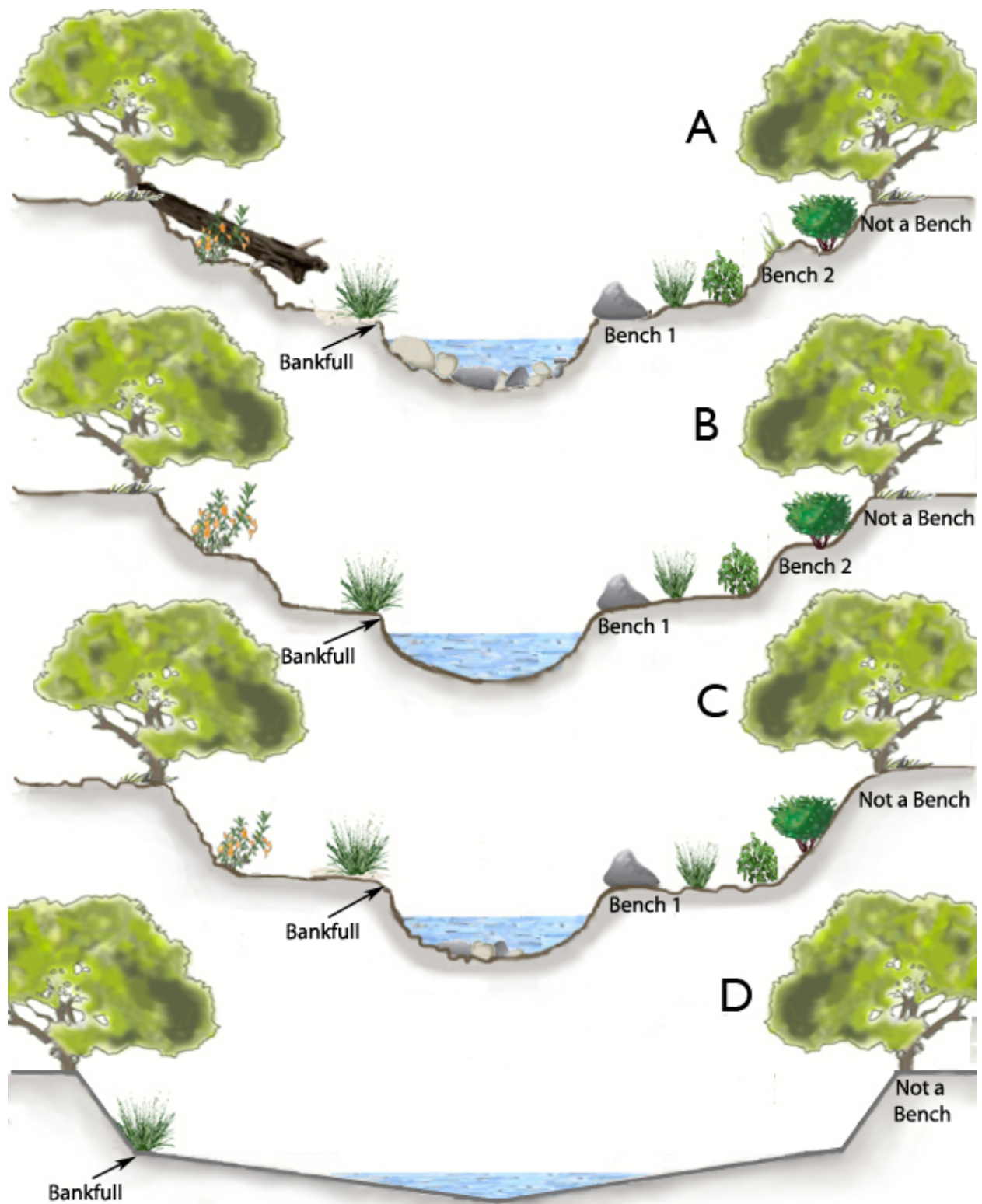
Table 16: Rating of Topographic Complexity for Riverine Wetlands.

