APPENDIX B.
HGM METHODOLOGY

A Guidebook for Assessment of the Functions of Waters of the United States Including Wetlands, on the Borden Ranch, Sacramento and San Joaquin Counties, California

Developed For

Wetlands Regulatory Office (WTR-8)
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Disclaimer

This draft guidebook was developed at the request of the U.S. Environmental Protection Agency, Region IX, San Francisco, California. It was created specifically for the application of a hydrogeomorphic approach (HGM) to assessment of the functions of waters of the U. S., including wetlands within the boundaries of the Borden Ranch, Sacramento and San Joaquin Counties, California. It provides a synthesis of information and data for the application of HGM functional assessments for the following three classes of waters/wetlands found on Borden Ranch:

1) Hydrologically isolated/closed and surface and shallow sub-surface flow-through depressions and their associated slope waters/wetlands,
2) Slope waters/wetlands at the headward extent of riverine waters/wetlands, and
3) First to Third order riverine waters/wetlands.

This guidebook is a draft document. It was developed, in part, with the benefit of information provided to the authors by (1) the U.S. Environmental Protection Agency, Region IX, (2) the owners of Borden Ranch, and (3) the public domain. Due to time and budget constraints associated with the Borden Ranch project, this guidebook has yet to go through all the developmental steps and peer review processes recommended by the Federal Interagency Hydrogeomorphic Implementation Team (NHIT) (Federal Register, 8/16/96 and 6/20/97).

This guidebook was developed for application of an HGM functional assessment approach within the Borden Ranch Property **only**. The reference systems, subclass profiles, and assessment models in this guidebook are developed from reference data collected on Borden Ranch. Consequently, the draft HGM models presented herein are not applicable at regional scales (*i.e.,* outside the Borden Ranch property boundaries).

The following steps must be taken prior to the utilization of this guidebook at regional scales:

1. An A-Team of regional experts on depressional, slope, and riverine waters/wetlands in the Central Valley of California must be identified.

2. Additional reference sites outside the Borden Ranch property must be sampled. The additional data then must be incorporated into the draft reference systems offered in this guidebook.

2. The "A" Team must complete all of the developmental and peer review steps outlined in the NHIT protocol for development and implementation of an HGM regional guidebook (Federal Register 8/16/96 and 6/20/97).

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II. Scope of the Draft Guidebook

A. HGM Classes, Subclasses and the Established Reference Domain

As discussed in Section I above, this draft Guidebook was developed to assist the EPA/LALC team in the application of an HGM approach to functional assessments for depressional, slpe, and riverine waters/wetlands on the Borden Ranch. Specifically, the Guidebook addresses five subclasses of Borden Ranch waters/wetlands. These are defined in Table 4 and illustrated in Figures 12.

Table 4. HGM Classes and Subclasses of Waters/Wetlands that Occur on Borden Ranch and which are Addressed by this Draft Guidebook

HGM Class	HGM Subclasses	Addressed by Guidebook
Depressions	Closed and/or hydrologically isolated (perched) depressions	Yes
	Surface and/or shallow sub-surface flow-through depressions	Yes
	Discharge depressions with or without outlet	No
Slopes	Slopes that are at the headward extent of riverine waters/wetlands	Yes
	Slopes that form inter-connections between or among depressions	Yes
Riverine	First, Second and Third Order (Strahler 1952, 1:24,000) riverine waters/wetlands	Yes

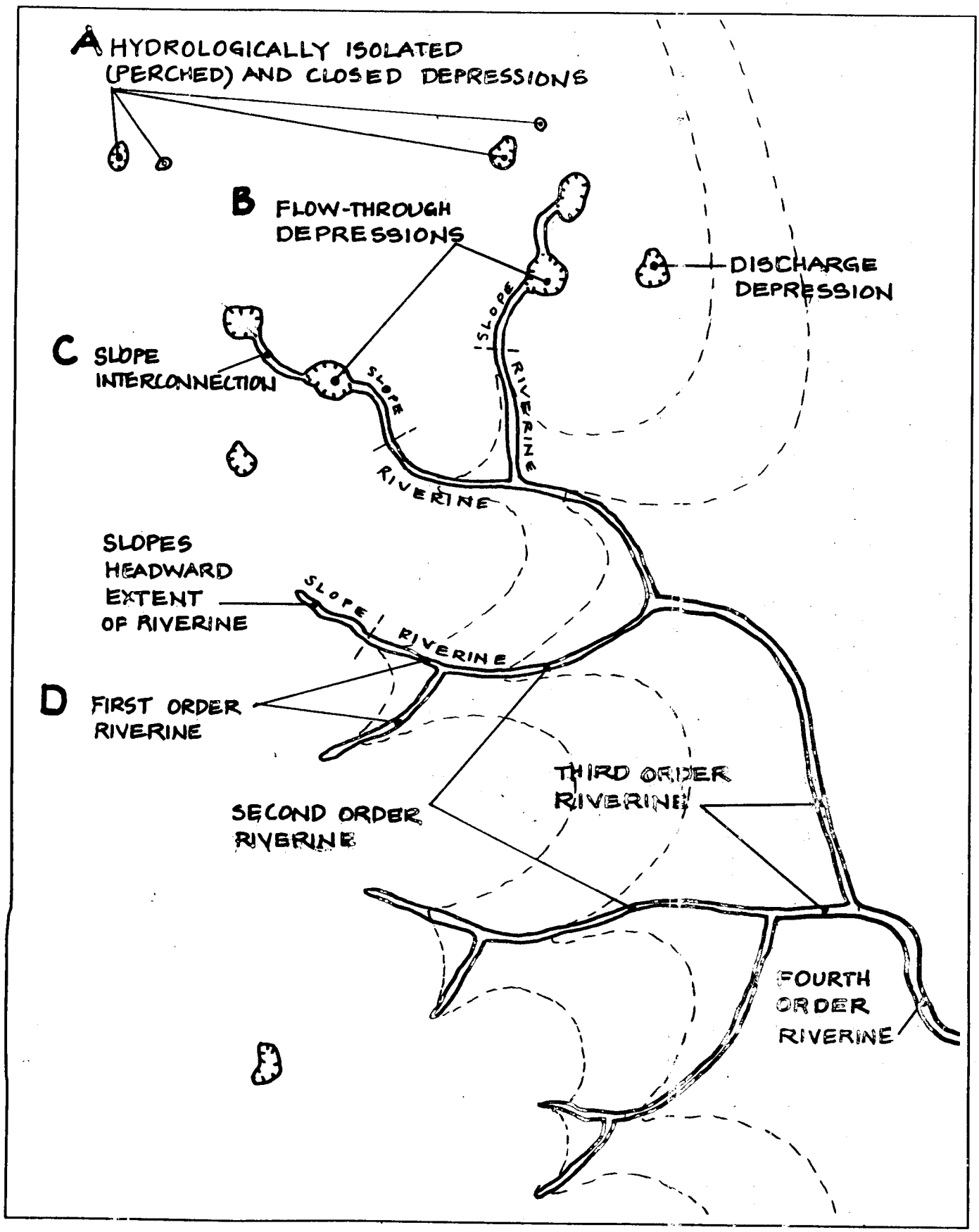
The reference "domains" addressed in this draft Guidebook (Table 1) therefore, consist of the waters/wetlands defined in Table 4 that can be identified within the property boundaries of the Borden Ranch (Figure 12). The draft HGM models included in this draft Guidebook were developed based on the best professional judgment of the EPA/LCLA team and data collected from a total of 90 reference sites: 30 depressions, 30 slopes, and 30 riverine waters/wetlands. Viewed as a group of samples, these 90 sites represent the established reference domains for the HGM models offered in the draft Guidebook.

B. Applicability of the Draft Guidebook at a Regional Scale

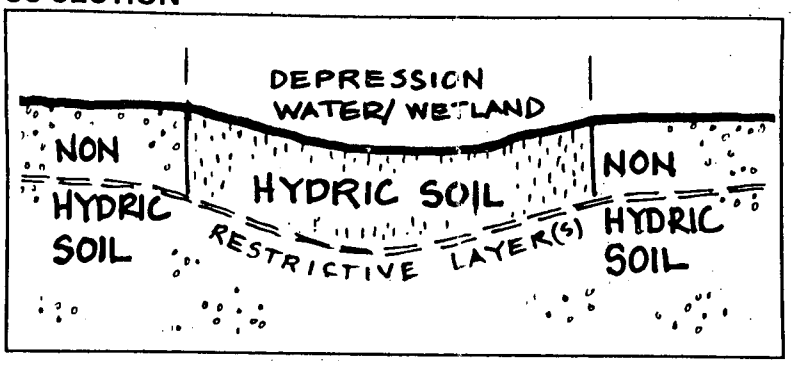
As discussed above, this draft Guidebook was developed exclusively for use on the Borden Ranch. Thus, the established reference domains for the draft HGM models offered in this draft Guidebook are restricted to the waters/wetlands classes and subclasses defined in Table 4 and described in detail in the subclass profiles offered in Section IV below. Similar waters/wetlands in an expanded geographic region (*e.g.* the Central Valley) represent the "potential reference domain" for a more regional HGM guidebook (Figure 13).

As has occurred in other areas of the U. S. (NWSTC 1996a, b, c; 1997) the Borden Ranch draft Guidebook could potentially serve as a generic template from which more regional HGM models could be developed. However, development of a more regional guidebook would require significant effort by regional experts. Specifically, while the structure of the models outlined in this draft (*i.e.*, the functions, variables, and indices of function) may apply to waters/wetlands in

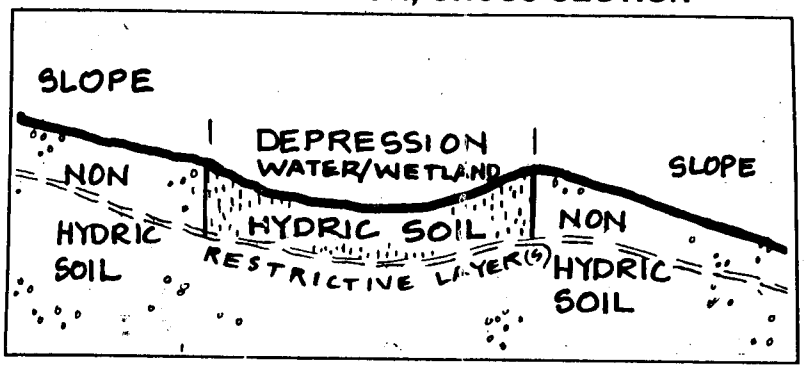
Figure 12. Classes and Subclasses of Waters/Wetlands on the Forden Ranch, Sacramento and



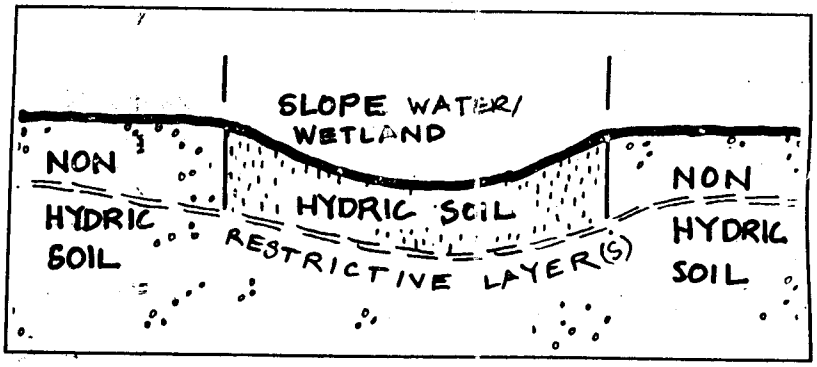
A. HYDROLOGICALLY ISOLATED (PERCHED) AND CLOSED DEPRESSION, CROSS SECTION



B. FLOW-THROUGH DEPRESSION, CROSS SECTION



C. SLOPE WETLAND, CROSS SECTION



D. RIVERINE WETLAND, CROSS SECTION

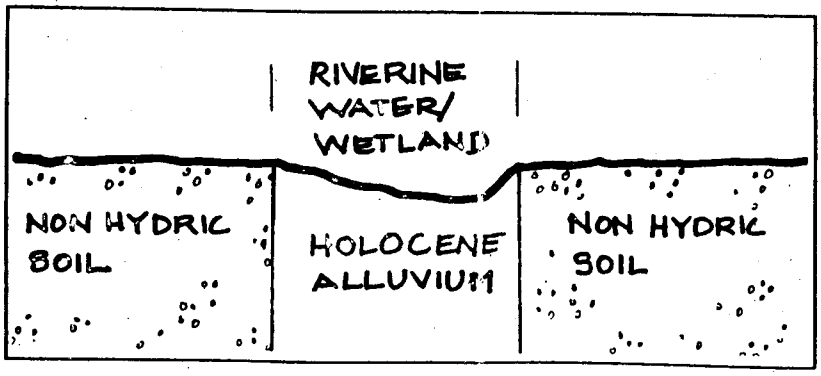
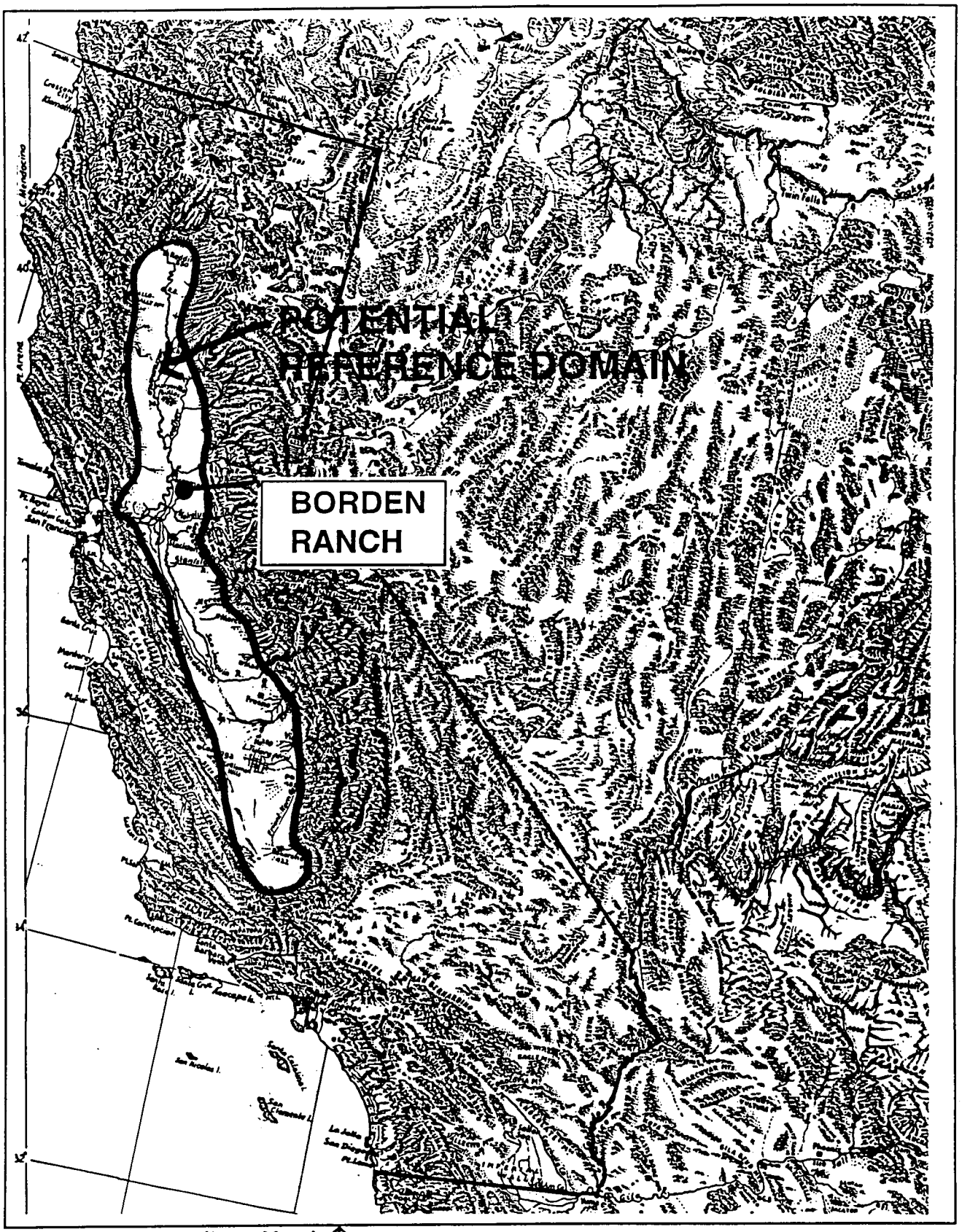


Figure 13. Potential Reference Domain



Scale 1" = 400 miles North ↑

the potential reference domain, proper application of an HGM approach requires that the draft models not be used outside their established domains until they are calibrated with appropriate reference systems. That is, until reference data are collected in other areas of the Central Valley of California and the draft models presented herein are calibrated by regional experts (*e.g.*, a regional interdisciplinary A-Team), the draft Borden Ranch models cannot be used outside of the established reference domain as defined above. Additional reference data is necessary in order to establish the link between this HGM draft Guidebook and specific ecosystem functions for similar classes and subclasses of waters/wetlands that exist outside the defined reference domain (*i.e.*, the Borden Ranch). Without additional reference sites, there are no tangible and accessible benchmarks that can be used to calibrate the functions of waters/wetlands, or to relate model scaling to reference standards that represent the highest level of functioning in the class(es) or subclass(es) in the Central Valley of California.

III. Methods

A. Identification of HGM Classes and Subclasses and Candidate Reference Sites

1. Identification of HGM Classes and Subclasses

As outlined in the introductory sections of this Guidebook, the EPA/LCLA technical team initiated field reconnaissance of the Borden Ranch site on April 10, 1997. In preparation for field reconnaissance efforts, supporting documentation was gathered and examined by team members in an attempt to develop detailed knowledge of the types and geographic distribution of waters/wetland ecosystems on the ranch. The sources and types of information examined included but was not limited to the Brinson (1993) HGM classification document, the jurisdictional delineation maps and report by Sugnet & Associates (Sugnet 1993), aerial photographs at several different scales and from several different years, U.S. Geological Survey (USGS) maps at several scales, USGS geologic survey reports, parcel ownership maps and records, NRCS soil surveys, etc. In addition, the EPA/LCLA team (1) initiated a literature search on Central Valley and California depression, slope and riverine waters/wetlands, and (2) conducted several interviews and field visits with Borden Ranch owners and their consultants.

During the reconnaissance efforts, the EPA/LCLA technical team made note of (1) typical geomorphic surfaces and (2) the geographic extent and type of land-use treatments that are present on the Borden Ranch. These treatments are summarized in Table 5. Team efforts were concentrated in both Sacramento and San Joaquin Counties, and particularly (1) in the study area identified in the AO, and (2) in areas where land preparation activities (*e.g.,* ripping, discing, irrigation system construction, etc.) were on-going since October, 1996.

Table 5. Chronological Summary of Land Treatments Observed on the Borden Ranch Property, Sacramento and San Joaquin Counties, California.

Land Use Condition	Activity	Photograph
Grazed/Preserve	Moderate to Heavy Grazing/Preserve	7
Site in Preparation	Ripped One-way	8
	Ripped Two-ways	9
	Ripped Two-ways Plowed and/or Disced	10
	Ripped Two-ways, Plowed and/or Disced and Rolled; Soil Amendments	11
	Ripped, Plowed and/or Disced, Rolled and Irrigation System Installed	12
	Ripped, Plowed and/or Disced, Rolled and Irrigation and Planted	13-14
Vineyard/Orchard	1 Year Old Vineyard/Orchard Plowed and/or Disced	13-14
	2 Year Old Vineyard/Orchard Plowed and/or Disced	
	3 Year Old Vineyard/Orchard	
	4 Year Old Vineyard/Orchard	

It became clear to the EPA/LCLA team that at least three distinct classes and potentially seven subclasses of waters/wetlands were present on the property. These are named and defined in

Figure 14.

HGM Subclasses of Depressional Waters/Wetlands at Borden Ranch, Sacramento and San Joaquin Counties, California

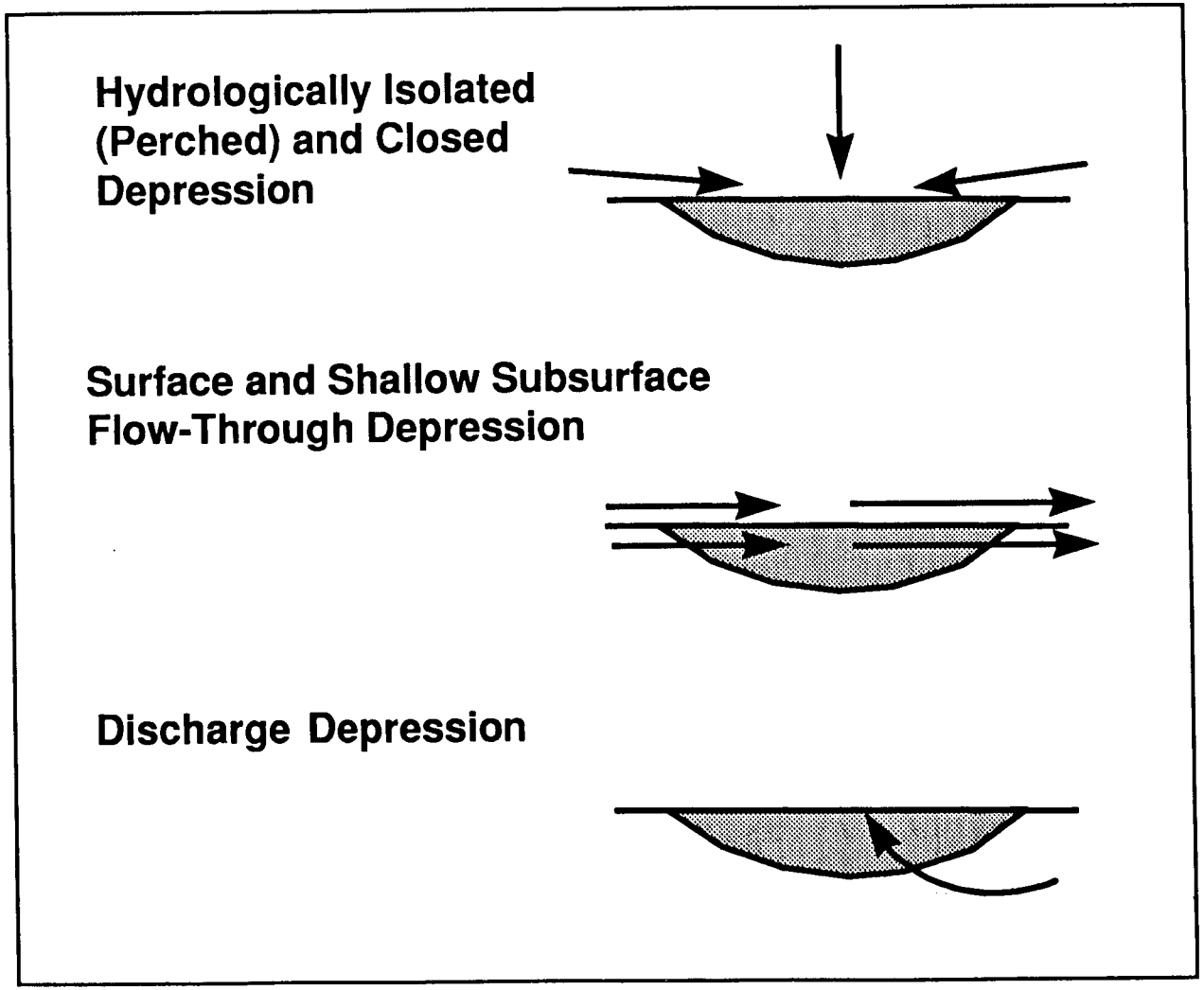


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Table 4. Figure 12 provides a generalized summary of the Borden Ranch HGM classes and subclasses, and Figures 12 & 14 provide details on the types of depressional and riverine waters/wetlands that are common on the ranch. The technical team also noted the following conditions with respect to the waters/wetland subclasses in the field:

a. The number of waters/wetlands per unit area (density) and pattern of distribution of the HGM subclasses changed at site specific and landscape scales in response to (1) geomorphic surface, (2) land use practices, (4) slope steepness, and (4) soil types.

b. The descriptions of geomorphic surfaces and correlations between geomorphic surface(s) and soil type(s) provided in the NRCS (Soil Conservation Service) Soil Surveys for Sacramento and San Joaquin Counties (Tugel 1993; McElhiney 1992) were particularly informative in setting the stage for closer examination of the subclasses of waters/wetlands that occurred in the study area at both site specific and landscape scales. Figures 15, 16, and17 and photographs 1,2,3, and 4 provide generalized summaries of the common geomorphic surfaces on the Borden Ranch. They are (1) high terrace, (2) dissected terrace face, (3) infrequently flooded Holocene terrace, and (4) frequently flooded Holocene floodways.

c. On Borden Ranch, it is important to recognize the scale at which waters/wetlands features occur on the landscape and to understand the relationship of scale to several very practical issues concerning application of an HGM assessment protocol. The slope subclasses are a case in point. (Table 4, Figure 12) The Sugnet & Associates map scale (1" = 400') often did not account for small, jurisdictional waters/wetlands that existed as slope interconnections between mapped pools. Further, definition of assessment area boundaries in these small slope areas would have required extremely detailed mapping. Costs and time investments would have been prohibitive, given the AO schedule and project budget to identify assessment area boundaries. Separation of the slopes that form the headward extent of riverine networks is relatively easy to accomplish in the field. On the other hand, separation of the slopes that form the interconnections among vernal pool depressions from the vernal pool depressions themselves is often very difficult. In any given area of the Borden Ranch, these slope interconnections can vary in size from a few feet in length and/or width to >50 feet. As discussed above, some of the interconnections among pools are jurisdictional waters/wetlands, many are not. Maintenance of the integrity of the slope interconnections is important to the functioning of flow-through depressions for several reasons (detailed in the subclass profiles below). Therefore, it was the best professional judgment of the EPA/LCLA technical team that the Borden Ranch HGM model should be responsive to scale and to the practical issues related to rapid functional assessments. Therefore, the team decided to subsume (bound) the slope interconnection subclass into the assessment area and logic for the flow-through depression models. This issue will be explained in detail in the HGM model section of this draft Guidebook.

d. On a similar note, four types of riverine waters/wetlands exist on the Borden Ranch. At a scale of 1:24,000, Borden Ranch riverine waters/wetlands exist as first, second, third and fourth order systems (Strahler 1952). For the purposes of this functional assessment study, first, second, and third order riverine ecosystems were lumped.