Rating	Alternative States (based on worksheet and diagrams in Figure 10 above)
A	AA as viewed along a typical cross-section has at least two benches at different elevations, above the active channel bottom (not including the thalweg or high riparian terraces not influenced by fluvial processes). Large point bars or in-channel bars above the active channel bed can be considered a bench. Additionally, each of these benches, plus the slopes between the benches, as well as the channel bottom area contain physical patch types or micro-topographic features such as boulders or cobbles, partially buried woody debris, undercut banks, secondary channels and debris jams that contribute to abundant micro-topographic relief as illustrated in profile A.
B	AA has at least two benches above the channel bottom area of the AA, but these benches mostly lack abundant micro-topographic complexity. The AA resembles profile B.
C	AA has a single bench that may or may not have abundant micro-topographic complexity, as illustrated in profile C.
D	AA as viewed along a typical cross-section lacks any obvious bench. The cross-section is best characterized as a single, uniform slope with or without micro-topographic complexity, as illustrated in profile D (includes concrete channels).

Attribute 4: 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. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is guided by a set of Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets.

A "plant" is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forb, or fern, whether submerged, floating, emergent, prostrate, decumbent, or erect, including non-native (exotic) plant species. Mosses and algae are not included among the species identified in the assessment of the plant community. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA *where the layer is expected.*

Non-native species owe their occurrence in California to the actions of people since shortly before Euroamerican contact. Many non-native species are now *naturalized* in California, and may be widespread in occurrence. "Invasive" species are non-native species that "(1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes" (CalIPC 2012). CRAM uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, *with augmentation by regional experts.*

Submetric A: Number of Plant Layers Present

To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer.* For instance, the aquatic layer called "floating" would be expected in the channel of the riverine systems, and would be judged as present if 5% of the channel area of the AA had floating vegetation. The "short," "medium," and "tall" layers might be found throughout the non-aquatic and aquatic areas of the AA, except in areas of exposed bedrock, deep water, or active point bars denuded of vegetation, etc. The "very tall" layer is usually expected to occur along the backshore, but may occupy most of the riparian area in some locations.

It is essential that the layers be identified by the actual plant heights (i.e., the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, a young sapling redwood between 0.5 m and 1.5 m tall would belong to the "medium" layer, even though in the future the same individual redwood might belong to the "Very Tall" layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all five non-aquatic layers in a riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers.

It should be noted that widespread species may occupy different layers in different parts of California, and the identification of dominant species must be based on an identification of the actual species present in the AA.

Layer definitions:

Floating Layer. This layer includes rooted aquatic macrophytes such as *Ruppia cirrhosa* (ditchgrass), *Ranunculus aquatilis* (water buttercup), and *Potamogeton foliosus* (leafy pondweed) that create floating or buoyant canopies at or near the water surface that shade the water column. This layer also includes non-rooted aquatic plants such as *Lemna* spp. (duckweed) and *Eichhornia crassipes* (water hyacinth) that form floating canopies.

Short Vegetation. This layer is never taller than 50 cm. It includes small emergent vegetation and plants. It can include young forms of species that grow taller. Vegetation that is naturally short in its mature stage includes *Rorippa nasturtium-aquaticum* (watercress), small *Isoetes* (quillworts), *Ranunculus flamula* (creeping buttercup), *Oxalis oregana* (redwood sorrel) and *Myosotis sylvatica* (forget-me-not).

Medium Vegetation. This layer ranges from 50 cm to 1.5 m in height. It commonly includes rushes (*Juncus* spp.), *Rumex crispus* (curly dock), *Rubus ursinus* (blackberry) and *Petasites frigidus* (coltsfoot).

Tall Vegetation. This layer ranges from 1.5 m to 3.0 m in height. It usually includes the tallest emergent vegetation, larger shrubs, and small trees. Examples include *Typha latifolia* (broad-leaved cattail), *Schoenoplectus californicus* (bulrush), *Baccharis pilularis* (coyote brush) and *Salix exigua* (narrow-leaf willow).

Very Tall Vegetation. This layer includes shrubs, vines, and trees that are greater than 3.0 m in height. Examples may include *Sambucus mexicanus* (blue elderberry), *Sambucus callicarpa* (red elderberry), *Salix lasiolepis* (arroyo willow), and *Corylus californicus* (hazelnut).

Special Note:

*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 vegetation should not be "held up" to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field.

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

Figure 11: Flow Chart to Determine Plant Dominance

Step 1: Determine the number of plant layers. Estimate which possible layers comprise at least 5% absolute cover of the portion of the AA that is suitable for supporting vascular vegetation.

< 5 %

≥ 5 %

It does not count as a layer, and is no longer considered in this analysis.

It counts as a layer.

Step 2: Determine the co-dominant plant species in each layer. For each layer, identify the species that represent at least 10% of the relative area of plant cover in that layer.

< 10 %

≥ 10 %

It is not a "dominant" species, and is no longer considered in the analysis.

It is a "dominant" species.

Step 3: Determine invasive status of co-dominant plant species. For each plant layer, use the list of invasive species (Appendix IV of the CRAM User's manual) or local expertise to identify each co-dominant species that is invasive. eCRAM software will automatically identify known invasive species that are listed as co-dominants.

Table 17: Plant layer heights for all Riverine wetland types.

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Non-confined Riverine	On Water Surface	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	> 3.0 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	> 3.0 m

Submetric B: Number of Co-dominant Species

For each plant layer in the AA, every species represented by living vegetation that comprises at least 10% relative cover within the layer is considered to be dominant in that layer, and should be recorded in the appropriate part of the Plant Community Metric Worksheet. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded. 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.

Submetric C: Percent Invasion

The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for California wetland and riparian plant species is based on the Cal-IPC list. However, the best professional judgment of local experts may be used in addition to the Cal-IPC list to determine whether or not a co-dominant species is invasive in a very localized context.

Plant Community Metric Worksheet: Co-dominant species richness for Riverine wetlands
(A dominant species represents ≥10% *relative* cover)

Special Note:

* Combine the counts of co-dominant species from all layers to identify the total species count. Each plant species is only counted once when calculating the Number of Co-dominant Species and Percent Invasion submetric scores, regardless of the numbers of layers in which it occurs.

Floating or Canopy-forming (non-confined only)	Invasive?	Short (<0.5 m)	Invasive?

Medium (0.5-1.5 m)	Invasive?	Tall (1.5-3.0 m)	Invasive?

Very Tall (>3.0 m)	Invasive?		
		Total number of co-dominant species for all layers combined (enter here and use in Table 18)	
		Percent Invasion (enter here and use in Table 18)	

Table 18: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
Non-confined Riverine Wetlands			
A	4 – 5	≥ 12	0 – 15%
B	3	9 – 11	16 – 30%
C	1 – 2	6 – 8	31 – 45%
D	0	0 – 5	46 – 100%
Confined Riverine Wetlands			
A	4	≥ 11	0 – 15%
B	3	8 – 10	16 – 30%
C	1 – 2	5 – 7	31 – 45%
D	0	0 – 4	46 – 100%

Metric 2: Horizontal Interspersion

Definition: Horizontal interspersion refers to the variety and interspersion of plant "zones." Plant zones are obvious multi-species associations (in some cases zones may be plant monocultures; for instance Himalayan blackberry thickets) that remain relatively constant in makeup throughout the AA and which are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in a two-dimensional plan view. Examples may include multi-layered "riparian forest" composed of alders and cottonwoods above a salmonberry and red elderberry understory; a shrub thicket dominated solely by arroyo willow; "riparian scrub" composed of native blackberry, snowberry and poison oak; or a "grass zone" with a widely varying composition of numerous Eurasian grasses. In all cases, the plant "zones" are defined by a relatively unvarying combination of physiognomy and species composition. Think of each plant zone as a vegetation complex of relatively non-varying composition extending from the top of the tallest trees down through all of the vegetation to ground level. A zone may include groups of species of multiple heights, and this metric is not based on the layers established in the Plant Community Submetric A.