Figure 15. Generalized Cross-Section View of the Major Geomorphic Surfaces on the Borden Ranch, Sacramento and San Joaquin Counties, California

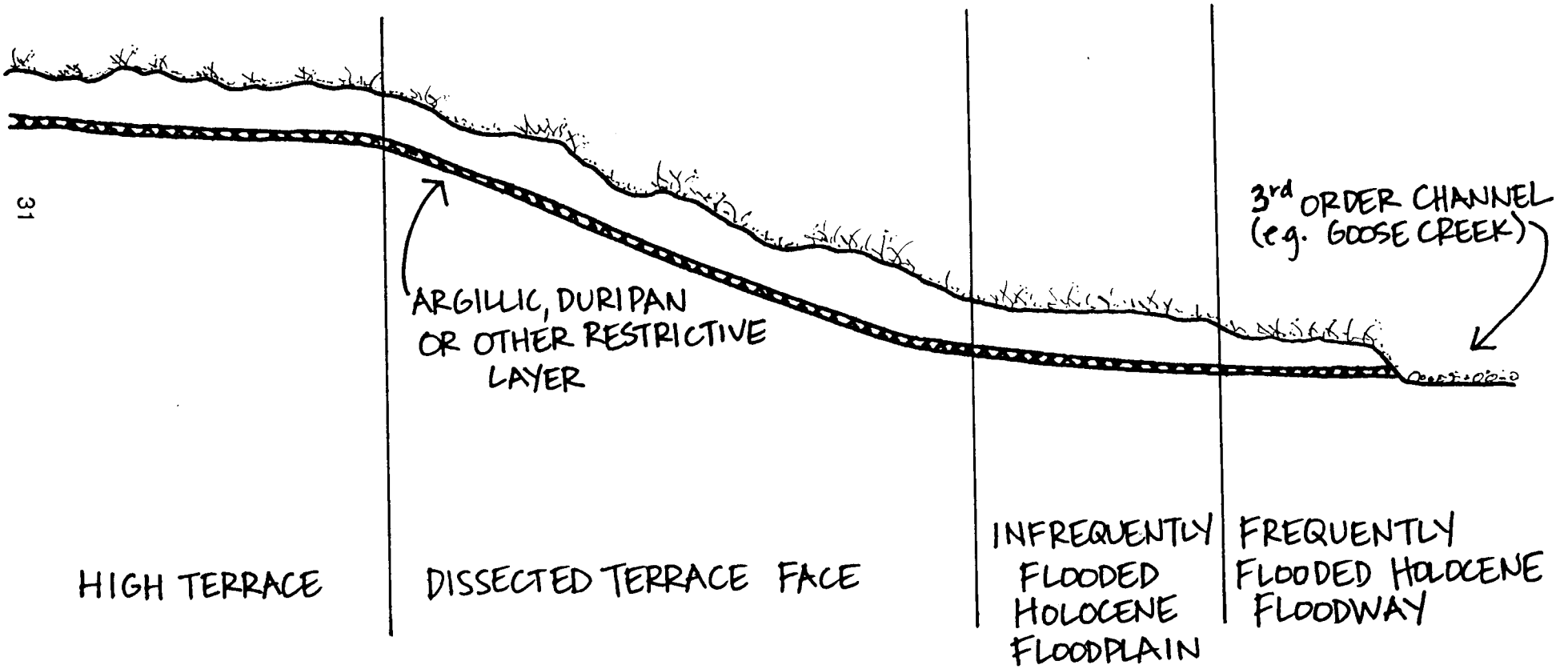


Figure 16. Geomorphic Surfaces Occurring on the Borden Ranch Property, Sacramento and San Joaquin Counties, California

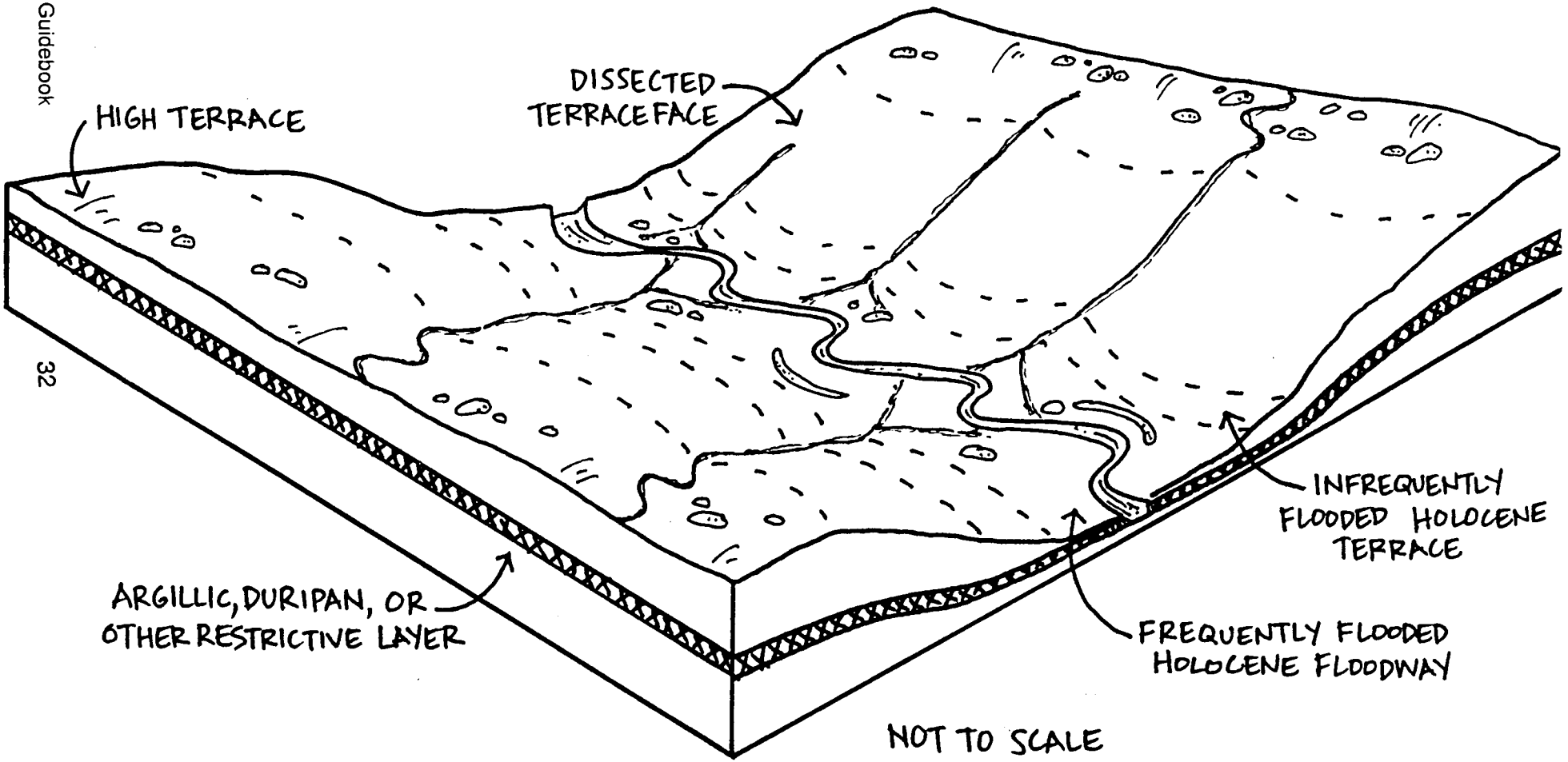
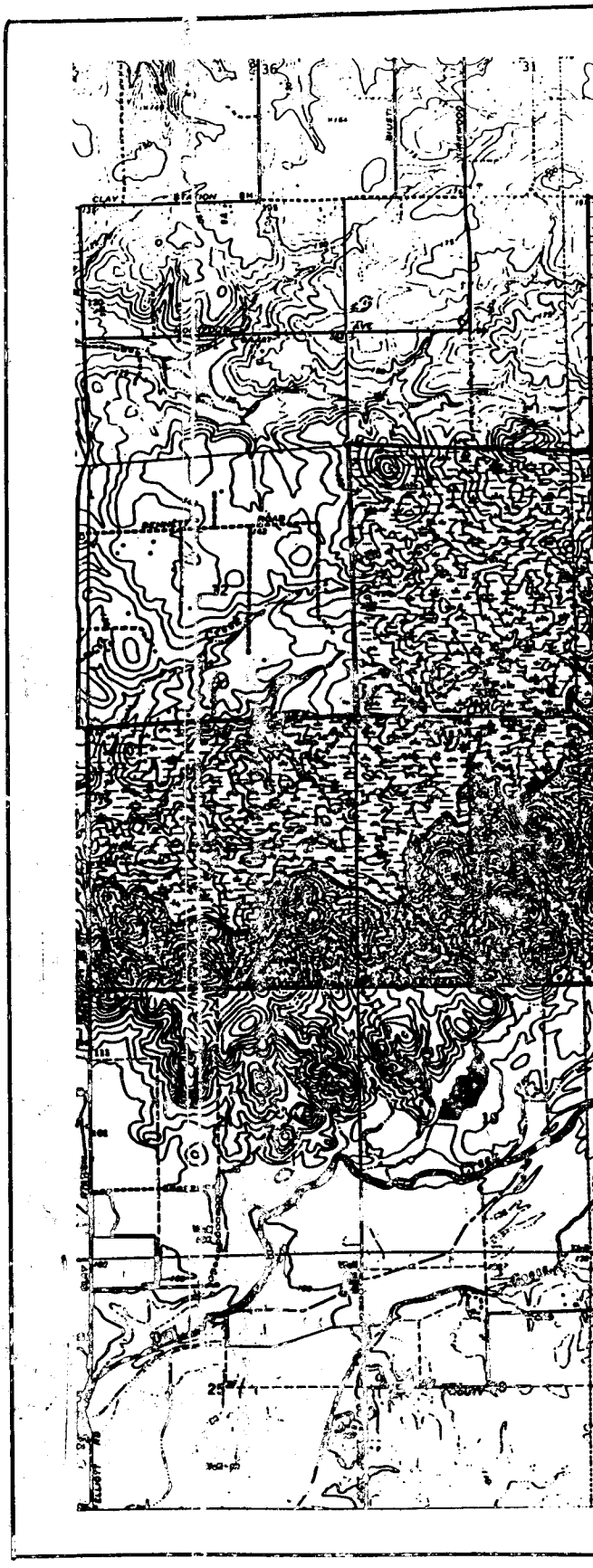


Figure 17. Geomorphic Surfaces Occurring Thre
Sacramento and San Joa



High Terrace

Dissected Terrace Face

Holocene Terrace and Floodplain

North

1 Mile

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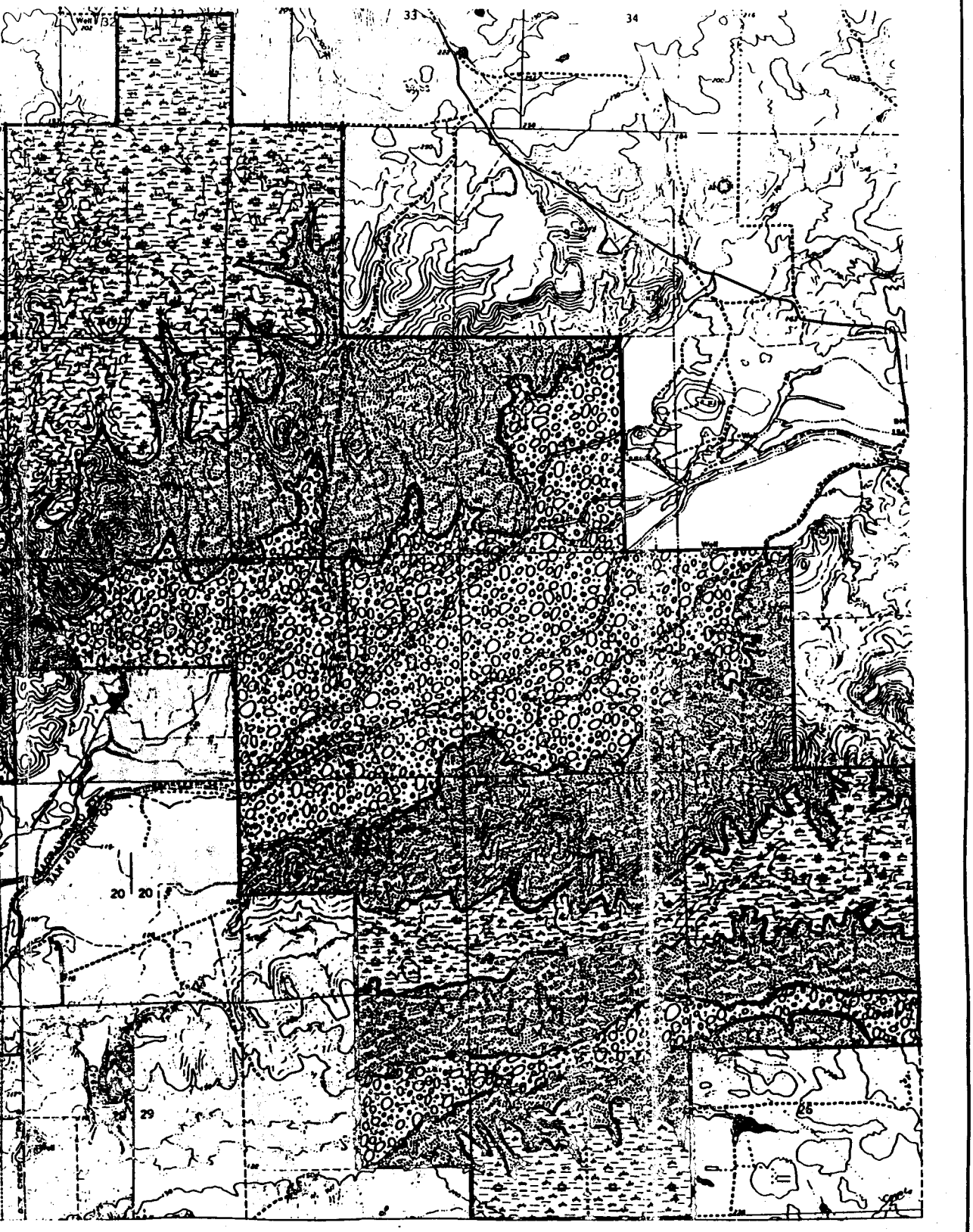
quin Counties, California



Fourth order ecosystems (*e.g.,* Dry Creek) were outside of the study area directly impacted by vineyard and/or orchard conversion operations.

e. As discussed above, there are basically three subclasses of depressions that occur on the Borden Ranch: hydrologically isolated (perched) and closed (Photograph 5), surface and shallow subsurface flow through (Photograph 6), and discharge (Table 4, Figures 12 and 14). By far, the most common types of depressions are closed/isolated and surface and shallow subsurface flow through (Photograph 6). Discharge depressions are very rare and unique on Borden Ranch. Because of their unique status on the landscape, discharge depressions were not included in the sampling or logic for the draft HGM models presented herein.

2. Chronological Sequence of Land-Use Treatments

A chronological sequence of land-use treatments that runs the gamut from moderately to heavily grazed pasture to vineyards in their 4th full growing season occurs (Photographs 7,8,9,10,11,12,13, and 14) on the Borden Ranch. Table 5 provides a summary of major land use conditions that the EPA/LCLA team found on the ranch. The EPA/LCLA team quickly developed familiarity with the common land-use practices and landscape positions on the Borden Ranch. With this background, team members found it relatively easy to distinguish among the various stages of development associated with conversion of pastures to vineyards. Thus, through field observations and with the assistance of information provided by Borden Ranch management staff, the chronological sequence of conversion activities was noted for each reference site.

B. Field Methods for Reference Sampling

Appendix A consists of the field data sheets used by the EPA/LCLA team to sample reference depressions, slopes, and riverine waters/wetlands on Borden Ranch. These data sheets were developed specifically for the Borden Ranch project, and reflect the EPA/LCLA team's best effort to capture field data that would be adequate to (1) build a first approximation reference system for each subclass of waters/wetland, and (2) support quantitative and qualitative scaling of the variables that are combined to estimated functions in the draft HGM models. The discussions of methods that follow are keyed to the data sheets in Appendix A.

1. Hydrology

a. Depressional Waters/Wetlands

(1) Identification Of Subclass and Geomorphic Setting

Each of the 30 depressional waters/wetlands reference sites was classified as either a hydrologically isolated (perched) and closed depression or a flow-through depression in the field. On Borden Ranch, closed contour and hydrologically isolated (perched) and closed depressions (Photograph 5) can occur on any geomorphic surface. They tend to occur most frequently in topographic lows with closed contours. They are frequently associated with low-permeability deposits. If, because of subtle microtopography or recent perturbation, any team members had doubts as to whether a particular depression had an outlet, then the EPA/LCLA

team convention was to use a David White Auto Laser 500 Model AEL-500 Laser level to determine elevations of closed contours and/or outlet locations.
Hydrodynamics in the closed/isolated depressions are dominantly vertical. The dominant hydrologic inputs are precipitation and surface and shallow subsurface flow from adjacent non-wetlands. The dominant hydrologic output is evapotranspiration.

Flow-through depressions (Photograph 6) occur in topographic lows with closed contours and low-permeability deposits, but inlets and outlets are present that allow water to flow into and out of the depression during periods of high water. The dominant hydrodynamics are vertical, although unidirectional flows can exist during high water events. The dominant hydrologic inputs are precipitation, surface and shallow subsurface flow from adjacent non-wetlands, and surface and shallow subsurface flow from up-gradient swale features. The dominant hydrologic outputs are evapotranspiration and surface and shallow subsurface flow through down-gradient swale features.

During the reference site sampling effort, geomorphic setting was determined by consulting topographic maps and the appropriate soil survey. Additionally, surface and shallow subsurface features of the assessment site and the immediately surrounding area were noted. Terminology and definitions used for descriptions of topographic settings, geomorphic surfaces, etc. are consistent with guidance provided by the Natural Resource Conservation Service (NRCS).

At each reference site, the shape of the depression was described as either concave or complex (Figure 18). Depressions were classified as concave if the depression bottom was relatively smooth. Depressions were classified as complex if the depression bottom undulated and contained non-wetland islands.

Abney and/or laser levels were used to measure depression slope(s) and a Silva Ranger compass was used to measure the true azimuth of the topographic fall line. Because depressional waters/wetlands on the Borden Ranch primarily occur in relatively level landscape positions (*e.g.*, high terraces), slope and azimuth measurements generally were not applicable or particularly informative.

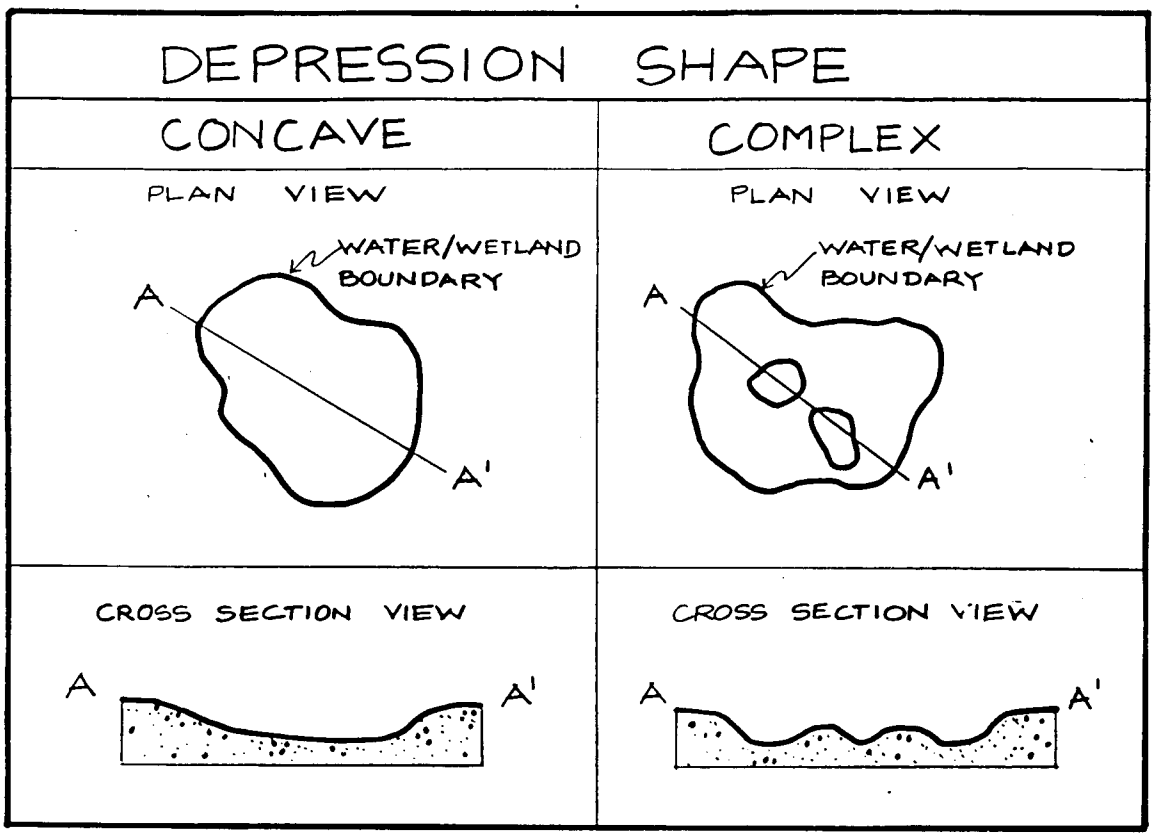
(2) Depression Dimensions

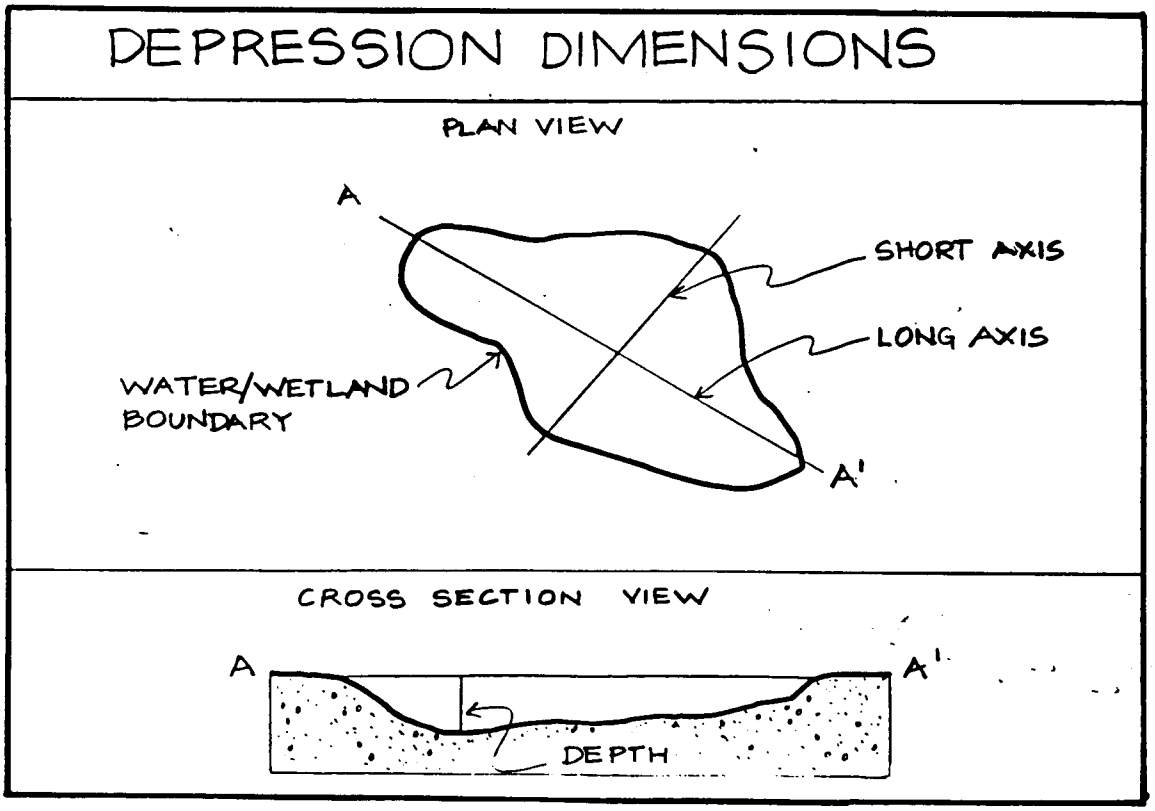
Long-axis and short-axis lengths of depressions were taken by measuring the planar distances between the waters/wetlands boundaries (Figure 18). Maximum depth was determined by measuring the maximum depth below the plane formed during the long-axis and short-axis measurements (Figure 18). Area and volume of the depression were calculated by assuming that depressions are (1) ellipses in plan view and (2) one half of an ellipsoid feature cut lengthwise when viewed in three dimensions.

(3) Depression Inlet and Outlet

Inlets and outlets were defined as swale features that connected the assessment site to other waters/wetlands. The team noted whether swale features were waters/wetlands or non-waters/wetlands. The relationship of the outlet elevation to the wetland jurisdictional boundary was determined by surveying several elevations along the waters/wetlands boundary, determining a mean elevation of the boundary, and surveying the relative elevation of the crest in the outlet swale feature. If necessary, the laser level was used.

Figure 18. Methods for Determining Depression Shape and Measuring Long and Short Axis Depression Dimensions





(4) Depression Water/Wetland Land Use, Buffer, and Contributing Area Characteristics

(a) Water/Wetland Land Use

The predominant land use and condition of the water/wetland was scored according to a disturbance scale that was described on the data sheet.

(b) Depression Buffer

Buffer widths were defined as 20 feet or to the top of the contributing area, whichever was the lesser distance (Figure 19). Buffer continuity is expressed as a percentage determined by dividing (a) the distance around the water/wetland edge that is bounded by a buffer divided by (b) the total distance around the water/wetland edge. In order for it to exist, the buffer must (1) be greater than one foot wide, (2) be grassland, (3) show no evidence of increased extent and/or rate of sediment deposition, and (4) have unfractured restrictive layers (*e.g.* argillic or durapan layers). The distance to disturbance was determined by measuring from the water/wetland boundary to the nearest disturbance within the buffer. This was performed at several points for each depressional water/wetland and a mean distance to disturbance was reported. The percent of disturbed buffer was calculated by dividing the mean distance from the waters/wetlands boundary to disturbance by the mean buffer width and subtracting that number from 100 (percent). The height of the forbs, graminoids, ferns, and fern allies in the buffer was measured in tenths of feet at a number of points and the mean height was reported. Percent cover of the forbs, graminoids, ferns and fern allies was visually estimated. Finally, the predominant land use and condition of the buffer was scored according to a disturbance scale that was included as a footnote on the data sheet.

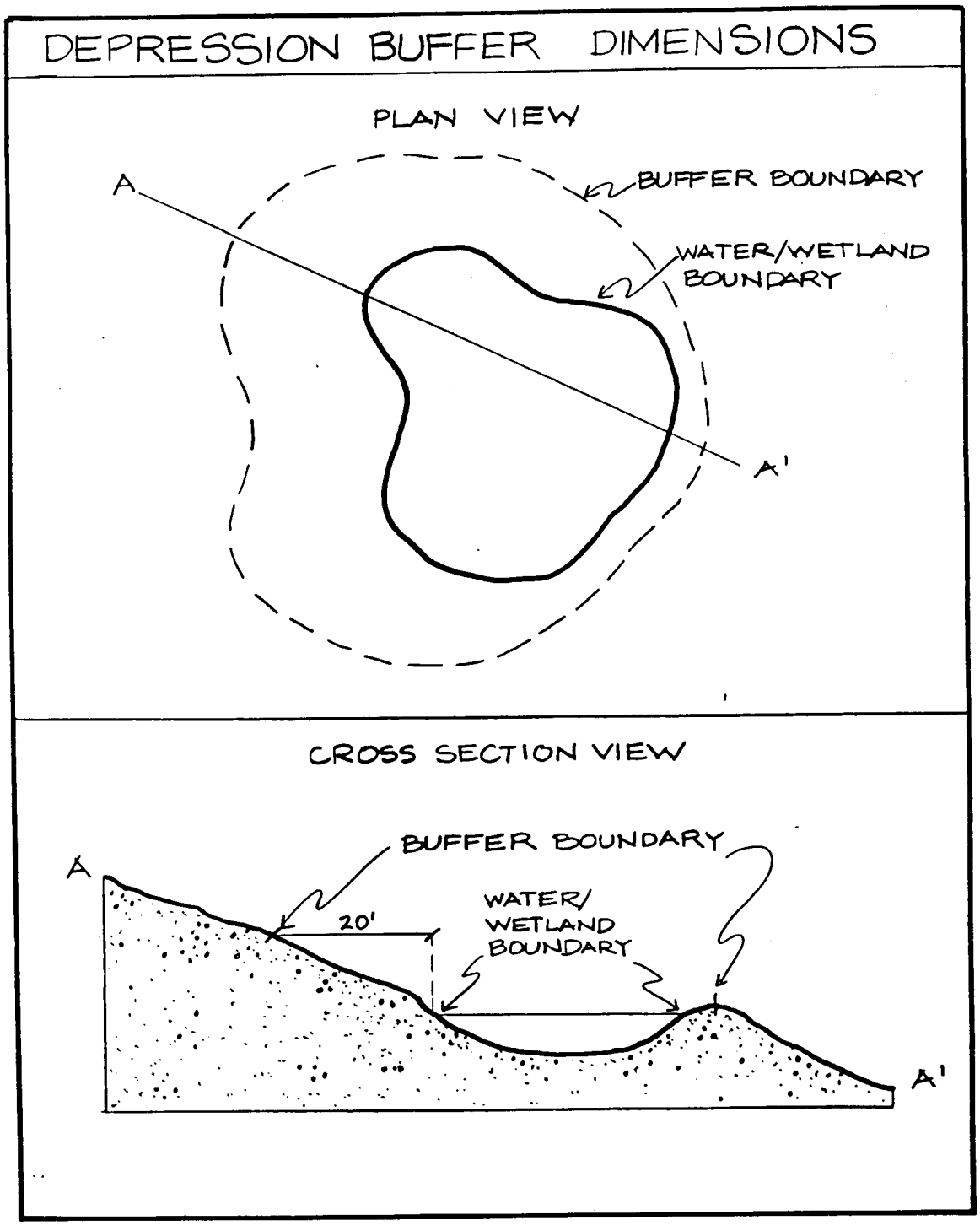
(c) Depression Contributing Area

The (hydrologic) contributing area was defined as that area that collects water and drains via surface and shallow subsurface flow to the depressional water/wetland. The predominant land use and condition of the contributing area was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A). If the predominant land use in the contributing area potentially could have altered the hydroperiod, then these potential alterations were briefly described.

(5) Hydrologic Connections of Depressions to Down-Gradient Waters/Wetlands

Flow-through depressions often are connected to down-gradient waters/wetlands through swale features that are either waters/wetlands or non-waters/wetlands (Photograph 6). Hydrologic connections to down-gradient waters/wetlands were assessed by reviewing the Sugnet & Associates delineation maps and by making field observations. The subclass(es) of waters/wetlands that were located down-gradient were described, and the predominant use and condition of the hydrologic connection was scored according to a disturbance scale that was included as a footnote on the data sheet.

Figure 19. Methods for Measuring Depression Buffer Dimensions



(6) Depression Microtopography

Microtopographic characteristics of depressions (Photographs 5 and 7) were measured by surveying changes in ground surface elevation with a laser level. Microtopography transects were established along the long axis, the short axis, and as a typical cross-section of the swale outlet feature if applicable (Figure 20). Microtopography was surveyed at intervals that allowed accurate description of the ground surface. No fixed intervals were specified.

(7) Identification of Depression Boundaries

Where there were distinct and observable changes in landscape form from depression to riverine class, the EPA/LCLA team described and measured the riverine waters/wetlands features. See B.7. below for a description of criteria that commonly indicated a change in wetland class.

b. Slope Waters/Wetlands

(1) Slope Geomorphic Setting

The geomorphic setting of slope waters/wetlands was determined in a manner similar to that for the depressional waters/wetlands described above. The EPA/LCLA team regularly referred to pertinent topographic maps and soil surveys. Additionally, surface and shallow subsurface features of the assessment site and the immediately surrounding area were noted. Terminology and definitions are consistent with guidance provided by the Natural Resource Conservation Service (NRCS).

(2) Slope Contributing Area

The contributing area for slope waters/wetlands is defined as the area that collects water and drains via surface and shallow subsurface flow to the slope water/wetland. The predominant land use and condition of the contributing area was scored according to a disturbance scale that was included as a footnote on the slope data sheet (Appendix A). If the predominant land use and condition of the contributing area potentially could have altered the hydroperiod, then these potential alterations were briefly described.

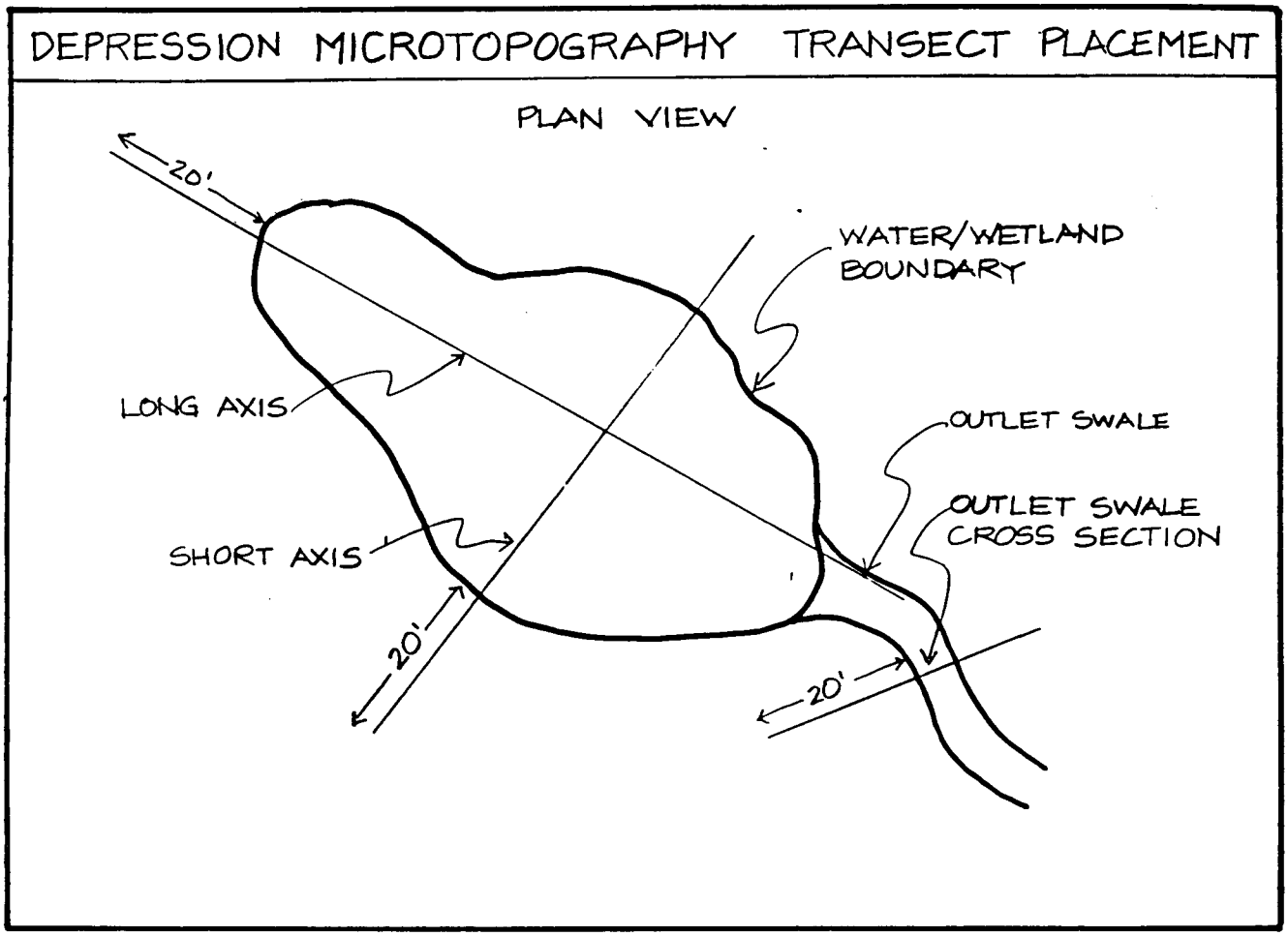
(3) Hydrologic Connections of Slope Waters/Wetlands to Down-Gradient Waters/Wetlands

Slope waters/wetlands often are connected to down-gradient waters/wetlands through swale features that are either waters/wetlands or non-waters/wetlands (Photograph 15). Hydrologic connections to down-gradient waters/wetlands were assessed by reviewing delineation maps and making field observations. The subclass(es) of waters/wetlands that were located down-gradient were described, and the predominant land use and condition of the connection was scored according to a disturbance scale that was included as a footnote on the data sheet.

(4) Slope Buffer Characteristics

Slope buffer widths were defined by the EPA/LCLA technical team as 20 feet or to the top of the contributing area, whichever was the shorter distance. Slope buffer continuity is defined as the

Figure 20. Methods for Measuring Depression Microtopography



distance around the water/wetland edge that is bounded by a buffer divided by the total distance around the water/wetland edge (expressed as a percentage). The buffer must (1) be greater than one foot wide, (2) be grassland, (3) show no evidence of increased extent and/or rate of sediment deposition, and (4) have an unfractured restrictive layer(s) (*e.g.,* unfractured argillic or durapan layers). The distance to disturbance was determined by measuring from the water/wetland boundary to the nearest disturbance within the buffer. This was performed at four points and a mean distance to disturbance was reported.

The percent of the buffer that was disturbed was calculated by multiplying the distance to the disturbance (at the four observation points) by the length of the assessment area (100feet for the slope subclass). These measurements capture the area of buffer that remains undisturbed. This undisturbed buffer area was subtracted from 4000/ft^2, the total possible buffer area for the slope assessment reach (i.e., the total possible buffer area is 20 feet wide (the buffer width by definition) multiplied by 100 feet long (the length of the assessment area for the slope class) multiplied by 2 (each side of the water/wetland). This number was then divided by 4000ft^2 and multiplied by 100 in order to report the percentage of the total buffer that was disturbed.

The height of the forbs, graminoids, ferns, and fern allies in the buffer was measured in tenths of feet at a number of points and the mean height was reported. Percent cover of the forbs, graminoids, ferns, and fern allies was visually estimated. Finally, the predominant use and condition of the buffer was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A).

(5) Slope Microtopography

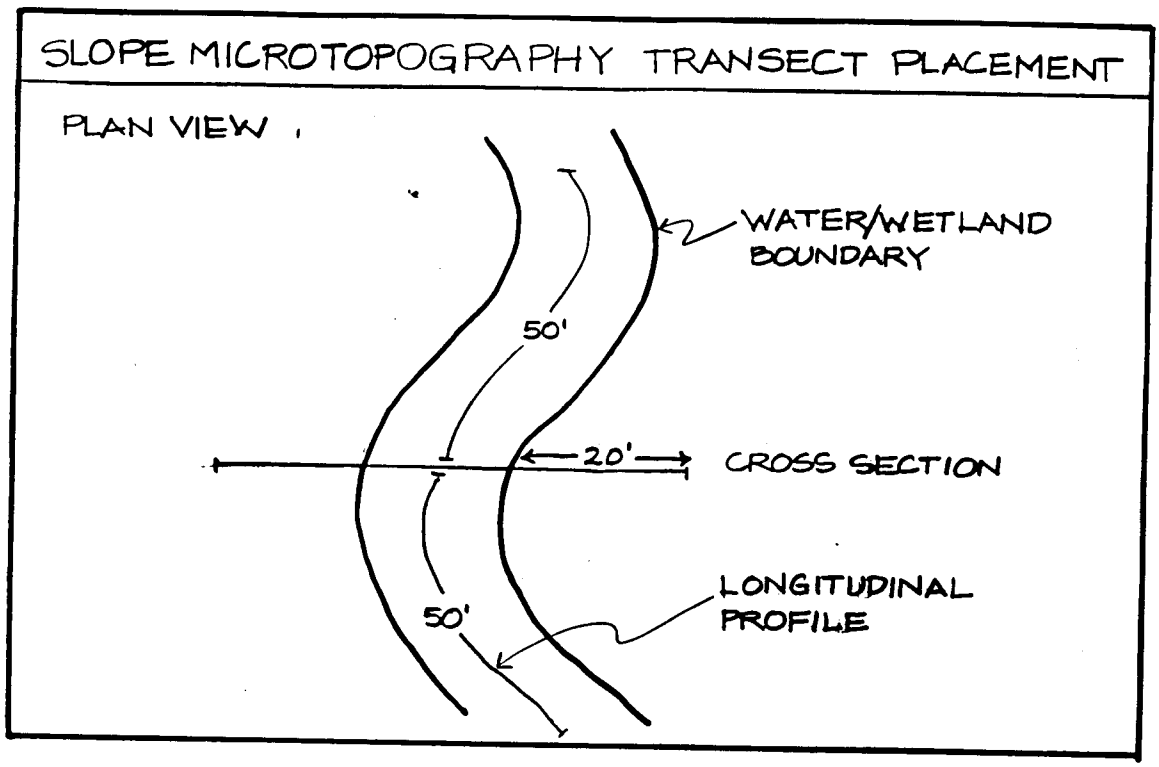
Microtopography of slope waters/wetlands was measured by surveying changes in ground surface elevation with a laser level. Microtopography transects were established as typical cross-sections and typical longitudinal profiles (Figure 21). Stations were surveyed at intervals that allowed accurate description of the ground surface. No fixed intervals were specified. Cross-sectional transects encompassed the width of the water/wetland and 20 foot buffers on each side. The default distance for the longitudinal profile transects was 100 feet.

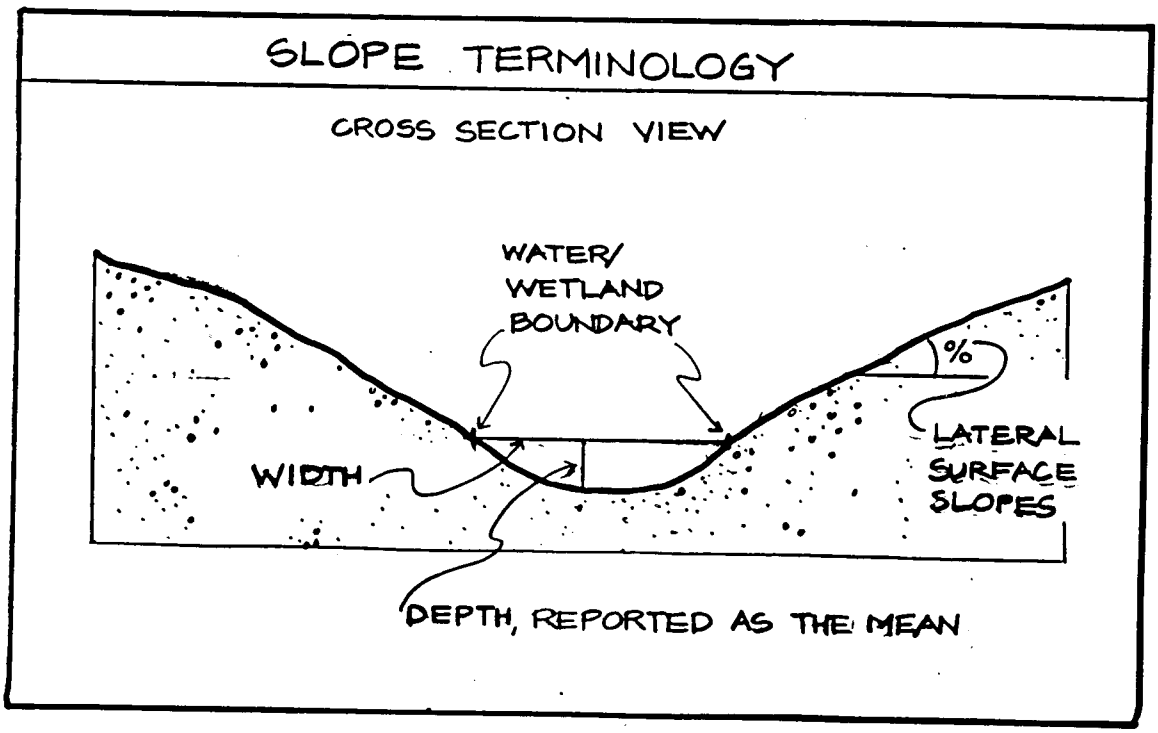
(6) Slope Water/Wetland Characteristics

The predominant use and condition of the water/wetland was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A). It was noted if the assessment site was potentially a sediment source, as well as if there was a change in subclass from slope water/wetland to riverine water/wetland due to formation and maintenance of bed and bank features. However, the assessment site was assessed as a slope water/wetland as long as the change to riverine water/wetland (*i.e.*, the formation and maintenance of bed and bank features) was apparently caused by land use activities.

Additional data were calculated from surveyed measurements of slope waters/wetlands. Mean water/wetland width was determined by measuring the planar distance between the waters/wetlands boundaries, while mean water/wetland depth was determined by taking multiple measurements of depths below the plane formed during the width measurement. Mean lateral surface slopes were measured using an Abney level. Mean longitudinal surface slope was calculated from the longitudinal profile transect.