Interspersion is essentially a measure of the number of distinct zones and the amount of edge between them. It is important to base the assessment of this metric on a combination of aerial image interpretation and field reconnaissance. The user should focus on the major zones that are visible in plan view (birds eye view) at a height from which the whole AA fills the view. It's important to note that the number of zones can be surprisingly high in some riparian areas, and this metric cannot be scored by simply "counting" the number of zones. 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.

Horizontal Interspersion Worksheet.

Use the spaces below to make a quick sketch of the AA in plan view, outlining the major plant zones (this should take no longer than 10 minutes). Assign the zones names and record them on the right. Based on the sketch, choose a single profile from Figure 12 that best represents the AA overall.
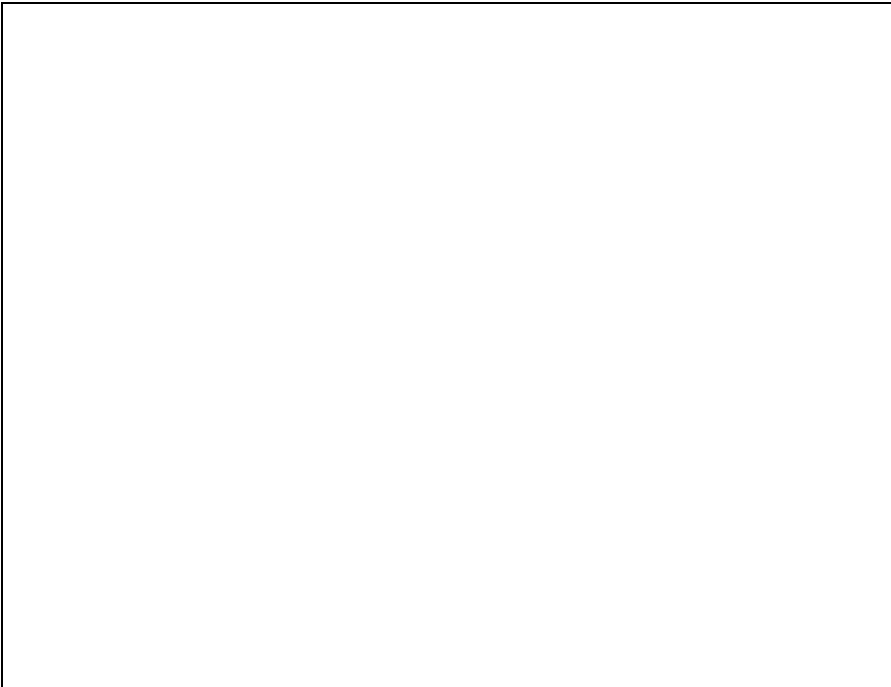
	Assigned zones:
	1)
	2)
	3)
	4)
	5)
	6)