Figure 21. Methods for Assessing Slope Microtopography and Morphometry





(7) Identification of the Riverine Water/Wetland Subclass

The EPA/LCLA technical team recognized, described, and measured riverine water/wetland features where there were distinct and observable changes in landscape form and position from either depression(s) to riverine or slope(s) to riverine subclasses. The most obvious field criteria that triggered recognition of a change in subclass was (1) expression of riverine sediment dynamics (*e.g.*, import, transport, storage and export) and other fluvial processes (*e.g.*, flowing water), and (2) formation and maintenance of channel bed and bank features. Riverine features were described as discontinuous or continuous, and the length of the features was measured in the field. All other measurements reported in the riverine water/wetland characteristics section of the data sheet were performed as described for riverine waters/wetlands (Section IC, below).

c. Riverine Waters/Wetlands

(1) Riverine Geomorphic Setting

The geomorphic setting associated with the riverine subclass on the Borden Ranch was determined by field observations of landscape position and through referral to topographic maps and soil surveys. Additionally, surface and shallow subsurface features of the assessment area and immediately surrounding areas were noted. As with depressions and slopes, terminology and definitions are consistent with guidance provided by the NRCS.

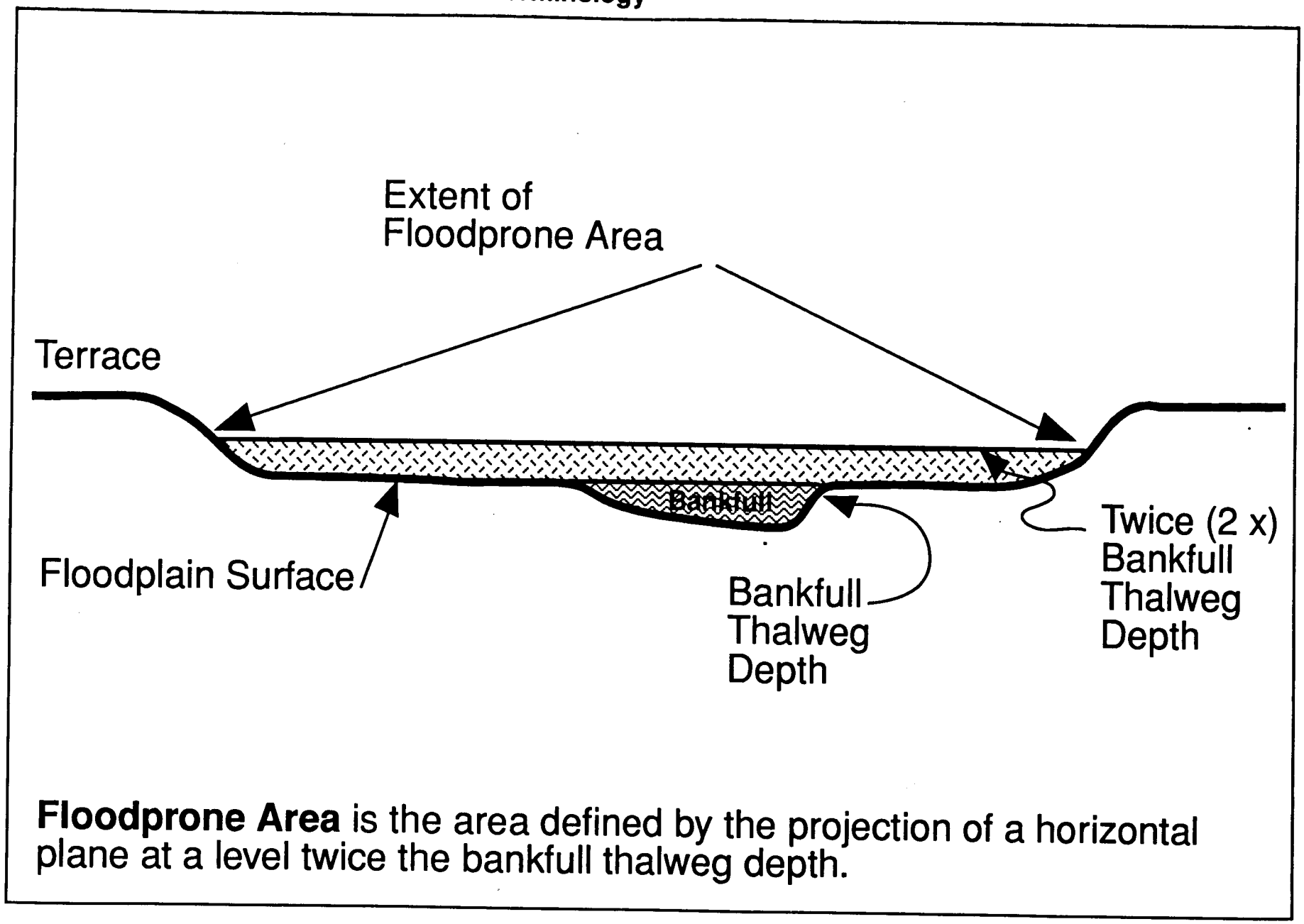
(2) Riverine Cross-Section Measurements

Riverine cross sections were calculated from field survey measurements. Water/wetland width was determined by measuring the planar distance between the waters/wetlands boundaries at regular intervals and finding the mean. Mean water/wetland depth was determined by taking multiple measurements of depths below the plane formed during the width measurement. Floodplains were defined as flat depositional surfaces that tend to occur near the ordinary high water mark. Extensive floodplains are uncommon in the riverine waters/wetlands of the Borden Ranch, but the widths of the floodplains were measured when they were observed. The floodprone area was defined by projecting a horizontal plane at twice the maximum ordinary high water (thalweg) depth. This is the area that has been empirically shown to flood at relatively regular intervals in a variety of hydrophysiographic provinces (Dunne and Leopold 1978; Rosgen 1994). Figure 22 offers a summary of metrics used in characterizing the cross sectional geometry of the riverine subclass on Borden Ranch.

Most of the rivers on the Borden Ranch are erosional rather than depositional (Photograph 16). Consequently, bank tops were defined as the pre-erosional surface. Bank heights were measured as the depth from the pre-erosional surface to the deepest point in the channel. Bank slopes were measured from the break in slope at the top of the bank to the break in slope at the bottom of the bank. Lateral surface slopes were measured using either Abney or laser levels.

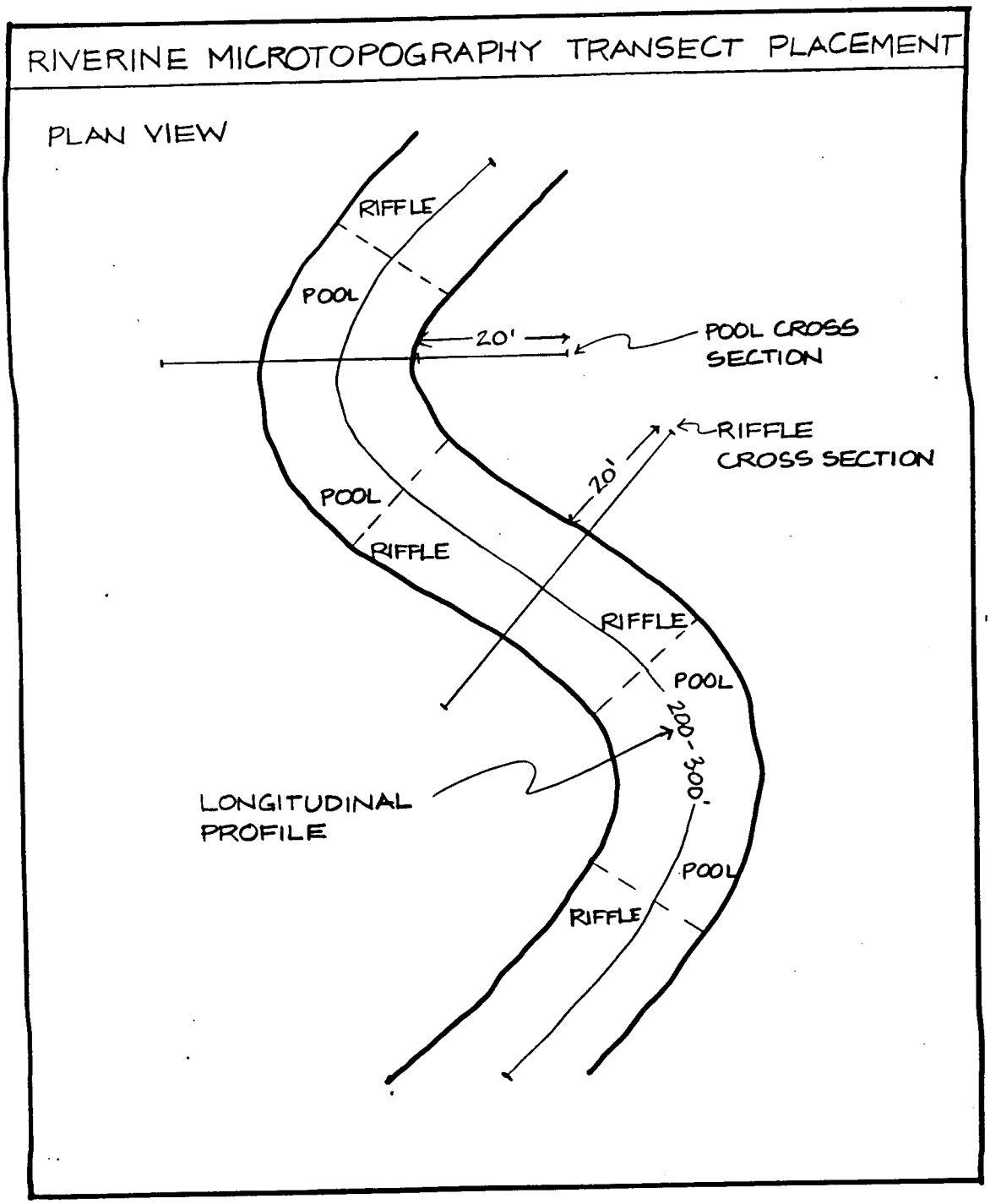
Measurements reported in the longitudinal profile section of the data sheet also were calculated from surveyed measurements (Figure 23). Reach length was measured in the field and was

Figure 22. Riverine Waters/Wetlands Terminology



Floodprone Area is the area defined by the projection of a horizontal plane at a level twice the bankfull thalweg depth.

Figure 23. Methods for Measuring Riverine Microtopography



used to bound the longitudinal length of the assessment site. Pool and riffle lengths were measured at the same time. Longitudinal surface slope was calculated from the longitudinal profile transect.

(3) Riverine Drainage Area/Contributing Area Characteristics

The drainage area/contributing area for the riverine subclass at Borden Ranch is defined as that area that collects water and drains via surface and shallow subsurface flow to the riverine water/wetland. Simply, it is the watershed area that contributes runoff to the riverine system in question. The predominant use and condition of the contributing area was scored according to a disturbance scale that was included as a footnote on the riverine data sheet (Appendix A). If the predominant use and condition of the contributing area potentially altered the hydroperiod, then these potential alterations were briefly described. Additionally, the spatial relationship and orientation of furrows and/or ripped areas to the water/wetland was noted.

(4) Riverine Assessment Site Characteristics

The predominant use and condition of the water/wetland was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A). The presence or absence of a terminal or "dead" furrow that could disconnect the riverine water/wetland from surface and shallow subsurface drainage from the contributing area was noted, and the rate of sediment delivery to the water/wetland was scored according to a scale provided on the data sheet.

(5) Riverine Buffer Characteristics

Buffer widths for the riverine subclass were defined as a 20 feet or to the top of the contributing area, whichever was the shorter distance. Buffer continuity is defined as the distance around the water/wetland edge that is bounded by a buffer divided by the total distance around the water/wetland edge (expressed as a percentage). The buffer must (1) be greater than one foot wide, (2) be grassland, (3) not have evidence of increased extent and/or rate of sediment deposition, and (4) have an unfractured restrictive layer (*e.g.*, unfractured argillic and/or durapan layers). The distance to disturbance was determined by measuring from the water/wetland boundary to the nearest disturbance within the buffer. This was performed at four points and a mean distance to disturbance was reported.

The percent of the buffer that was disturbed was calculated by dividing the area of the disturbance (at the four observation points) by the total area. These measurements capture the area of buffer that remains undisturbed. This undisturbed buffer area was subtracted from 8000 ft^2, the total possible buffer area for the riverine assessment reach (i.e., the total possible buffer area is 20 feet wide (the buffer width by definition) multiplied by 200 feet long (the length of the assessment area for the riverine class) multiplied by 2 (each side of the water/wetland). This number was then divided by 8000 ft^2 and multiplied by 100 in order to report the percentage of the total buffer that was disturbed.

The height of the forbs, graminoids, ferns, and fern allies in the buffer was measured in tenths of feet at a number of points and the mean height was reported. Percent cover of the forbs,

graminoids, ferns, and fern allies was visually estimated. Finally, the predominant use and condition of the buffer was scored according to a disturbance scale that was included as a footnote on the data sheet.

(6) Hydrologic Connections of Riverine Waters/Wetlands to Down-Gradient Waters/Wetlands

Hydrologic connections from riverine reference sites to down-gradient waters/wetlands were assessed by reviewing delineation maps, air photos, and through direct field observations. The predominant use and condition of the connection was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A), and disruption(s) to the connection were noted and described.

(7) Riverine Microtopography

Microtopographic characteristics for the riverine subclass were measured by surveying changes in ground surface elevation with a laser level. Microtopography transects were established as typical cross-sections in pools and riffles and typical longitudinal profiles (Figure 23). Microtopography was surveyed at intervals that allowed accurate description of the ground surface. No fixed intervals were specified. Cross-sectional transects encompassed the width of the water/wetland and 20 foot buffers on each side. The default distance for the longitudinal profile transects was 100 feet.

(8) Pebble Count

The channel particle size distribution was determined by performing a pebble count. The pebble count procedure entails walking down the channel in a random or zig-zag pattern. Samples were collected by reaching down to a point in front of the toe with eyes closed or averted and touching the channel substrate with an extended finger. The first particle that was touched was picked up and measured in millimeters along its intermediate axis (*i.e.*, neither the longest nor shortest axis). The measurement was recorded as the lower limit of the size class into which the rock falls.

2. Soils

a. Depression, Slope, and Riverine Waters/Wetlands

The general methods and data sheets used in the collection of soils information were consistent between depressional, slope, and riverine waters/wetlands (Appendix A). The exact soil sampling protocols varied slightly among subclasses of waters/wetlands and when perturbations to systèms associated with soil ripping, discing, and cultivation required alternative methods. In general, the goals of the soils investigations were to characterize modal soil conditions at each sample site and to place observed conditions in the soils in the context of the surrounding landscape, geomorphic surface(s), and land-use practices.

At each sample site, a main soil pit was excavated by hand to the depths possible in the dry season using shovels, augers, and standard excavation tools. If possible, adjacent cut faces or other landscape features that would allow a deeper look into the soil profile were examined, and conditions were noted. In addition to the main pit, several ancillary pits were excavated or

probed in an attempt to characterize the condition of restrictive layers and/or to confirm observations taken at the main pit. Landscape position and land-use practices were carefully noted.

(1) Soil Survey And Taxonomy

The Sacramento and San Joaquin County Soil Surveys (Tugel 1993, McElhiney 1992) and the arrays showing SCS soil types provided on the Sugnet and Associates delineations maps were used throughout this project. All reference sites were located on the appropriate soil survey maps and the mapped NRCS soil type was noted. The mapped NRCS soil type was confirmed or rejected for the assessment site following the soil pit excavation and description. Acceptance or rejection of the NRCS mapped soil was accomplished by comparing the field data to the soil type description published in the soil survey. Hydric soils were identified using standard criteria provided in the U.S. Army Corps of Engineers Wetland Delineation Manual (Corps 1987) and more recent guidance and technical documentation (*e.g.,* Hurt *et al.* 1996).

The Keys To Soil Taxonomy (USDA, NRCS 1996) served as the guide to all soil taxonomic decisions and nomenclature. In addition, Dr. Lee met with the NRCS Soil Survey Staff in Davis, California, and with technical staff of the NRCS Wetland Institute, Laurel, Maryland to clarify technical issues regarding (1) approaches for description of ripped soils, (2) definition and characterization of truncated soil profiles, and (3) field recognition and characterization of argillic and duripan layers characteristic to the Borden Ranch landscape.

(2) Geomorphic Setting

Geomorphic setting was determined in the field by consulting topographic maps and soil surveys. Additionally, surface and shallow subsurface features of the assessment site and the immediately surrounding area were noted. Terminology and definitions were consistent with guidance provided by the NRCS.

(3) Evidence of Flooding, Ponding and Saturation

Evidence of the occurrence of flooding, ponding and saturation and an estimate of the duration of each were noted in the field. Evidence of flooding, ponding, or saturation occurrence and duration included, but were not limited to, direct observations, presence or absence of hydric soils, presence of algal mats on soil surfaces, water-stained organic material, drift lines, erosion features, and sediment deposits.

(4) Organic Matter

Throughout this study, organic matter was defined to include all non-living and/or senescent vegetative material accumulated on the soil surface. This definition included algal crusts common in areas where water ponded for long duration. The percent cover of the organic mat was estimated visually in an area immediately surrounding the main soil pit. The thickness of the organic mat was measured and the predominant source of the organic material was noted at the main soil pit.

(5) Restrictive Layer

The presence or absence of a restrictive layer was noted (Photograph 17). For the purposes of this study, the term "restrictive layer" was defined to include (1) argillic and duripan layers in truncated soil profiles, and (2) abrupt soil textural changes that would perch water. At each site the team estimated the degree to which the restrictive layer was fractured in the water/wetland and in the buffer following the excavation of a series of small pits and or probe holes. Often, and especially because of the dry soil conditions experienced in the field for the duration of the study, it was impossible to distinguish between argillic, duripan, and/or lithic contact at depth. When these circumstances occurred, it was standard practice of the EPA./LCLA team to note the presence or absence of a restrictive layer and to estimate its condition, regardless of its exact composition.

(6) Approximate Area and Volume of Fill in the Reference Sites

The approximate area and volume of sediment input and/or "fill" was determined by field measurements. Approximate areas of fill were determined through measurements of aerial coverage. The approximate depths of fill were measured by probing or with small soil pits in a few areas, and a mean depth of fill was calculated. Approximate volumes of fill or sediment were determined by multiplying the aerial coverage of fill by the mean depth of fill.

(7) Soil Profile Characterization

Given the dry soil conditions that existed throughout this study, soil pits were excavated by hand to practicable depths. This usually resulted in pits to the depth of the restrictive layer. Identification and nomenclature of the soil horizons were consistent with NRCS guidance (Tugel 1993; McElhiney 1992; USDA, NRCS 1996). Soil colors were determined from moist samples using Munsell soil color charts (Munsell 1994).

3. Flora and Fauna

a. Depression, Slope, and Riverine Waters/Wetlands

As with soils methods detailed above, the field sampling approaches and data sheets used in the collection of information concerning flora and fauna were consistent among depression, slope, and riverine waters/wetlands subclasses (Appendix A). The principal objective of the sampling efforts for vegetation was to characterize the abundance, structure, and species composition of the dry phase plant communities at each reference site. All plant taxonomic nomenclature and species identifications for this study follow the Jepson Manual (Hickman 1993).

With respect to the faunal community, sampling focused on observation of direct evidence of use of the sample site by faunal species (*e.g.,* direct observation of an animal in the waters/wetland). In the absence of direct observation, sign, scat, tracks, beds, kills, browse, and other types of indirect evidence of use of the water/wetlands was recorded. No trapping efforts, incubations, or formal observation intervals were possible in the context of the AO schedule.

(1) Vegetation Presence and Abundance

Because both plant abundance and species composition change across the stages of the hydrologic cycles characteristic to all subclasses of waters/wetlands on the Borden Ranch, two approaches were used to characterize vegetation presence and abundance. To assess abundance, only those individuals that were living (*i.e.*, actively photosynthesizing and/or reproducing) were measured. No attempt was made to measure the abundance of non-living plant materials. The height of the forbs, graminoids, ferns, and fern allies in the water/wetland was measured in tenths of feet at a number of points and the mean height was reported. Percent cover of forbs, graminoids, ferns and fern allies, algal crust, and bare ground was visually estimated at a number of points, and the mean percent cover was reported. Percent cover estimates of bare ground included areas that were covered with non-living plant materials.

To assess species composition, a list of dominant taxa was made at each site. Living plants were identified to species whenever possible; if identifications could not be made on-site, vouchers were collected and identifications verified later. Plants were identified to the lowest taxonomic category possible, given the condition of the vegetation. Senescent or non-living individuals were therefore occasionally identified only to family or genus level.

(2) Habitat Components and Faunal Evidence

Each reference site was scanned for habitat components (*e.g.,* vegetation structure and composition) and evidence of use by faunal species. For example, in addition to direct observations of animals, indirect evidence such as tracks, scat, beds, browse and the presence of chitonous exoskeletons was considered sufficient proof that the sample site was used by vertebrates or invertebrates. Most observations were limited to waters/wetlands, however, some observations of species use were made and recorded in buffers.

(3) Land Use and Condition

The predominant land use and condition in a circle with a 3000-foot radius centered at the sample site was scored according to a disturbance scale that was included as a footnote on the data sheet (Appendix A). A 3000-foot radius was used because regional experts have suggested that it is reasonable to assume that 3000 feet is the approximate distance that wide-ranging amphibians and/or avifauna might travel to access waters/wetlands.

(4) Contiguity

Habitat contiguity was determined in each of eight "sectors" of a circle with a 3000-foot radius centered at the sample site. Specifically, the 3000-foot radius circle was separated into eight sectors, each with an interior angle of 45°. Within each sector, the predominant land use and condition was observed and recorded. If the predominant land use and condition was moderate to heavy grazing, then discontinuities such as fences, roads, or vineyards were noted and distances to these discontinuities were measured or estimated. Discontinuity in areas of relatively intact waters/wetlands habitats (*i.e.,* grazed areas) will affect the movement of animals across the landscape. (Hanson *et al.* 1995)

C. Data Analyses and Profile/Model Development

Following the field components of the reference sampling effort, all data were quality assured and quality controlled (QA/QC) by the EPA/LCLA team. All data were then entered into electronic format and QA/QC was performed on the electronic data matrices. When possible, descriptive data were converted to numeric ranges. Other descriptive data were used to characterize sites. Data analyses and syntheses were completed using a range of standard analytical techniques. These included, but were not limited to, standard parametric statistical test, non-parametric analyses, and multivariate analyses (*e.g.*, detrended correspondence analysis). The statistical analyses were conducted on the quantitative data (and the converted descriptive data) with the overall objective of determining (1) measured attributes with the greatest influence on the structure and functioning of the subclass, and (2) similarity/dissimilarity among sampled sites (Hill 1979, Gauch and Hill 1982, ter Braak 1987, Jongman *et al.* 1987). Quantitative data were also analyzed graphically (*e.g.*, bar graphs) and statistically to determine trends. In this effort, simple and standard statistical analyses were used to find ranges of values, averages, standard deviations, etc. (Zar 1984).

The graphic displays of the reference data were sorted according to the following land-use conditions: (1) preserve, (2) sites that were ripped, disced and rolled, but not planted, (3) vineyards with vegetation between rows, and (4) vineyards without vegetation between rows. The results of this sorting and analyses of the sorted data were used to numerically describe several reference conditions , including the influences of anthropogenic disturbances on ecosystem functions. All of the data analyses described above were used to develop and refine the second approximation draft HGM models for the Borden Ranch. In particular, it is important to emphasize that the reference data collected during the course of this study were used to support the scaling of variables in the draft HGM models.

D. Field Testing/Revision of Second Approximation HGM Assessment Models

Once preliminary data analyses were complete and the second approximation HGM models were drafted, the EPA/LCLA team conducted a series of field tests on the draft models. Field testing was accomplished during the interval August 19 - 21, 1997. In this effort, the EPA/LCLA team visited several sites within each subclass on the Borden Ranch. A range of land-use conditions was tested for each subclass (*e.g.*, preserve areas, recently ripped and disced sites, 1, 2, and 3 year old vineyards, etc.). Based on the results of the field tests, the second approximation models were revised and edited, and the third approximation models presented in this Guidebook were developed.

B. *Draft HGM Model for Closed and Flow-Through Depression Waters/Wetlands and Associated Slope Waters/Wetlands on Borden Ranch, Sacramento and San Joaquin Counties, California*

1. Definitions of Functions

a. Hydrologic Functions

1) Surface and Shallow Subsurface Water Storage and Exchange (Closed and Flow-Through)

This function refers to the capacity of a water/wetland (1) to collect and detain surface and shallow subsurface water as static water above the soil surface, pore water in the saturated zone, and soil moisture in the unsaturated zone, and (2) to allow for the exchange of water between surface and shallow subsurface compartments. The land use and condition of the contributing area and the buffer affect the timing, duration, and amount of surface and shallow subsurface water flowing into the water/wetland. The presence or absence and elevation of an outlet affect the amount of surface and shallow subsurface water a water/wetland can detain. An intact soil profile is critical to this function since (1) perching above the restrictive layer is the primary mechanism of surface and shallow subsurface water storage, and (2) exchange of water occurs between surface and shallow subsurface compartments (*i.e.*, between the pool and the upper part of the soil). Fine root turnover maintains soil pore space for shallow subsurface water storage and maintains soil permeability to allow for the exchange of water between surface and shallow subsurface compartments. Sediment input changes the soil pore space characteristics and, therefore, alters the way in which shallow subsurface water is stored and exchanged.

2) Landscape Hydrologic Connections (Flow-Through)

This functions refers to the hydrologic connectivity of contributing areas to flow-through depressions and slope waters/wetlands, and to other downgradient waters/wetlands. Flow-through depression and slope waters/wetlands have land-dominated hydrographs so the timing, duration, and amount of water delivered to the channel is dependent upon the condition of the watershed and the buffer. The high-order seasonal and perennial streams depend upon intact connections from the upper portions of the watershed to maintain flow and sediment transport characteristics.

b. Biogeochemical Functions

1) Element and Compound Cycling (Closed and Flow-Through)

Element and compound cycling includes the abiotic and biotic processes that convert compounds from one form to another. These are primarily recycling processes wherein elements and compounds are cycled between atmosphere, water, soil and vegetation. Additionally, elements and compounds are temporarily removed from cycling processes through retention/detention in soils and sediments. The critical attributes and processes are in the soil and vegetation. The water/wetland buffer filters incoming surface and shallow subsurface

water. Soil provides habitat for soil microorganisms that mediate the cycling processes, and also provides space where elements and compounds can be stored. Vegetation takes up, transforms, and temporarily stores elements and compounds and also provides oxygen to the rooting zone.

2) Organic Carbon Export (Flow-Through)

Organic carbon is exported from waters/wetlands in dissolved and particulate forms. Mechanisms of organic carbon export include leaching, displacement, and erosion. Sources of organic carbon include herbaceous vegetation both in the water/wetland and in the buffer, as well as organic matter incorporated in to the soil profile. Export of organic carbon from the flow-through depression and associated slope waters/wetlands is dependent upon the status/condition of the hydrologic connection to downgradient waters/wetlands.

c. Plant Community/Habitat Functions

1) Plant Community (Closed and Flow-Through)

Attributes of plant community include species composition and physical characteristics of the living plant biomass. The emphasis is on the composition and structure of the plant community. Species composition is influenced by physical processes that maintain the characteristic hydrologic functions of ephemeral depressional wetlands (*e.g.*, soil structure and hydraulic conductivity) and biological processes (*e.g.*, presence of viable populations of native pollinators). In addition, because ephemeral depressional waters/wetlands are habitat islands, the condition, areal extent and distribution of depressional wetlands habitat in the surrounding landscape (*i.e.*, surrounding land use and density of wetlands), which provides a regional source of colonists (propagules) to balance local extinctions within single pools, is critical to maintaining viable plant communities. Physical structure and attributes of the vegetation are also components of this function, including characteristic aerial cover, vertical and horizontal spatial distributions, and accumulation of organic matter.

2) Faunal Habitat (Closed and Flow-Through)

This function refers to the capacity of a water/wetland to support animal populations and guilds by providing heterogeneous habitats that provide food, cover, and reproductive opportunities. The emphasis is on species that require depressional waters/wetlands as an essential component for some or all parts of their life history.

3) Faunal Habitat Interspersion and Connectivity (Closed and Flow-Through)

Faunal habitat interspersion and connectivity is the capacity of a water/wetland to permit vertebrate and invertebrate aquatic organisms to enter or leave via surface or shallow subsurface connections, as well as the capacity of a water/wetland to permit access by terrestrial invertebrates and vertebrates to contiguous areas of food, cover, and reproductive opportunities.

4) Invertebrate Assemblage (Closed and Flow-Through)

This function refers to the population of terrestrial and/or aquatic invertebrates supported by the water/wetland.

5) Vertebrate Assemblage (Closed and Flow-Through)

This function refers to the population of terrestrial and/or aquatic vertebrates supported by the water/wetland.

2. Function Equations

Surface and Shallow Subsurface Water Storage and Exchange (Closed and Flow-Through)

Closed:

$$\text{Function} = (V_{OUT} \times (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{VEGABUND})/5)^{1/2}$$

Flow-Through:

$$\text{Function} = (V_{OUT} \times (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND} + V_{LONGCON})/7)^{1/2}$$

Landscape Hydrologic Connections (Flow-Through)

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{LONGCON})/4$$

Element and Compound Cycling (Closed and Flow-Through)

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/7$$

Organic Carbon Export (Flow-Through)

$$\text{Function} = ((V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + (V_{SOILINT} + V_{OM} + V_{VEGABUND})/3 + V_{OUT} + V_{LONGCON})/4$$

Plant Community (Closed and Flow-Through)

$$\text{Function} = (V_{OM} + V_{SOILINT} + V_{VEGABUND} + V_{PRATIO} + V_{DSINDSP} + (V_{WETDEN} + V_{LANDCOND})/2)/6$$

Faunal Habitat (Closed and Flow-Through)

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/7$$

Faunal Habitat Interspersion and Connectivity (Closed and Flow-Through)

Closed:

$$\text{Function} = (V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{WETDEN})/3$$

Flow-Through:

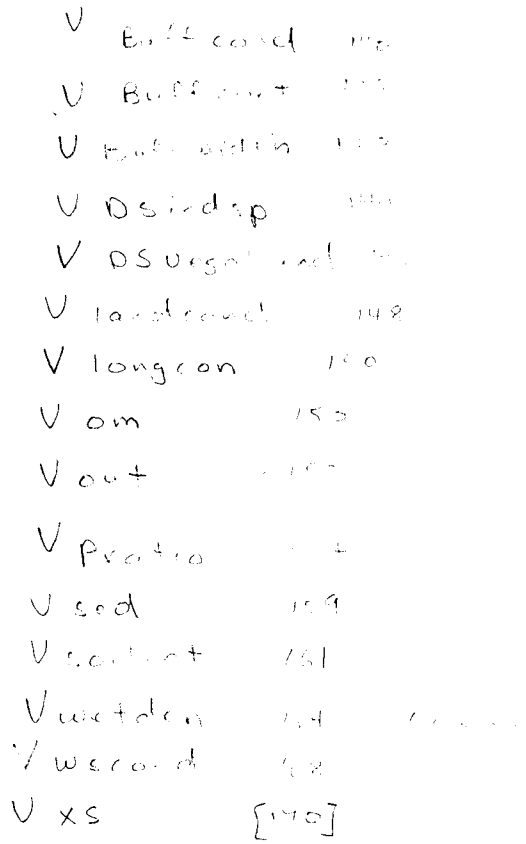
$$\text{Function} = (V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{LONGCON} + V_{WETDEN})/5$$

Invertebrate Assemblage (Closed and Flow-Through)

Direct Assessment

Vertebrate Assemblage (Closed and Flow-Through)

Direct Assessment



3. Variables

Variable: BUFFER CONDITION

Definition: Predominant land use or condition of the area 20 feet, perpendicular to and outward from the water/wetland edge or to the top of the contributing area divide whichever is less.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the water/wetland buffer in the assessment area. Compare to all the descriptions provided in the scaling for the $V_{BUFFCOND}$ variable and choose the lowest score that appropriately describes the predominant land use and/or condition of the buffer.

Scaling: The predominant use and condition of the buffer was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{BUFFCOND}$: Buffer Condition

Measurement or Condition	Index
Land condition is light or no grazing and management has explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, b) increase the abundance of native plant species, c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land use is characterized by moderate to heavy grazing. There is no management intended explicitly to: a) reduce the abundance of non-native and/or invasive plant species, b) increase the abundance of native plant species, c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
CONDITION 1: The buffer is characterized by a) maintenance plowing, disking, harrowing, or raking, **and** b) an unfractured restrictive layer. **OR** **CONDITION 2:** The buffer is characterized by a) accelerated rates of sediment deposition **and** b) an unfractured restrictive layer.	0.5
The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) cultivated crops (*e.g.*, vineyards or orchards), d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25
CONDITION 1: The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) cultivated crops (*e.g.*, vineyards or orchards), d) maintenance plowing, disking, harrowing, or raking between rows, **and** e) little to no herbaceous vegetation growing between rows. **OR** **CONDITION 2:** The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, **and** c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
The buffer is characterized by anthropogenic impervious surfaces (*e.g.*, roads, parking lots, buildings).	0.0

Variable: BUFFER CONTINUITY

Definition: Continuity of the buffer (20 feet perpendicular to and outward from the water/wetland edge or to the top of the contributing area divide, whichever is less) around the water/wetland edge. Continuity is defined as the distance around the water/wetland edge that is bounded by an intact buffer divided by the total distance around the water/wetland edge. The buffer must (1) greater than or equal to one foot wide, (2) be vegetated with herbaceous species, (3) have no evidence of increased area and/or rate of sediment deposition, and (4) have an unfractured restrictive layer.

Measurement Protocol: Within the assessment area, measure the distance around the water/wetland edge that is bounded by an intact buffer. Divide this measurement by the total distance around the water/wetland edge in the assessment area to reach the percent continuity of the water/wetland buffer. Compare the percent continuity for the buffer to all the descriptions provided in the scaling for the $V_{BUFFCONT}$ variable and choose the lowest score that appropriately describes the continuity of the buffer and/or the recoverability of the buffer continuity. Note that the buffer must (1) be greater than one foot wide, (2) be dominated by herbs, (3) have no evidence of increased area and/or rate of sediment deposition, and (4) have an unfractured restrictive layer.

Scaling: Buffer continuity was defined as the distance around the water/wetland edge that was bounded by an intact buffer divided by the total distance around the water/wetland edge (expressed as a percentage). The buffer had to (1) be greater than one foot wide, (2) be vegetated with herbaceous species, (3) have no evidence of increased sediment deposition, and (4) have an unfractured restrictive layer.

The data are bimodal. Buffer continuity tended to be 100 percent or 0 percent. The bimodal nature of the data did not allow for the determination of whether relationships between buffer continuity and ecosystem attributes and processes (*e.g.*, sediment accretion) were linear or curvilinear. Thus, the relationship was assumed to be linear.

Confidence: Medium.

$V_{BUFFCONT}$: Buffer Continuity

Measurement or Condition	Index
100% of the water/wetland edge is bounded by an intact buffer.	1.0
75% to <100% of the water/wetland edge is bounded by an intact buffer.	0.75
50% to <75% of the water/wetland edge is bounded by an intact buffer.	0.5
25% to <50% of the water/wetland edge is bounded by an intact buffer.	0.25
0% to <25% of the water/wetland edge is bounded by an intact buffer. Variable is recoverable and sustainable through natural processes and under current conditions.	0.1
0% to <25% of the water/wetland edge is bounded by an intact buffer. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: BUFFER WIDTH

Definition: Mean width of the buffer (20 feet perpendicular to and outward from the water/wetland edge or to the top of the contributing area divide whichever is less). The buffer must (1) be vegetated with herbaceous species, (2) not have evidence of increased area and/or rate of sediment deposition, and (3) have an unfractured restrictive layer.

Measurement Protocol: Within the assessment area, measure the mean width of the water/wetland buffer. A minimum of four measurements should be made to calculate the mean width. Measurements are made perpendicular to the water/wetland edge a maximum distance of 20 feet (20 feet is the maximum width of the buffer, by definition). Compare the mean buffer width to all the descriptions provided in the scaling for the $V_{BUFFWIDTH}$ variable and choose the lowest score that appropriately describes the mean width of the buffer and/or the recoverability of the width of the buffer.

Scaling: Buffer widths were defined as 20 feet or to the top of the contributing area, whichever was the lesser distance. The buffer must (1) be greater than one foot wide, (2) be vegetated with herbaceous species, (3) have no evidence of increased sediment deposition, and (4) have an unfractured restrictive layer. The distance to disturbance was determined by measuring from the water/wetland boundary to the nearest disturbance within the buffer. This was performed at multiple points and a mean distance to disturbance was reported.

The data are bimodal. Buffer widths tended to be greater than or equal to 20 feet or 0 feet. The bimodal nature of the data did not allow a determination whether relationships between buffer widths and ecosystem attributes and processes (*e.g.*, sediment accretion) were linear or curvilinear. Thus, the relationship was assumed to be linear.

Confidence: Medium.

$V_{BUFFWIDTH}$: Buffer Width

Measurement or Condition	Index
Mean buffer width is greater than or equal to 20 feet **or** to top of contributing area.	1.0
Mean buffer width is between 15 and 20 feet **or** to top of contributing area.	0.75
Mean buffer width is between 10 and 15 feet **or** to top of contributing area.	0.5
Mean buffer width is between 0 and 15 feet **or** to top of contributing area.	0.25
Mean buffer width is between 0 and 5 feet **or** to the top of contributing area. Variable is recoverable and sustainable through natural processes and under current conditions.	0.1
Mean buffer width is between 0 and 5 feet **or**. Variable is not recoverable and sustainable through natural processes and under current conditions or to top of contributing area.	0.0

Variable: DEPRESSION/SLOPE INDICATOR SPECIES

Definition: The presence of plant taxa that are restricted to, or indicative, characteristic or typical of, depression and slope waters/wetlands in the Sacramento Region of the Central Valley of California.

Measurement Protocol: A list of the dominant taxa (*i.e.*, all taxa that make up > 50% of the total vegetative cover, plus taxa that make up > 20% total cover) is made from visual inspection of 1 square meter plots in the assessment area. At least 10 plots should be made at random points within the assessment area. Dominant taxa are compared with lists of restricted or associated plants compiled from the literature, and the percent of taxa that is restricted or associated is calculated by dividing restricted/associated taxa by total taxa and multiplying by 100. Compare the percent indicators to all the descriptions provided in the scaling for the $V_{DSINDSP}$ or the V_{RINDSP} variable and choose the lowest score that appropriately describes the condition. This variable can be assessed when vegetation is senescent if taxa can be identified.

Scaling: The presence of indicator species was assessed by listing the dominant taxa within the assessment area and checking these taxa against lists of taxa restricted to, or typically associated with ephemeral depression or slope wetlands in the Central Valley of California. The lists were compiled from (1) data collected in depression and slope waters/wetlands on Borden Ranch and (2) the literature on the vegetation of vernal pools in the Central Valley. The variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

Note: Confidence in this variable is medium because $V_{DSINDSP}$ was scored during the dry stage when vegetation is senescent, due to constraints of time. Because plant identifications are more difficult at this time, some taxa could only be identified to genera. The scoring of this variable is conservative, however, because taxa that could be identified only to genus level were classified as restricted or associated if any members of that genus are restricted or associated in California.

$V_{DSINDSP}$: Depression/Slope Indicator Species

Measurement or Condition	Index
> 90% of the dominant taxa present are restricted to ephemeral depression/slope wetlands in California (see attached lists),	1.0
> 50% to 90% of the taxa present are restricted to ephemeral depression/slope wetlands in California or are frequently or typically associated with depression and slope waters/wetlands in California (see attached lists).	0.75
a) at least 50% of the dominant taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) other taxa present are from the surrounding annual grasslands (*e.g.*, *Lolium*, *Hordeum*, *Briza*, *Juncus bufonius*).	0.5
a) 25% to 50% of the dominant taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) > 50% of the dominant taxa are typical of more permanently wet soils (*e.g.*, *Typha*, *Salix*, *Cyperus*, *Cynodon*, *Erodium*, *Echinochloa*, *Juncus*) or adventive annuals from more open, disturbed habitats (*e.g.*, *Atriplex*, *Rumex*, Chenopodiaceae, *Matricaria*, *Lolium*, *Polypogon*, *Malva*)	0.25
CONDITION 1: a) < 25% of the taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) > 50% of the taxa are typical of more permanently wet soils (see list above) or open, disturbed habitats (see list). **OR** **CONDITION 2:** No vegetative cover, but variable is recoverable and sustainable through natural processes and under current conditions.	0.1
No vegetative cover; variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: DEPRESSION/SLOPE VEGETATION ABUNDANCE

Definition: Characteristics of vegetation abundance and structure in the waters/wetland (including height, cover, stem density, spatial distribution, and phenological sequence).

Measurement Protocol: Measurement of this variable is keyed to the different stages in the wet-to-dry cycle that characterizes depression, slope and riverine wetlands on Borden Ranch. Depending on the time of year when the assessment is conducted, choose one of the three stages in the cycle, either wetting/wet, drying, dry (see Glossary for definitions of stages) and use the descriptions for that stage. Vegetative cover is visually estimated by assessing the percent cover of actively photosynthesizing vegetation within 1 square meter plots. At least 10 plots should be made at random points within the assessment area and an average of these 10 observations should be calculated. The vegetation within the water/wetland is visually inspected (*i.e.*, physiognomy, spatial distribution of species, and species composition) to determine if vegetation within the assessment area can be distinguished from the vegetation outside the assessment area. Compare percent cover, distinctness of the vegetation within the assessment area, and species composition to all descriptions provided in the scaling for the $V_{DSVEGABUND}$ variable and choose the lowest score that appropriately describes the condition.

Scaling: Vegetation abundance was assessed by measuring the percent cover and species composition of the dominant taxa, as well as describing the nature of the boundary between the vegetation of the assessment area and vegetation of the surrounding areas. This variable was scaled separately for the wetting wet, drying and dry stages of the seasonal wet-to-dry cycle, because vegetation abundance and species composition both change over time. The $V_{VEGABUND}$ variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{DSVEGABUND}$: Depression/Slope Vegetation Abundance

Measurement or Condition	Index
Drying Stage: a) dominants are low growing (<1') native, annual forbs; **and** b) form concentric rings of different species along gradient from depression center to margin (may be one 'ring' in slopes); **and** c) boundaries between depression/slope vegetation and surrounding grassland vegetation are distinct and clear; **and** d) cover of vegetation in waters/wetlands lower (*i.e.*, 63% to 85%) than in surrounding grasslands (*i.e.*,·90% to 100%).	1.0
Dry Stage: a) vegetative cover is <5% **and;** b) boundaries of the plant community are clear and distinct either as a water-filled depression, or as dry, open ground with a cover of senescent *Eryngium*; **and** c) no invasion by species from the surrounding annual grasslands.	
Wetting/Wet Stage: Data not collected.	

Measurement or Condition	Index
Drying Stage: a) dominants are low growing, annual forbs; **and** b) form concentric rings along gradient from depression center to margin; **and** c) boundaries between depression vegetation and grassland are clear and distinct, but margins may contain increased cover from surrounding grassland plants; **and** d) cover of vegetation in the margins >85% where grassland species have invaded. **Dry Stage**: a) vegetative cover is <5%; **and** b) boundaries of plant community are clearly visible either as water-filled depression, or as dry open ground which contains mostly senescent *Eryngium*; **and** c) may contain some species from the surrounding annual grasslands. **Wetting/Wet Stage: Data not collected.**	0.75
No standard for this score.	0.5
All Stages: a) cover of spring/summer vegetation is >85% and >50% of dominants area non-native plants typical of more permanently wet soils (*e.g.*, *Echinochloa*, *Typha*, *Salix*, *Cyperus*, *Rumex*, *Lolium*), or adventives (*e.g. Chenopodium, Taraxacum, Atriplex,*); **and** b) cover/height of vegetation remains unchanged during time of year when depressions/slopes are normally dry (*i.e.*, summer); **and** c) no distinct boundary is recognizable between vegetation in depressions/slopes and surrounding area; **and** d) no clear wetting/wet stage (*i.e.*, standing water), although vegetation may be senescent during late fall/winter months.	0.25
All Stages: a) vegetative cover is <5% at all times; **and** b) during late fall/winter boundaries of original plant community may be visible with some ponding of water; **and** c) variable is recoverable and sustainable through natural processes and under current conditions.	0.1
All Stages: a) vegetative cover is <5 at all times; **and** b) boundaries of original plant community are not visible; **and** c) no short (>7 days) or very short (i.e. >1 day) ponding of water occurs during or after winter rains; **and** d) variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: LAND USE OR CONDITION

Definition: *Predominant land use or condition within a 3000-foot radius of the centroid of the assessment site.*

Measurement Protocol: This variable is assessed through visual observations during site review and/or by using other available information (*e.g.*, aerial photos, maps etc.). Recent aerial photographs can facilitate the identification of land uses within the 3,000-foot radius. Compare to all the descriptions provided in the scaling for the $V_{LANDCOND}$ variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) land use within a 3,000-foot radius of the centroid of the assessment area.

Scaling: The predominant use and condition of the area within a circle with a 3000-foot radius centered on the centroid of the assessment site was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{LANDCOND}$: Land Use or Condition

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management component. The plan has the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
No standard for this score.	0.5
The area is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops that have been in place for 2 or more years (*e.g.*, vineyards or orchards).	0.25
CONDITION 1: The area is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops that have been in place for 2 or more years (*e.g.*, vineyards or orchards). **OR** **CONDITION 2:** The area is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) no cultivated crops (*e.g.*, vineyards or orchards), d) no disking or rolling in preparation for planting, and e) some vegetation and/or microtopographic variation exists.	0.1
The area is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) no cultivated crops (*e.g.*, vineyards or orchards), d) disking or disking and rolling in preparation for planting, and e) little to no vegetation and/or microtopographic variation exists.	0.0

Variable: LONGITUDINAL CONNECTIONS TO DOWN-GRADIENT WATERS/WETLANDS

Definition: Land use or condition of the longitudinal connections to down-gradient waters/wetlands within 500 feet of the assessment area or to the next water/wetland (measurement from top of assessment area to 500' down-gradient). Flow-through depression waters/wetlands often form the headward extent of slope waters/wetlands, and slope waters/wetlands often form the headward extent of riverine waters/wetlands. The connections provide pathways for surface and shallow subsurface water flow, particulate transport, organic carbon export, and flora and fauna movement.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the longitudinal hydrologic connection(s) to down-gradient waters/wetlands within 500 feet of the assessment area. Compare to all the descriptions provided in the scaling for the $V_{LONGCON}$ variable and choose the lowest score that appropriately describes the predominant land use or condition of the longitudinal hydrologic connection(s) to down-gradient waters/wetlands.

Scaling: The predominant use and condition of the longitudinal connections to down-gradient waters/wetlands was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{LONGCON}$: Longitudinal Connections to Downgradient Waters/Wetlands

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management component. The plan has the explicit intent to a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
CONDITION 1: The longitudinal connection is characterized by a) maintenance plowing, disking, harrowing, or raking **and** b) an unfractured restrictive layer. **OR** **CONDITION 2:** The longitudinal connection is characterized by a) accelerated rates of sediment deposition **and** b) an unfractured restrictive layer. **OR** **CONDITION 3:** The longitudinal connection is characterized by a) discontinuous disruptions to surface and/or shallow subsurface water flow (*e.g.*, road crossings, buried pipelines, and small ripped areas), **and** b) an unfractured restrictive layer.	0.5
The longitudinal connection is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops (*e.g.*, vineyards or orchards), **and** d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25

Measurement or Condition	Index
CONDITION 1: The longitudinal connection is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) maintenance plowing, disking, harrowing, or raking between rows; **and** e) little to no herbaceous vegetation growing between rows. OR **CONDITION 2:** The longitudinal connection is characterized by a) a ripped soil profile, b) a fractured restrictive layer, and c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
Longitudinal connections disconnected by anthropogenic activities and no longer exist (*e.g.*, channel bed cannot be identified).	0.0

Variable: PERCENT COVER OF ORGANIC MATERIAL IN THE WATER/WETLAND

Definition: Percent cover of the organic detrital material on the soil surface. The organic detrital material is composed of algal mats and/or accumulated plant litter from forbs, graminoids, ferns, and fern allies.

Measurement Protocol: Make a visual assessment using 1 square meter plots of the percent cover of organic material within the assessment area. At least 10 plots should be made at random points within the assessment area and an average of these 10 observations should be calculated. Compare the average percent cover of organic material in the assessment area to all the descriptions provided in the scaling for the V_{OM} variable and choose the lowest score that appropriately describes the percent cover of organic material.