Figure 12: Schematic diagrams illustrating varying degrees of interspersion of plant zones, open water and bare ground for all riverine wetlands. Each plant zone must comprise at least 5% of the AA. The red box represents the boundary of an AA, each color represents a unique plant zone, the speckled background represents the background "matrix" vegetation zone, and the blue represents the water.
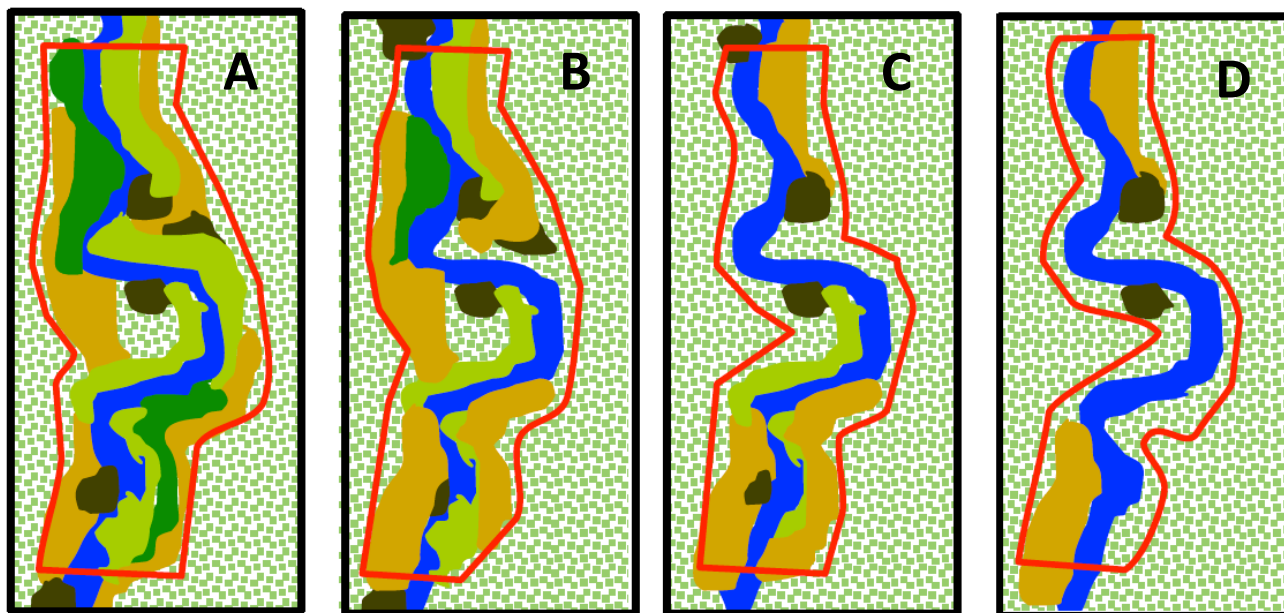
Special Note:

When assessing this metric, it is helpful to assign names of plant species or associations of species, as well as open water and bare ground to the colored patches in Figure 12. Also, many first-order (as well as almost all "zero-order" and some higher than first-order) streams in mountainous regions lack a "riparian" corridor with vegetation that differs from the surrounding landscape. In these cases the matrix penetrates all the way to the stream, and is not confined to the outermost portion of the "riparian" area within the AA.

Table 19: Rating of Horizontal Interspersion for Riverine AAs.

Rating	Alternative States (based on Worksheet drawings and Figure 10)
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.

Special Note:

*The "A" condition can be obtained only when >50% of the entire AA has three layers that overlap abundantly.

*It is important to accurately estimate the extent of overlap, particularly when the AA contains only two layers. The aerial imagery can help in determining the extent of overlap between layers.
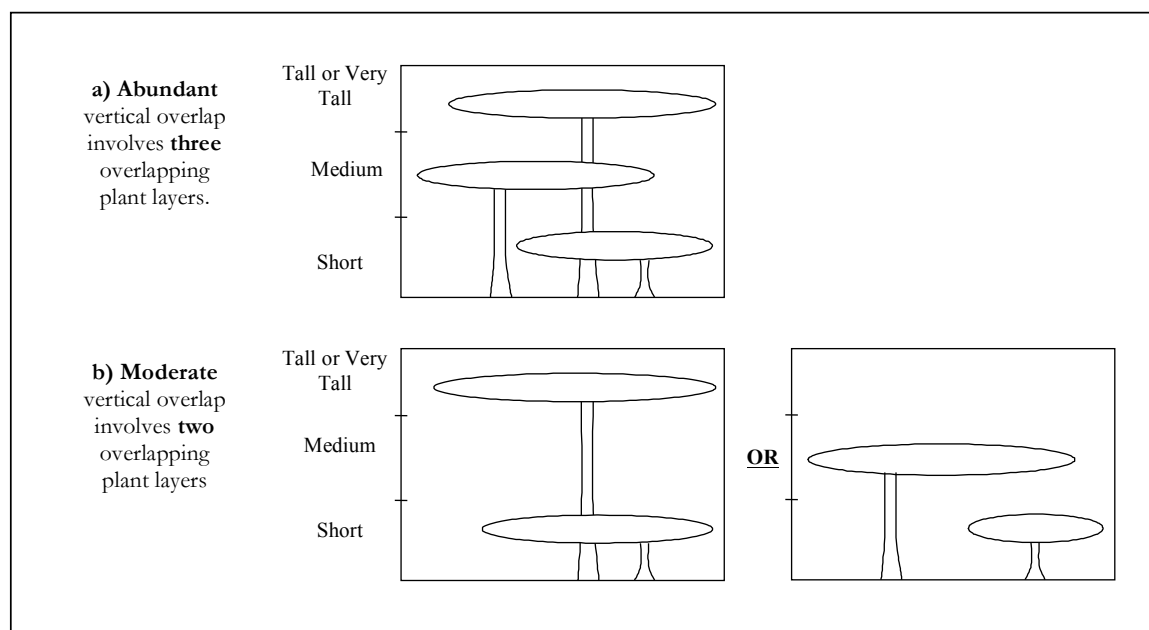