Scaling: The percent cover from organic matter in the assessment area was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High

V_{OM}: Organic Material

Measurement or Condition	Index
Depression and Slope: Cover of organic material (OM) is > 75%. **Riverine:** Cover of OM is > 50% to 70%; OM can be composed of algal and/or plant material accumulating where the kinetic energy of surface water is low.	1.0
Depression and Slope: Cover of OM is > 50% to 75%. **Riverine:** Cover of OM is > 30% to 50%; OM can be composed of algal and/or plant material accumulating where the kinetic energy of surface water is low.	0.75
Depression and Slope: Cover of OM is > 25% to 50%. **Riverine:** Cover of OM is > 20% to 30%,	0.5
Depression and Slope: Cover of OM is > 10% to 25%. **Riverine:** Cover of OM is > 5% to 20%.	0.25
Depression and Slope: **CONDITION 1:** Cover of OM is < 10%. **OR** **CONDITION 2:** Cover is high (> 90% locally) in response to irrigation return flow or in areas where irrigation has caused algal blooms in areas of ponding on the surface. **Riverine**: **CONDITION 1:** Cover of OM is <5%. **OR** **CONDITION 2:** Cover is high (> 60% locally) in response to irrigation return flow or in areas where irrigation has caused algal blooms in areas of ponding on the surface.	0.1
Depression, Slope, and Riverine: No OM. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: OUTLET

Definition: Presence or absence and elevation of a natural or constructed surface and shallow subsurface water outlet.

Measurement Protocol: Determine the presence or absence of a hydrologic outlet in the depressional wetland and thus if the depressional water/wetland is an isolated or flow-through depression. If an outlet is absent, the depression is thus isolated and scores a 1.0 on the variable scaling. If an outlet is present, determine if the outlet has been altered (*i.e.*, raised or lowered). If the outlet has been artificially raised it scores a 0.75 on the variable scaling. If the outlet has been lowered from its original elevation (*i.e.*, excavated), measure the relative elevation of the excavated outlet. Compare the elevation of the excavated outlet to the elevation of the maximum depth of the depression. Compare to all the descriptions provided in the scaling for the V_{OUT} variable and choose the lowest score that appropriately describes the elevation of the excavated outlet.

Scaling: Outlets were defined as swale features that connected the assessment site to other waters/wetlands. The swale features were waters/wetlands or non-waters/wetlands. The outlet elevation relative to the jurisdictional boundary was determined by surveying relative elevations of the waters/wetlands boundary, determining a mean relative elevation of the boundary, and surveying the relative elevation of the crest in the outlet swale feature. Data were plotted and assessed in the context of field notes and photographs.

Confidence: Medium.

V_{OUT}: Outlet

Measurement or Condition	Index
Closed: No outlet present. Flow-Through: Outlet present. Elevation of the outlet not modified by anthropogenic activities.	1.0
Closed: No score for this scale. Flow-Through: Outlet present. Outlet elevation raised resulting in surface water impoundment.	0.75
Closed and Flow-Through: Outlet present. Outlet excavated to a depth of up to 50% of the depression depth.	0.5
Closed and Flow-Through: Outlet present. Outlet excavated to a depth of up to 75% of the depression depth.	0.25
Closed and Flow-Through: Outlet present. Outlet excavated to a depth of up to 90% of the depression depth.	0.1
Closed and Flow-Through: Outlet excavated to the maximum depth of the depression. Depression drains and does not store surface water.	0.0

Variable: PERCENT OF NATIVE PLANT SPECIES

Definition: The percent of the dominant plant taxa present in the waters/wetlands that are native to California.

Measurement Protocol: A list of the dominant taxa (*i.e.*, all taxa that make up > 50% of the total vegetative cover plus taxa that make up > 20% total cover) is made from visual inspection of 1 square meter plots in the assessment area. At least 10 plots should be made at random points within the assessment area. Dominant taxa are recorded as either natives or non-natives using the Jepson Manual. The percent of native taxa is calculated by dividing the number of native taxa by total taxa. Compare the percent native taxa to all the descriptions provided in the scaling for the V_{PRATIO} variable and choose the lowest score that appropriately describes the condition. This variable can be assessed when senescent vegetation is present if taxa can be identified.

Scaling: The percent of native species was assessed by listing the dominant taxa within the assessment area and checking these taxa against the Jepson Manual to determine native/non-native status in California. The variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium

Note: Confidence in this variable is medium because V_{PRATIO} was scored during the dry stage when vegetation is senescent, due to constraints of time. Because plant identifications are more difficult at this time, some taxa could only be identified to genera. The scoring of this variable is conservative, however, because taxa that could be identified only to genus level were classified as native if any members of that genus are native to California.

V_{PRATIO}: Percent of Native Plant Species

Measurement or Condition	Index
Depression, Slope, and Riverine: > 90% of the taxa are native.	1.0
Depression and Slope: a) >70% to 90% native taxa; **and** b) individuals from surrounding non-native annual grasslands may be present. **Riverine**: 90 a) >50% to 75% of the taxa are natives; **and** b) individuals from surrounding non-native annual grasslands may be present.	0.75
Depression and Slope: a) >50% to 70% native taxa; **and** b) non-native taxa are from the surrounding annual grasslands (*e.g.*, *Lolium*, *Briza*, *Aira*, *Hordeum*, *etc.*). **Riverine**: a) >25% to 50% native taxa; **and** b) non-native taxa from surrounding annual grasslands (*e.g.*, *Lolium*, *Hordeum*, *Briza*, *Aira*), or non-native adventives (*e.g.*, *Taraxacum*, *Atriplex*, *Salsola*, *Rumex*) are present.	0.5

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Percent of Native Plant Species cont.

Measurement or Condition	Index
Depression and Slope: a) >20% to 50% are natives; **and** b) >50%of taxa are either non-natives typical of more permanently wet habitats (*e.g.*, *Echinochloa*, *Erodium*, *Ranunculus*, *Cyperus*), or taxa typical of open, disturbed habitats (*e.g.*, *Chenopodium*, *Rumex*, *Salsola*, *Taraxacum*). **Riverine**: a) >5% to 25% native taxa; **and** b) >75% are non-native taxa typical of more permanently wet habitats (*e.g.*, *Echinochloa*, *Cynodon*, *Erodium*, *Ranunculus*, *Cyperus*) or taxa typical of open, disturbed habitats (*e.g.*, *Chenopodium*, *Rumex*, *Salsola*, *Taraxacum*).	0.25
Depression and Slope: CONDITION 1: <20% native taxa. **OR** CONDITION 2: No vegetation present. Variable is recoverable and sustainable through natural processes and under current conditions. **Riverine**: CONDITION 1: <5% native taxa. **OR** CONDITION 2: No vegetation present. Variable is recoverable and sustainable through natural processes and under current conditions	0.1
Depression, Slope, and Riverine: There is no vegetation present. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: SEDIMENT DEPOSITION

Definition: Area and/or rate of sediment deposition in the water/wetland.

Measurement Protocol: Make a visual assessment of the area and/or rate of sediment delivery to the water/wetland within the assessment area. Compare to all the descriptions provided in the scaling for the V_{SED} variable and choose the lowest score that appropriately describes the condition/status of sediment delivery to the water/wetland within the assessment area.

Scaling: The approximate area and volume of fill in the assessment site was determined by field measurements. Approximate areas of fill were determined through measurements of aerial coverage. The approximate depths of fill were measured in a few areas, and a mean depth of fill was calculated. The approximate volumes were determined by multiplying the aerial coverage of fill by the mean depth of fill.

This scaling for this variable was based upon the V_{SED} variable from the *Operational Draft Guidebook to HGM Functional Assessments in Temporary and Seasonal Depressional Waters/Wetlands in the Northern Prairie Pothole Region* (*The Northern Prairie Depressional HGM Guidebook*)(Lee *et al.* 1997). *The Northern Prairie Depressional HGM Guidebook* has been through peer review and is one of the most mature HGM guidebooks in the nation. The scaling was modified by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High.

V_{SED}: Sediment Deposition

Measurement or Condition	Index
No evidence of increased area or rate of sediment deposition in the water/wetland from anthropogenic sources.	1.0
Historical evidence suggests that the area and/or rate of sediment deposition in the water/wetland increased in the past. a) Evidence may include, but is not limited to, stabilized fans and/or sediment layering on the soil surface; **and** b) The current condition is stable as evidenced by intact plant communities and/or the development of distinct soil structural and morphological features in the sediment layers.	0.75
The area and/or rate of sediment deposition in the water/wetland has slightly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, discontinuous bank shear, a veneer of fine sediment located where kinetic energy of surface water is low (*e.g.*, small pits), and/or sediment staining on detritus and/or plant materials; **and**. b) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.5
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently developed and/or developing fans and sediment layering on the soil surface; **and** b) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.25
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently ripped soil profiles; **and** b) 100% of the assessment site ***area*** is filled; **and** c) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.1
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently ripped, disked, and rolled soil profiles; **and**. b) 100% of the assessment site ***volume*** is filled **and** c) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.0

Variable: SOIL PROFILE INTEGRITY

Definition: Presence and condition of the soil profile in the assessment area.

Measurement Protocol: Excavate a representative soil pit in the assessment area. Characterize the soil pit consistent with NRCS protocols (USDA 1993). Compare to all the descriptions provided in the scaling for the $V_{SOILINT}$ variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) soil condition of the water/wetland within the assessment area.

Scaling: Soil pits were excavated to practicable depths, usually to the depth of the restrictive layer. Identification and nomenclature of the soil horizons were consistent with NRCS guidance. Colors were determined from wet samples and were reported as Munsell Soil Colors. The $V_{SOILINT}$ variable was scaled by the interdisciplinary team and is based upon the soil pit data and best professional judgment.

Confidence: High.

$V_{SOILINT}$: Soil Profile Integrity

Measurement or Condition	Index
Depression and Slope: a) Soil profile is intact and undisturbed. Typically, the soil profile has a thin O horizon over well-developed A (and/or E), B, and C horizons. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile is intact and undisturbed. Typically, the soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured.	1.0
Depression and Slope: a) Soil profile is truncated due to compaction by domestic livestock. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** **CONDITION 1:** a) Soil profile is truncated due to compaction by domestic livestock. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. ***CONDITION 2:*** a) Soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured; **and** c) A veneer of fine sediment is present. Typically, the veneer of fine sediment is located where kinetic energy of surface water is low (*e.g.*, small pits).	*0.75*
Depression and Slope: a) Soil profile has an Ap horizon due to plowing, disking, harrowing, or raking. Restrictive layers, where present, occur in the B and/or C horizon(s) **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured; **and** c) Soil profile altered by discontinuous disruptions (*e.g.*, road crossings and/or small ripped areas).	0.5
Depression and Slope: a) Soil profile has not been ripped, but it is buried under recently deposited sediment (*e.g.*, silt, sand, gravel, and/or cobble). Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile plowed, disked, harrowed, or raked. An Ap horizon may be present.. Restrictive layer(s), where present, occur in the B and/or C horizons; **and** b) Restrictive layer(s), where present, are unfractured.	0.25

Measurement or Condition	Index
Depression, Slope, and Riverine: a) Soil profile has been ripped and, possibly, disked, rolled, or excavated. C horizons dominate throughout the soil profile.; **and** b) Restrictive layers, where present, are fractured.	0.1
Depression, Slope, and Riverine: The substrate is anthropogenically-derived impervious surface (*e.g.*, roads, parking lots, buildings).	0.0

Variable: WETLAND DENSITY

Definition: The percent of the total area that is occupied by depressional, slope, and riverine waters/wetlands within a 3000-foot radius of the centroid of the assessment site.

Measurement Protocol: First determine which geomorphic surface the assessment area is located on (*e.g.*, high terrace, dissected terrace face, Holocene terrace and floodplain, etc.). This will determine which set of variable scaling scores to use for the assessment area water/wetland. Next determine the density of waters/wetlands through visual observations during site review and/or by using other available information (*e.g.*, aerial photos, maps, etc.). Recent aerial photographs can facilitate the identification of wetland types within the 3,000-foot radius. Compare the density to all the descriptions provided in the scaling for the V_{WETDEN} variable and choose the lowest score that appropriately describes the density of waters/wetlands within a 3,000-foot radius of the centroid of the assessment area.

Scaling: The percent of the total area within a 3000-foot radius of the assessment area was determined by measuring the area covered by depressions, slopes, riverine waters/wetlands from 1:6000 scale aerial photographs taken of the Borden Ranch site at the time of the assessment in August 1997. The variable was scaled separately for each geomorphic surface because densities of the different waters/wetland classes differ among high terrace, dissected terrace face and Holocene terrace and floodplain. The variable was scored according to the disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High

V_{WETDEN}: Wetland Density

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >50% to 75% of the total area, with large depressions/complexes of depressions present; Slope waters/wetlands: >50% to 75% of the total area; with large complexes of slopes/depressions Riverine waters/wetlands: >5% to 10% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >15% to 25% of the total area, with depressions smaller than on high terrace, often isolated; Slope waters/wetlands: >30% to 50% of the total area Riverine waters/wetlands: >10% to 20% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >20% to 30% of the total area Slope waters/wetlands: >40% to 60% of the total area Riverine waters/wetlands: >40% to 50% of the total area **AND** No fragmentation due to anthropogenic activities	1.0
High Terrace: Depressional waters/wetlands: >40% to 50% of the total area Slope waters/wetlands: >40% to 50% of the total area Riverine waters/wetlands: >5% to 10% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >10% to 15% of the total area Slope waters/wetlands: >20% to 30% of the total area Riverine waters/wetlands: >5% to 10% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >10% to 20% of the total area Slope waters/wetlands: >30% to 40% of the total area Riverine waters/wetlands: >30% to 40% of the total area **AND** Fragmentation by fencing, roads and activities associated with moderate to heaving grazing.	0.75

V_{WETDEN}: **Wetland Density** (cont)

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >20% to 40% of the total area, with few large, connected complexes Slope waters/wetlands: >20% to 40% of the total area Riverine waters/wetlands: >1% to 5% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >5% to 10% of the total area Slope waters/wetlands: >10% to 20% of the total area Riverine waters/wetlands: > 1% to 5% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >5% to 10% of the total area Slope waters/wetlands: >20% to 30% of the total area Riverine waters/wetlands: >20% to 30% of the total area **AND** Fragmentation due to large areas with fractured restrictive layers (*e.g.* ripped and disked or ripped, disked and cultivated)	0.5
High Terrace: Depressional waters/wetlands: >10% to 20% of the total area, with no large connected complexes Slope waters/wetlands: >10 to 20% of the total area Rverine waters/wetlands: <1% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: > 1% to 5% of the total area Slope waters/wetlands: >5 to 10% of the total area Riverine waters/wetlands: <1% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: <5% of the total area Slope waters/wetlands: >10% to 20% of the total area Riverine waters/wetlands: >10% to 20% of the total area **AND** Fragmentation due to large areas with fractured restrictive layers (e.g. ripped and disked or ripped, disked and cultivated)	0.25

V_{WETDEN}: **Wetland Density** (cont)

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >5% to 10% total area Slope waters/wetlands: > 5% to 10% total area Riverine waters/wetlands: < 1% total area **Dissected Terrace Face**: Depressional waters/wetlands: < 1% total area Slope waters/wetlands: < 5% total area Riverine waters/wetlands: < 1% total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: > 1% to 5% total area Slope waters/wetlands: > 5% to 10% total area Riverine waters/wetlands: > 5% to 10% total area **AND** Fragmentation due to large areas with fractured restrictive layers (*e.g.*, ripped and disked or ripped, disked and cultivated)	0.1
High Terrace: Depressional waters/wetlands: < 5% Slope waters/wetlands: < 5% Riverine waters/wetlands: none present **Dissected Terrace Face**: Depressional waters/wetlands: none present Slope waters/wetlands: none present Riverine waters/wetlands: none present **Holocene Terrace and Floodplain**: Depressional waters/wetlands: none present Slope waters/wetlands: none present Riverine waters/wetlands: none present	0.0

Variable: WATERSHED CONDITION

Definition: Predominant land use or condition of the contributing area.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the watershed/contributing area. Compare to all the descriptions provided in the scaling for the V_{WSCOND} variable and choose the lowest score that appropriately describes the predominant land use or condition of the watershed/contributing area.

Scaling: The predominant use and condition of the contributing area was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

V_{WSCOND}: Watershed Condition

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management. The plan has the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species; **and** b) increase the abundance of native plant species; **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species; **and** b) increase the abundance of native plant species; **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
The watershed is characterized by a) maintenance plowing, disking, harrowing, or raking **and** b) an unfractured restrictive layer.	0.5
The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25
CONDITION 1: The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) maintenance plowing, disking, harrowing, or raking between rows, **and** e) little to no herbaceous vegetation growing between rows. **OR** **CONDITION 2:** The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer, **and** c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
The watershed is characterized by anthropogenic impervious surfaces (*e.g.*, roads, parking lots, buildings).	0.0

Variable: SWALE OR CHANNEL CROSS-SECTION

Definition: Condition of the swale or channel cross-section in terms of widths, depths, cross-sectional areas, and width:depth ratios. NOTE: This variable should not be used to assess isolated depressions; for use in slope, riverine or flow-through depressions.

Measurement Protocol: Make a visual assessment of the channel cross-section/outlet swale. Compare to all the descriptions provided in the scaling for the V_{XS} variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) land use and/or condition of the channel cross-section/outlet swale.

Scaling: Microtopography was measured by surveying changes in ground surface elevation with a laser level. Microtopography transects were established as typical cross-sections in pools and riffles and typical longitudinal profiles. Stations were surveyed at intervals that allowed accurate description of the ground surface. There were no fixed intervals specified. Cross-sectional transects encompassed the width of the water/wetland and 20 foot buffers on each side. Data were plotted and assessed in the context of field notes and photographs.

Confidence: High.

V_{XS}: Swale or Channel Cross-Section

Measurement or Condition	Index
Swale or channel cross-section unaltered as evidenced by intact soil profiles and plant communities.	1.0
Swale or channel cross-section altered by portions of the swale margin/channel bank that have been pushed or pulled in by ripping and/or disking operations and/or cattle grazing (*e.g.*, bank trampling, shear).	0.75
Swale or channel cross-section altered by discontinuous entrenchment (*i.e.*, small areas that are incipient headcuts).	0.5
CONDITION 1: Swale or channel cross-section altered by continuous entrenchment. **OR** **CONDITION 2:** Swale or channel cross-section altered by discontinuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, road crossings and small ripped areas).	0.25
a) Swale or channel cross-section altered by continuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, entirely ripped and/or disked); **and/or** b) Discontinuous areas with poorly-developed channel cross-sections occur; **and** c) May include areas with infrequent or no maintenance cultivation (*i.e.*, disking, mowing, etc.)	0.1
Swale or channel cross-section altered by continuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, entirely ripped and/or disked). No areas with channel cross-sections can be identified.	0.0

VI. Application and Use of HGM Guidebooks and Models

A. Overview

As discussed in the introductory sections of this draft Guidebook, the HGM approach to assessing the functions of waters/wetlands can be used as the basis for (1) impact assessment, (2) restoration design, and (3) development of monitoring protocols and contingency measures (Brinson 1993, Brinson *et al.* 1995, NWSTC 1996). It was the best professional judgment of the EPA/LCLA technical team that use of an HGM approach in performing the rapid assessments of waters/wetland functions required in the AO was appropriate because an HGM approach is consistent with (1) current federal guidance and (2) use of the best current scientific methods. For example, the Clinton Administration has recognized that (1) "...all wetlands are not the same...," (2) a fair, flexible approach should be encouraged that allows restoration of wetland functions, and (3) an HGM approach should be used to measure wetland functions (Clinton Administration Wetland Policy 1993). It is the current administration's goal to encourage development of HGM approaches in hopes that policies regarding "no-net-loss of wetland area and/or functions" can be more consistently and effectively implemented. As detailed in the Federal Register (Federal Register 8/16/96, 6/20/97), HGM is in the process of being developed in several areas of the U.S. and thus adopted by several federal and state agencies.

With particular respect to Borden Ranch, application of the draft HGM approach offered in this guidebook should be accomplished consistent with draft model logic and with conventions for field observations and measurements that are necessary to complete an assessment. This section of the draft Guidebook provides guidance on how to use the draft Guidebook to run HGM models in Borden Ranch waters/wetlands.

B. Recommended Steps for Performing HGM Functional Assessments on Borden Ranch

1. When Not To Use The Draft HGM Models/How To Score Zero

In perturbed landscapes, situations are often encountered where waters/wetlands are entirely eliminated through filling and other activities. Similarly, situations can exist where waters/wetlands are so highly altered that they no longer can be classified within the same HGM class and/or subclass. That is, perturbations can cause a change of state (*i.e.,* from a slope to a riverine waters/wetland). In either of these cases (*i.e.,* elimination or change of state) it is inappropriate to apply the HGM models offered in this draft Guidebook. Therefore, consistent with the draft guidance for use of reference systems in the HGM approach (NWSTC - in Prep), the answers to questions concerning functioning of either former (eliminated) or "state- changed" waters/wetlands is "0." The rationale for this logic is easy. First, waters/wetlands that do not exist cannot perform waters/wetland functions. Second, waters/wetlands that have undergone a change of

state from one class or subclass to another cannot perform functions associated with the initial (reference) state.

2. Recommended Steps and Procedures

Table 9 summarizes the steps for performing an HGM assessment. Steps must be taken in three broad areas: office preparation for field work, field work itself, and preparation of an assessment report. The paragraphs offered below offer rationale and explanations for each step.

Table 9. Recommended Steps and Procedures for Performing HGM Functional Assessments

Office Preparation for the Field

1. Collect and review information relevant to the site.

Field Work

1. Assemble Field Equipment and Field Data Sheets.
2. Identify the HGM Class and Subclass.
3. Bound the assessment area(s).
   a. Determine the geographic extent of any other subclasses that may be present.
   b. Determine the geographic extent of each subclass within the project area.
   c. Determine the geographic extent of each pertinent fire and/or anthropogenic disturbance regime.
4. Score the variables.
   a. Score the variables using standards for that variable listed in the Guidebook HGM models.
5. Calculate the indices of function.
   a. Always calculate the indices of function in the field.
   b. Review functional index scores in the field to ensure accuracy.

Preparation of an Assessment Report

The following outline represents recommended minimum submittals for HGM assessment reports:

1. Introduction to the project and assessment objectives
2. Background of the assessment team members, their expertise and training, including training in HGM
3. A written and graphic documentation of the assumptions used by the assessment team to locate, classify, and bound the assessment area
4. Citations to the guidebook and models used to conduct the assessment
5. A detailed description of the study and assessment areas. Include maps, aerial photos, site photos, soils maps and data, hydrologic data, etc.
6. A detailed discussion of field reconnaissance and sampling protocols
7. A list of all written, cartographic and/or photographic materials used to conduct the assessment and a description of how each piece of information was used.
8. All field data sheets that show variable scores and the rationale used to select a score for each variable
9. All variable scores and calculations of functional capacity indices
10. Any calculations of functional capacity units and their basis.
11. A synthesis and interpretation of assessment results
12. Appendices with data, substantiating information, etc.

Office Preparation for the Field

HGM functional assessments cannot be performed without a thorough review of the assessment area and its context in the field. While the HGM context can be used to structure discussion of ecosystem functions, an HGM functional assessment is not completed until a site review is performed. This is due to the fact that many of the variables require field measurement, and remote techniques lack the precision and accuracy that is required for useful data. The exception to the rule about making a field assessment only occurs in review of designs for development projects and for enhancement, restoration, and creation projects. In these situations, HGM functional assessments can be performed on data collected or synthesized from design documents.

Step 1. Collect and Review Information that is Relevant to the Site

Any field effort requires advance preparation. Prior to performing a field or design document review, it is important to collect information that is relevant to the assessment site. Aerial photographs, topographic maps, geologic maps, soil surveys, NWI maps, jurisdictional delineation documents, and other relevant information should be compiled and reviewed to provide a firm base of knowledge. During this review, particular attention should be paid to the geomorphic setting of the assessment area. Understanding the geomorphic setting will facilitate the functional assessment by providing geomorphic boundaries to the assessment area(s). For instance, data may be compiled that suggest the existence of depression and riverine waters/wetlands in a given area, and these subclasses will need to be assessed separately (see below). Also, attention should be focused on the land-use history and landscape context of the assessment area, as these factors may affect the boundaries of the assessment area(s) or on variable scores. For example, on Borden Ranch a proposed assessment area may be 0.5 acres in size. A portion of it may be moderately to heavily grazed grassland, and 200 acres of it could be recently ripped or converted to vineyards. Such conditions will have bearing on HGM assessment model results and they should be carefully noted. If necessary, separate assessment areas will need to be defined.

Field Work

Step 1. Assemble Field Equipment and Field Data Sheets

The following equipment is a minimum list for use of this draft Guidebook in the field. A more complete list of equipment is provided in Appendix G

a. Field sampling gear required to measure variables
b. Copies of the field forms provided in Appendix G
c. Calculator or computer for calculation of functional scores
d. Supporting documentation (*e.g.*, flora, soil surveys, maps, photos, hydrologic information, etc.)

Step 2. Identify the HGM Class and Subclass Correctly

The draft HGM models presented here are intended for application only within the specified classes and subclasses of waters/wetlands defined for the Borden Ranch. The

subclass profiles presented in Section IV of this draft Guidebook provide detailed profiles of key physical and biological attributes of the depressions, slopes and riverine waters/wetlands on Borden Ranch. In addition, Table 10 is a "Key to Classes and Subclasses of Waters/Wetlands on Borden Ranch." Use of the Key is fundamental to proper application of the draft HGM models. Specifically, draft Guidebook users should run through the key to correctly identify which class and subclass of waters/wetlands on Borden Ranch they intend to assess. This basic classification step will allow Guidebook users to quickly identify the correct draft HGM models for the assessment.

Table 10. Key to Classes and Subclasses of Waters/Wetlands on Borden Ranch, Sacramento and San Joaquin Counties, California.

1a. The water/wetland consists of a depression with or without an outlet. It has an intact restrictive layer and no evidence of very long duration ponding and/or saturation of soils as a result of groundwater upwelling or discharge. - **2**

2a. The water/wetland is a closed depression without an outlet.

3a. Water/wetland has an intact restrictive layer and no evidence of very long duration ponding and/or saturation of soils as a result of groundwater upwelling or discharge through fractures in the restrictive layer - **Depression, Closed and hydrologically isolated (perched).**

3b. Water/wetland has a relatively intact restrictive layer and clear evidence of ponding and/or saturation of soils as result of groundwater upwelling or discharge - **Depression, Closed and discharge (not a subclass addressed by the draft HGM models in this report).**

2b. The water/wetland is a depression with an outlet. The outlet is a jurisdictional water/wetland or non-jurisdictional slope feature that can convey surface and/or shallow subsurface water from the depression down-gradient during periods of high water. Depression may or may not exhibit very long duration ponding and/or saturation of soils as a result of groundwater upwelling - **4**

4a. Depression receives virtually all of its hydrologic inputs from precipitation and from surface and shallow subsurface flow. It does not exhibit plant community or hydric soil characteristics that would indicate very long duration ponding and/or saturation of soils as a result of groundwater upwelling.--- **Depression, surface and shallow subsurface flow-through.**

4b. Depression exhibits very long duration ponding and/or saturation of soils as a result of groundwater upwelling. - **Depression, flow-through, discharge (not a subclass addressed by the draft HGM models in this report).**

1b. The waters/wetland has a generally linear shape. Its slope is nearly level (<1%) to moderate (>2% - <10%). It may or may not have bed and bank channel features and evidence of sediment import, storage and transport - **5**

5a. The water/wetland forms the headward most extent of a drainage network. Its contributing area is relatively small. Its slope is nearly level (<1%) to moderate (>2% and <10%). No channel features (*e.g.,* bed and bank) and no significant sediment import, storage and transport processes are evident. - **Slope, Headward extent of riverine waters/wetlands.**

5b. The water/wetland exists as part of an ephemeral or intermittent drainage network. It is not a perennial stream. Its contributing area is relatively large. Its slope is nearly level (<1%) to moderate (>2% - 10%) or (rarely) steep (>10%). Continuous channel features (*e.g.,* bed and bank) are evident in relatively pristine and in grazed conditions. Sediment import, storage and transport processes are clearly evident. - **Riverine First, Second or Third Order.**

Step 3. Define and Bound the Assessment Area(s)

After classification, the next task in the field is to bound or delimit the assessment area(s). In order to complete bounding, conduct a reconnaissance of the entire study area. Walk completely around the site. Draw a map of the assessment area boundaries and its landscape context. Make sure to observe (1) the range of variation of variable conditions that exist on the site, and (2) landscape context and condition. Note the watershed boundaries and waters/wetlands boundaries. All these areas should be reviewed carefully, particularly those that appear to be distinct from each other during office preparation. It is critical that the assessment area(s) be bounded correctly for three reasons:

First, if the project site includes uplands and wetlands, then the assessment area must be bounded such that only the portion that is part of the waters/wetland subclasses treated by this Guidebook is included in the assessment (Figures 73 and 74). In the case of this draft Guidebook, only depression, slope and riverine waters/ wetlands should be included. Recall, however, that sites that are not currently functioning as waters/wetlands due to natural or anthropogenic disturbance should not be assessed or they should be assigned a score of "0."

Second, if different subclasses exist on the same project site, then separate models must be used in the functional assessments of these areas. For example, where depressional waters/wetlands occur adjacent to riverine waters/wetlands (*e.g.,* active channels and floodplains), each subclass should be assessed using the appropriate model for its subclass.

Third, if different stages of development and/or different disturbance regimes exist on the same project site, then separate functional assessments may need to be performed for each area (Figure 75). For example, consider a project site that contains waters/wetlands within a single subclass (*e.g.*, a third order riverine waters/wetland). If a portion (*e.g.*, the upper one-half) of this waters/wetland is undisturbed, while the lower one-half has been impacted by human disturbance, these areas may need to be separated into two assessment areas.

Step 4. Score the Model Variables

a. Number of Assessments Required and Field Forms

The HGM models in this draft Guidebook are composed of several variables that are combined in a variety of ways in the calculation of the indices of function. Most of the variables are used in several indices. In order to streamline the functional assessment for a particular waters/wetland in a given condition (*e.g.,* current condition), each of the variables called by an individual model should be scored once and tabulated on a field assessment form (Appendix G). If future conditions (*e.g.,* absence of cattle grazing or some proposed restoration activity) need to be assessed, each of the variables called by the model will need to be scored again.

b. Complete Field Measurements of Variable Conditions

In Appendix G, the variables are arranged in alphabetical order. To perform an HGM assessment, each of these variables must be scored according to the measurement protocols detailed in the models.

Do not estimate variable conditions if measurements are required. This will result in significant errors.

Record the measurement result, the associated variable score, and the team's rationale in selecting the variable score on the field data sheet. Please note that the field data sheets include space for recording rationale or making comments on the decision. The authors intent here is to provide model users with an opportunity to make notes on each variable score and to facilitate meaningful discussions at a later date.

Groups of variables require different ranges or scales of observation within the assessment area. For example, the variable "Soil Profile Integrity" ("$V_{soilint}$") requires observations of soil conditions within the waters/wetland; the variable "Watershed Condition" (V_{wscond}) requires observation of the predominant land use or condition of the contributing area. The variable "Wetland Density" (V_{WDEN}) requires observations within 3,000 feet of the centroid of the assessment area. Figures 76 and 77 summarize the scale at which each variable should be observed.

Step 5. Calculate Indices of Function

In order to streamline the functional assessment, functions for depressions, slopes and riverine waters/wetlands and their corresponding indices of function are condensed into field data sheets (Appendix G). The indices of function should be calculated in the field.

Preliminary assessment results should be reviewed by the assessment team members in the field, not in the office.

Again, the field data sheets include space for recording rationale or making comments on the decision with the intent of facilitating meaningful discussions on later dates.

Preparation of an HGM Assessment Report

Consistent with the guidance offered in Table 10, a written report of all HGM assessment results should be prepared by the assessment team. Table 10 lists minimum submittals for such a report.

Figure 73. HGM Assessment Bounding

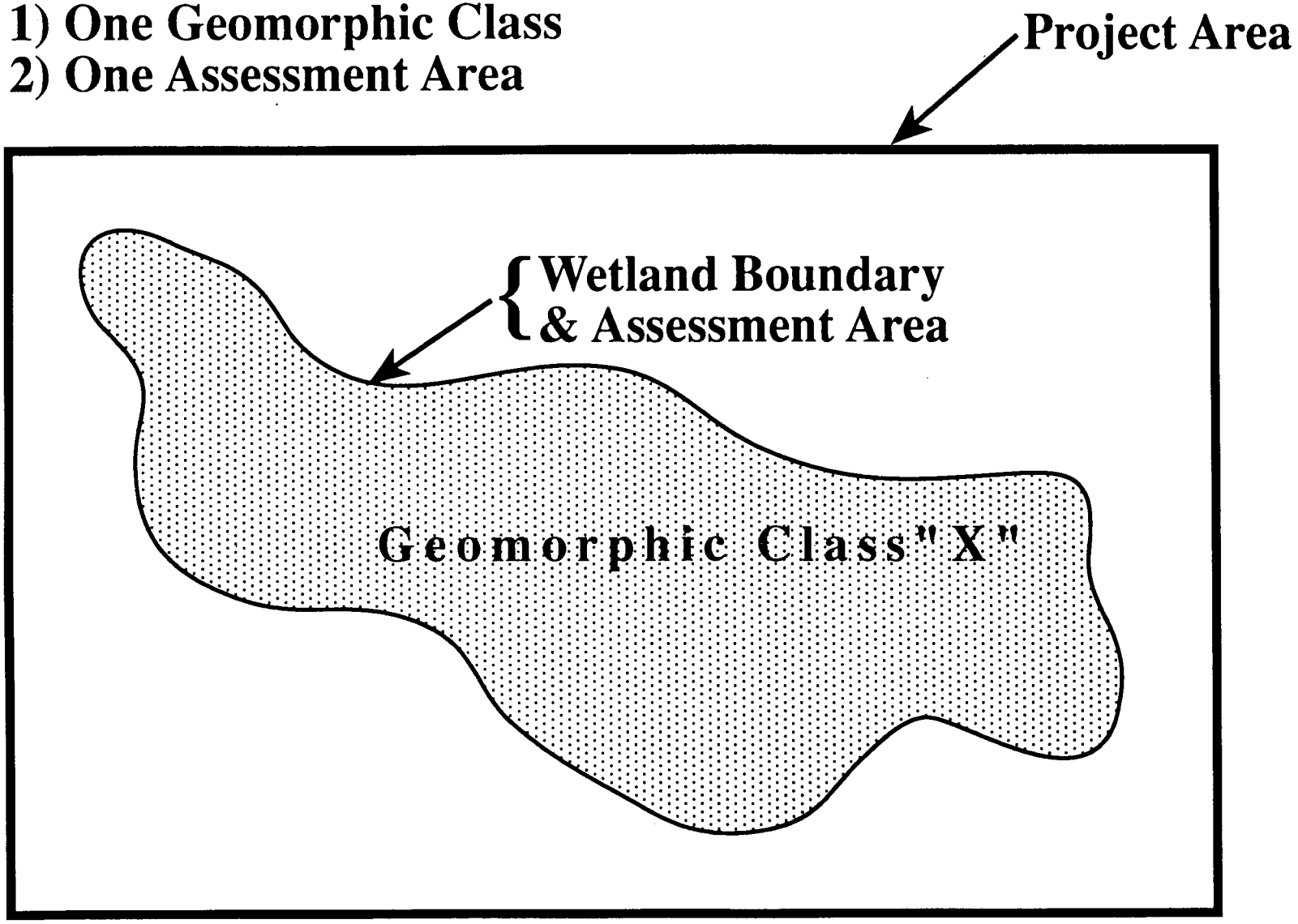


Figure 74. HGM Assessment Bounding

1) One Geomorphic Class
2) One On Site Assessment Area (Project Area) &

Separate Off Site &/or Cumulative Effects Assessment

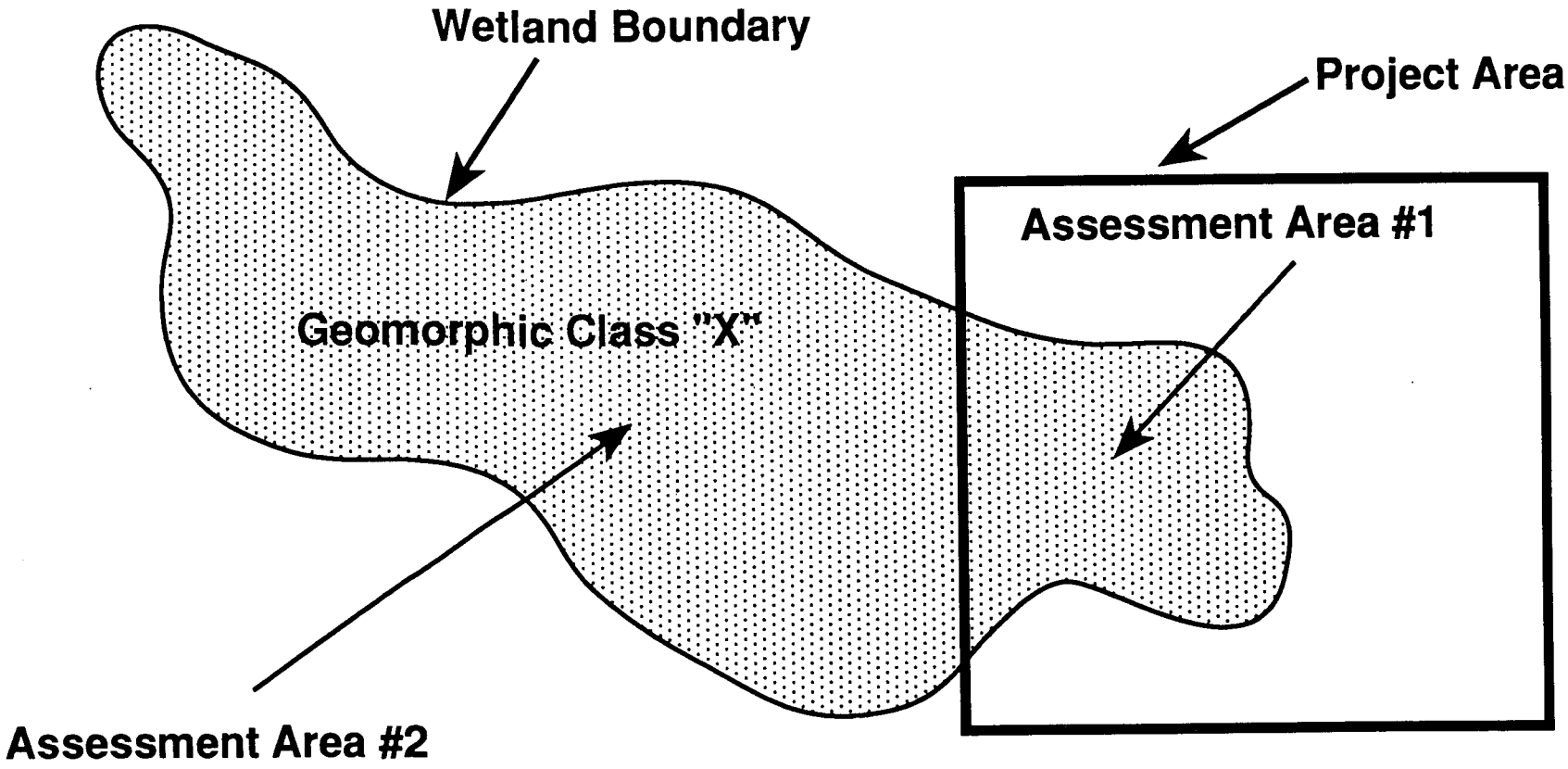


Figure 75. HGM Assessment Bounding

1) One Geomorphic Class
2) Two Assessment Areas

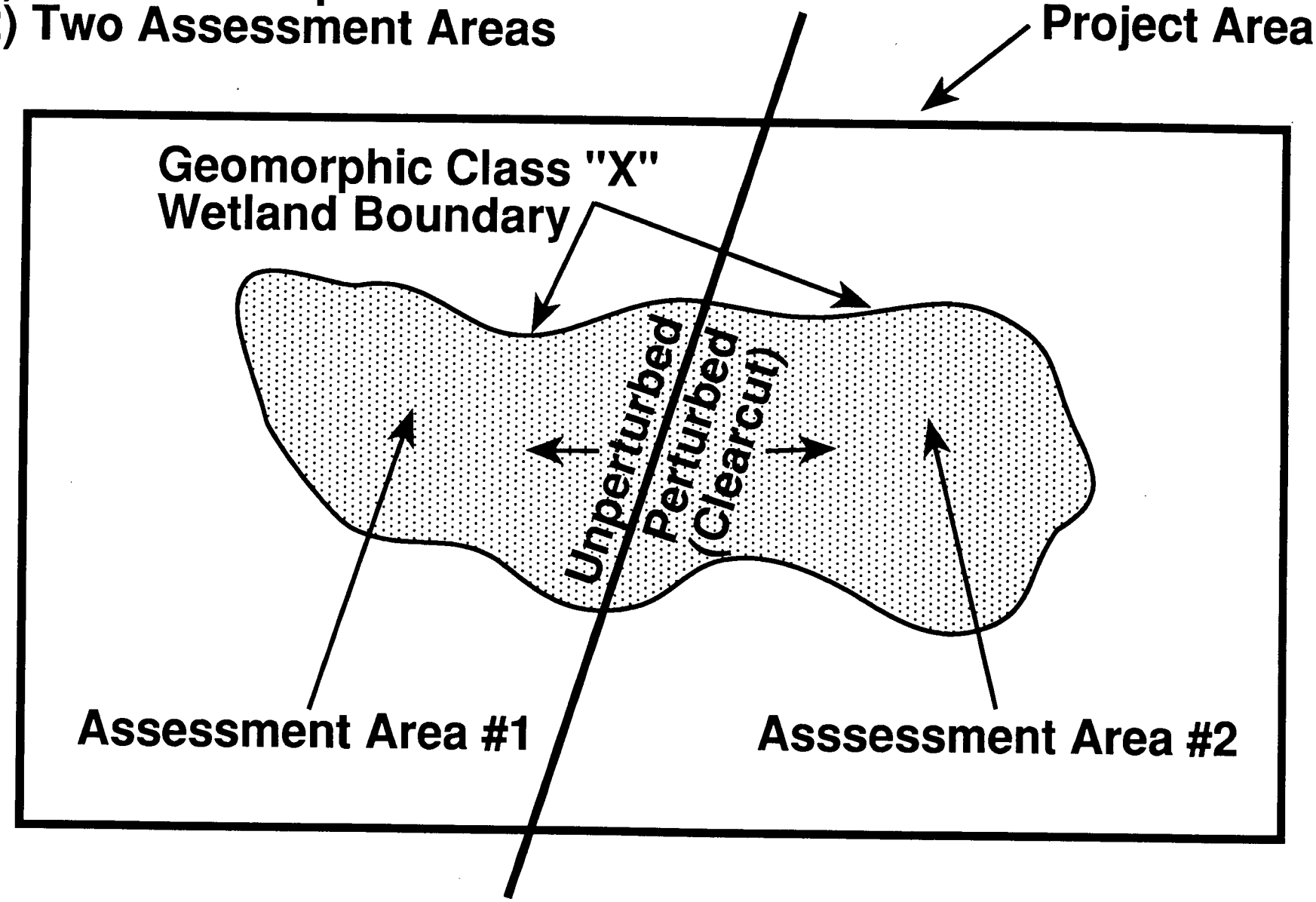
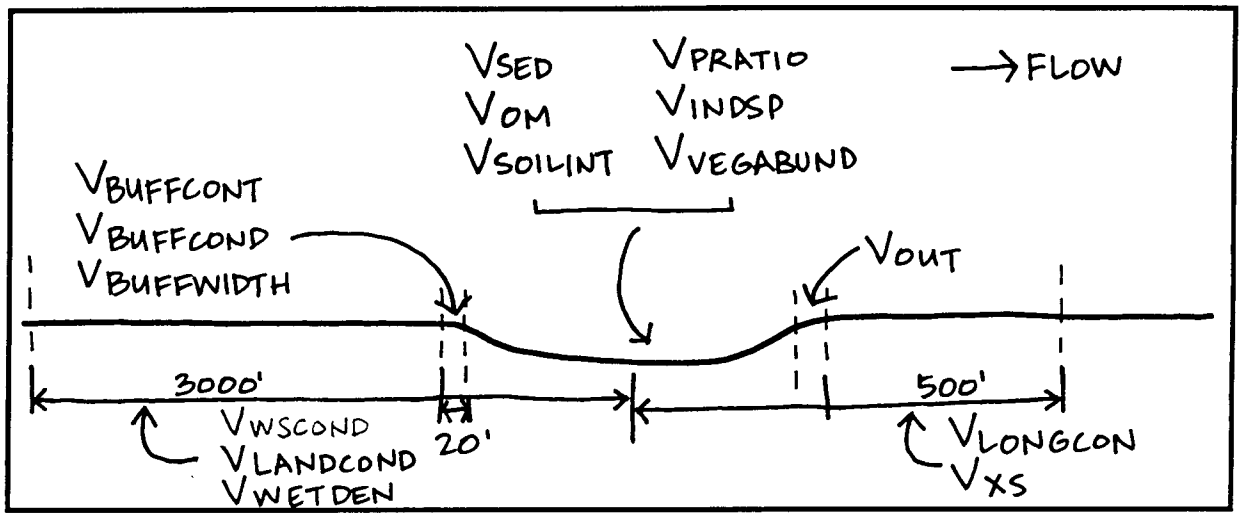
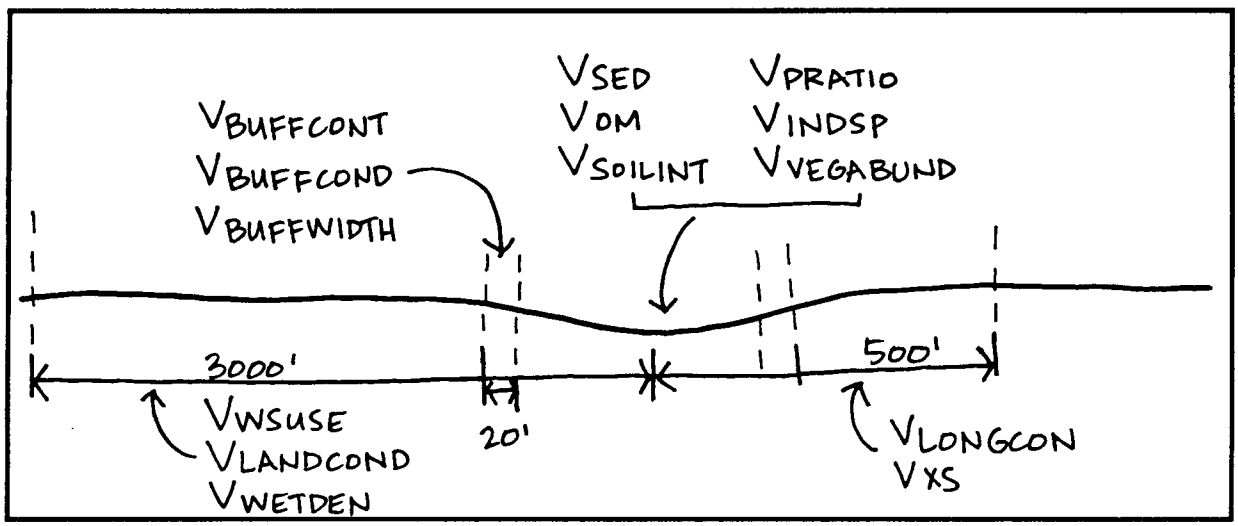