Figure 13: Schematic diagrams of (a) abundant and (b) moderate vertical overlap of plant layers for Riverine AAs.

Table 20: Rating of Vertical Biotic Structure for Riverine AAs

Rating	Alternative States
A	More than 50% of the vegetated area of the AA supports **abundant** overlap of 3 plant layers (see Figure 13a).
B	More than 50% of the area supports at least **moderate** overlap of 2 plant layers (see Figure 13b).
C	25–50% of the vegetated AA supports at least **moderate** overlap of 2 plant layers, **or** 3 plant layers are well represented in the AA but there is little to no overlap.
D	Less than 25% of the vegetated AA supports **moderate** overlap of 2 plant layers, **or** 2 layers are well represented with **little** overlap, **or** AA is sparsely vegetated overall.

Guidelines to Complete the Stressor Checklists

Definition: A stressor, as defined for the purposes of the CRAM, is an anthropogenic perturbation within a wetland or its 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.

The process to identify stressors is the same for all wetland 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 for Wetland disturbances and conversions

Has a major disturbance occurred at this wetland?	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 wetland been converted from another type? If yes, then what was the previous type?	depressional	vernal pool	vernal pool system	
	non-confined riverine	confined riverine	seasonal estuarine	
	perennial saline estuarine	perennial non-saline estuarine	wet meadow	
	lacustrine	seep or spring	playa	

Stressor Checklist Worksheet

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		

CRAM Score Guidelines

Step 1: Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
Step 2: Calculate raw Attribute Score	For each Attribute, calculate the Raw Attribute Score as the sum of the numeric scores of the component Metrics, except in the following cases: • For Attribute 1 (Buffer and Landscape Context), the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Landscape Connectivity metric, using the following formula: $$\left(\left(\boxed{\text{Buffer Condition}} \times \left(\boxed{\text{\% AA with Buffer}} \times \boxed{\text{Average Buffer Width}}\right)^{\frac{1}{2}}\right)^{\frac{1}{2}}\right) + \boxed{\text{Landscape Connectivity}}$$ • Prior to calculating the Biotic Structure Raw Attribute Score, average the three Plant Community sub-metrics. • For vernal pool systems, first calculate the average score for all three Plant Community sub-metrics for each replicate pool, then average these scores across all six replicate pools, and then calculate the average Topographic Complexity score for all six replicates.
Step 3: Calculate final Attribute Score	For each Attribute, divide its Raw Attribute Score by its maximum possible score, which is 24 for Buffer and Landscape Context, 36 for Hydrology, 24 for Physical Structure, and 36 for Biotic Structure.
Step 4: Calculate the AA Score	Calculate the AA score by averaging the Final Attribute Scores. Round the average to the nearest whole integer.