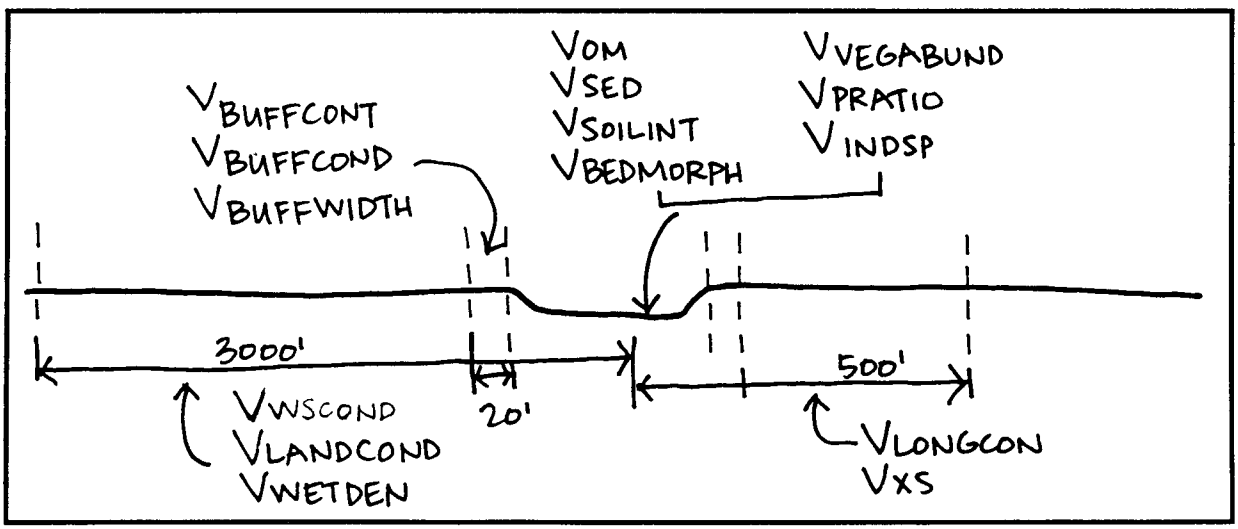
Figure 76. Cross-Sections Locating Areas In Which To Focus the Assessment of Variables in Wetlands on the Borden Ranch Property



Depression



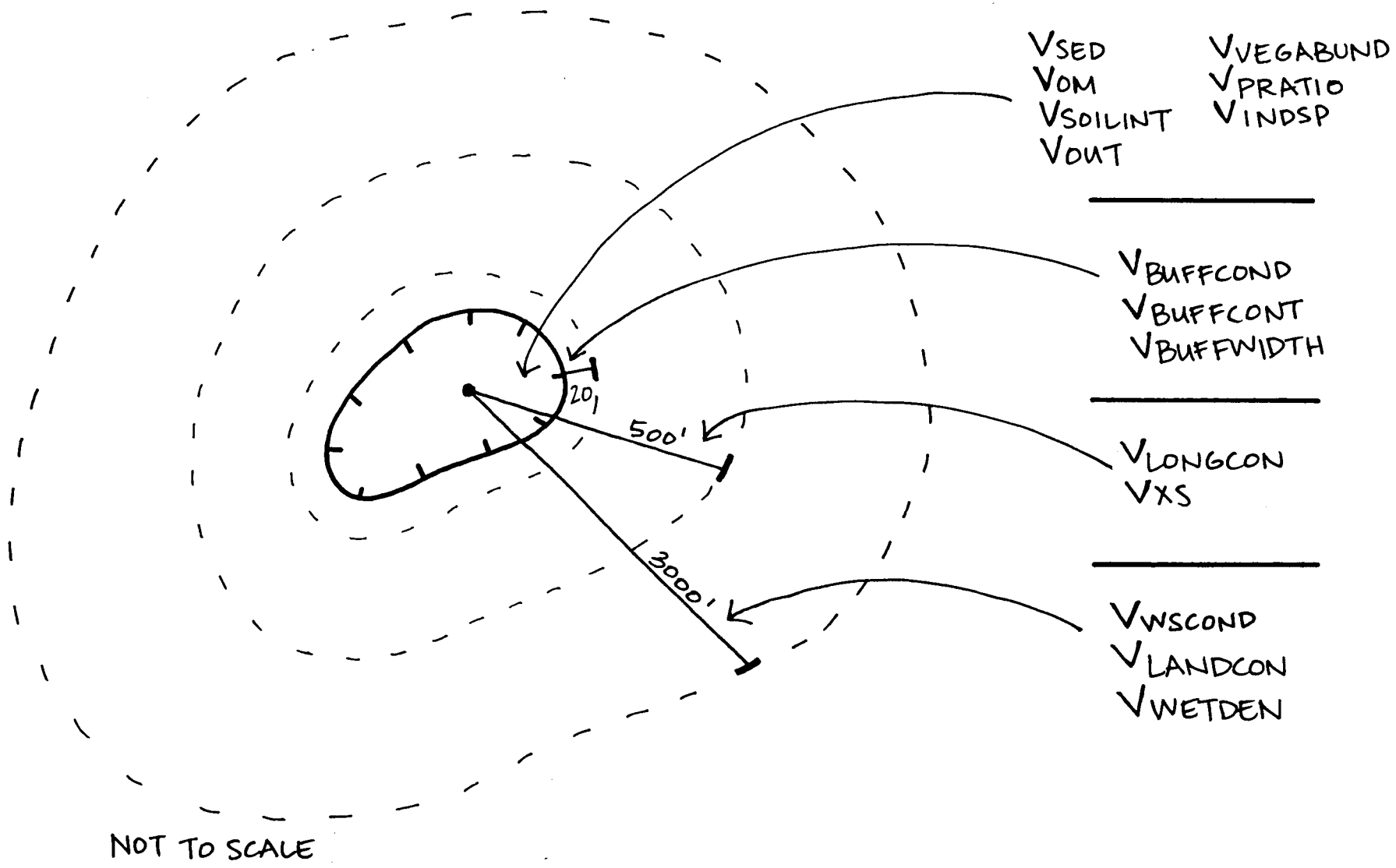
Slope



Riverine

NOT TO SCALE

Figure 77. Plan View Locating Areas In Which To Focus the Assessment of Variables in Depression Wetlands on the Borden Ranch Property



APPENDIX G

FIELD ASSESSMENT FORMS FOR

APPLICATION OF THE HGM MODELS

Borden Ranch

Complete Gear List For Running Draft HGM Functional Assessment Models

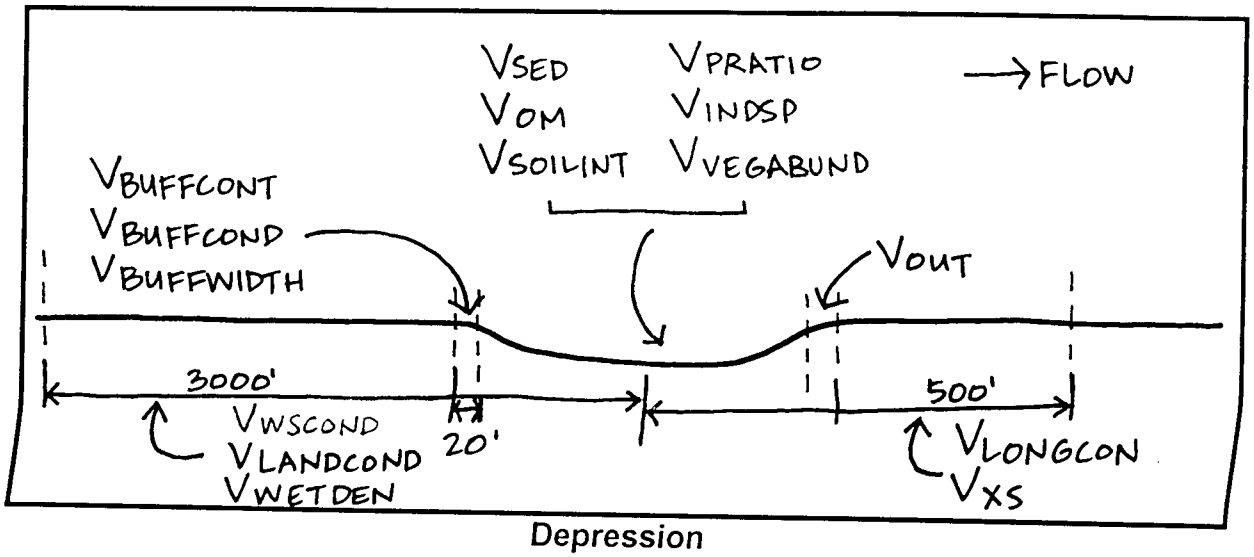
I. Essential Gear

A. Sacramento and San Joaquin County Soil Surveys
B. Aerial Photos
C. Shovel(s) and soil probes
D. 300+ foot measuring tape(s)
E. 100 Fooot spences tape(s)
F. Abney level &/or clinometer
G. Clipboard
H. Ruler(s) (metric and English)
I. Engineer's Rule
J. Camera & film'
K. Water
L. Jepson Manual
M. Plastic bags

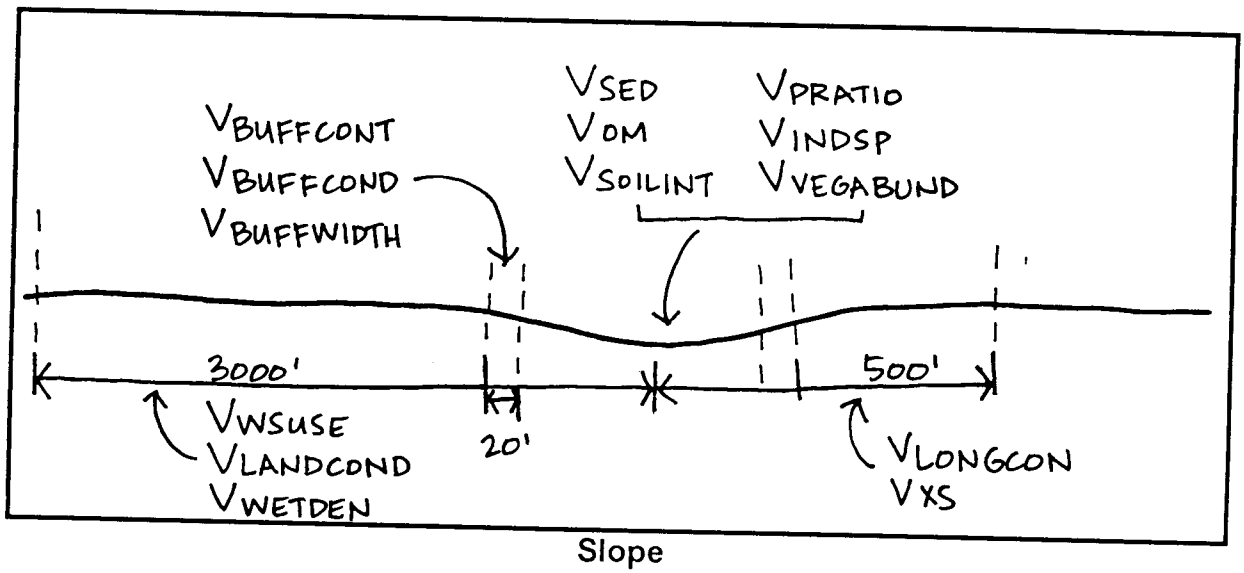
II. Desireable Gear

A. GPS
B. Laser level, tripod, rod, target

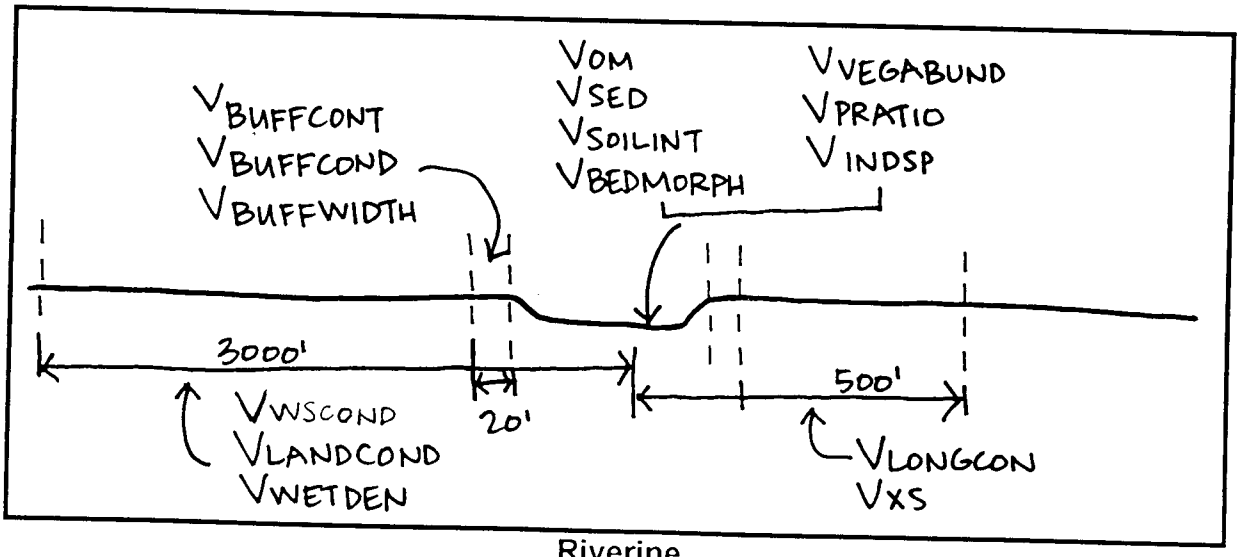
Figure 76. Cross-Sections Locating Areas In Which To Focus the Assessment of Variables in Wetlands on the Borden Ranch Property



Depression



Slope



Riverine

NOT TO SCALE

Figure 77. Plan View Locating Areas In Which To Focus the Assessment of Variables in Depression Wetlands on the Borden Ranch Property

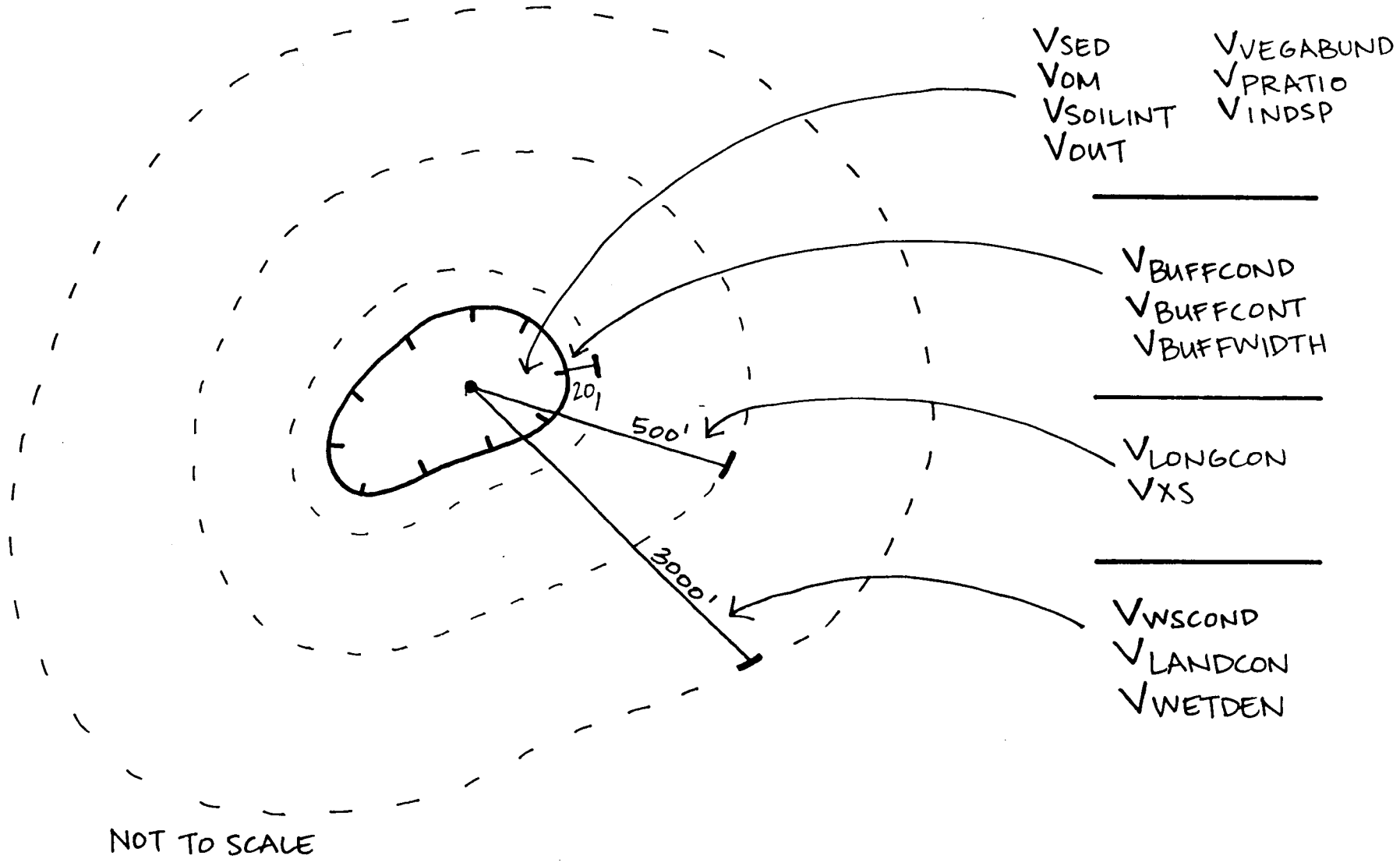


Table G-1. Variable Score Field Form

Variable		Indicator Measurement Result (e.g. stems/acre; canopy coverage, etc.)	Method/ Approach used to estimate Indicator Measurement	Variable Score from HGM Model	Discussion / Rationale
$V_{BEDMORPH}$:	Channel Bed Morphology				
$V_{BUFFCOND}$:	Buffer Condition				
$V_{BCONTINUITY}$:	Buffer Continuity				
V_{BWIDTH}:	Buffer Width				
$V_{DSINDSP}$:	Depression/Slope Indicator Species				
$V_{DSVEGABUND}$:	Depression/Slope Vegetation Abundance				
$V_{LANDCON}$:	Land Use or Condition				
$V_{LONGCON}$:	Longitudinal Connections to Down-Gradient Waters/Wetlands				
V_{OM}:	Organic Material				
V_{OUT}:	Outlet				
V_{PRATIO}:	Percent of Native Plant Species				
V_{RINDSP}:	Riverine Indicator Species				
$V_{RVEGABUND}$:	Riverine Vegetation Abundance				
V_{SED}:	Sediment Deposition				
$V_{SOILINT}$:	Soil Profile Integrity				
V_{WETDEN}:	Wetland Density				
V_{WSCOND}:	Watershed Condition				
V_{XS}:	Swale of Channel Cross-Section				

Table G-2. Function Score Field Form for Depressional Waters/Wetlands on Borden Ranch

FUNCTION	INDEX	Functional Index Score	Rationale/ Comments
Surface and Shallow Subsurface Water Storage and Exchange (Closed and Flow-Through)	Closed: $(V_{OUT} \times (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{VEGABUND})/5)^{1/2}$ Flow-Through: $(V_{OUT} \times (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND} + V_{LONGCON})/7)^{1/2}$		
Landscape Hydrologic Connections (Flow-Through	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{LONGCON})/4$		
Element and Compound Cycling (Closed and Flow-Through)	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/7$		
Organic Carbon Export (Flow-Through)	$((V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + (V_{SOILINT} + V_{OM} + V_{VEGABUND})/3 + V_{OUT} + V_{LONGCON})/4$		
Plant Community (Closed and Flow-Through)	$(V_{OM} + V_{SOILINT} + V_{VEGABUND} + V_{PRATIO} + V_{DSINDSP} + (V_{WETDEN} + V_{LANDCOND})/2)/6$		
Faunal Habitat (Closed and Flow-Through)	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/7$		
Faunal Habitat Interspersion and Connectivity (Closed and Flow-Through	Closed: $V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{WETDEN})/3$ Flow-Through: $(V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{OUT} + V_{LONGCON} + V_{WETDEN})/5$		
Invertebrate Assemblage (Closed and Flow-Through)	Direct Assessment		
Vertebrate Assemblage (Closed and Flow-Through)	Direct Assessment		

Function Score Field Form for Slope Waters/Wetlands on Borden Ranch

FUNCTION	INDEX	Functional Index Score	Rationale/ Comments
Surface and Shallow Subsurface Water Storage and Exchange	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND} + V_{LONGCON})/7$		
Sediment Retention	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND})/6$		
Landscape Hydrologic Connections	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON})/3$		
Element and Compound Cycling	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$		
Organic Carbon Export	$((V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + (V_{SOILINT} + V_{OM} + V_{VEGABUND})/3 + V_{LONGCON})/3$		
Plant Community	$(V_{OM} + V_{SOILINT} + V_{VEGABUND} + V_{PRATIO} + V_{DSINDSP} + (V_{WETDEN} + V_{LANDCOND})/2/6$		
Faunal Habitat	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$		
Faunal Habitat Interspersion and Connectivity	$(V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON} + V_{WETDEN})/4$		
Invertebrate Assemblage	Direct Assessment		
Vertebrate Assemblage	Direct Assessment		

Function Score Field Form for Riverine Waters/Wetlands on Borden Ranch

FUNCTION	INDEX	Functional Index Score	Rationale/ Comments
Surface and Shallow Subsurface Water Storage and Exchange	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{BEDMORPH} + V_{SOILINT} + V_{SED} + V_{VEGABUND} + V_{LONGCON})/8$		
Sediment Mobilization, Transport and Deposition	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{BEDMORPH} + V_{SOILINT} + V_{SED} + V_{VEGABUND})/7$		
Energy Dissipation	$(V_{XS} + V_{BEDMORPH} + V_{SED} + V_{VEGABUND})/4$		
Landscape Hydrologic Connections	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON})/3$		
Element and Compound Cycling	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$		
Organic Carbon Export	$((V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + (V_{SOILINT} + V_{OM} + V_{VEGABUND})3 + V_{LONGCON})/3$		
Plant Community	$(V_{OM} + V_{SOILINT} + V_{VEGABUND} + V_{PRATIO} + V_{RINDSP} + (V_{WETDEN} + V_{LANDCOND})/2)/6$		
Faunal Habitat	$(V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$		
Faunal Habitat Interspersion and Connectivity	$(V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON} + V_{WETDEN})/4$		
Invertebrate Assemblage	Direct Assessment		
Vertebrate Assemblage	Direct Assessment		

C. *Draft HGM Model for Slope Waters/Wetlands at the Headward Extent of Riverine Waters/Wetlands on Borden Ranch, Sacramento and San Joaquin Counties, California*

1. Definitions of Functions

a. Hydrologic Functions

1) Surface and Shallow Subsurface Water Flow and Storage

The focus of this function is on the ability of a slope water/wetland to moderate the rate of surface and shallow subsurface water flow as water moves into, through, and out of the assessment site. Increases in flows and/or flow velocities are not increases in functional capacity. Intact slope waters/wetlands dissipate hydrologic energy and moderate rates of surface and shallow subsurface water flow. Moderate rates of surface and shallow subsurface water flow maintain soil moisture in the assessment site and maintain baseflows in down-gradient riverine waters/wetlands. Slope waters/wetlands have land-dominated hydrographs so the timing, duration, and amount of water delivered to the swale is dependent upon the condition of the watershed and the buffer. Surface and shallow subsurface water flow and storage characteristics are further modified by swale dimension, transmissivity in the upper part of the soil profile, and roughness characteristics (*e.g.*, herbaceous cover and fine root biomass).

2) Sediment Retention

Intact slope waters/wetlands are characterized by very low rates of sediment mobilization. It is these low rates of sediment mobilization that limit the development of riverine morphological features such as channel beds and banks. Low rates of sediment mobilization are the result of surface and shallow subsurface water flow moderation. Slope waters/wetlands have land-dominated hydrographs so the timing, duration, and amount of water delivered to the swale is dependent upon the condition of the watershed and the buffer. Thus, the kinetic energy of the water as it flows into, through, and out of the slope water/wetland is affected by the condition of the contributing area and the buffer. The upper parts of the profile are mobilized, transported, and deposited when slope waters/wetlands become sediment sources. Thus, intact soil profiles and a lack of sediment deposition are indicative of sediment retention. Sediments are retained, in part, due to the energy dissipation and fine root biomass provided by vegetation.

3) Landscape Hydrologic Connections

This function refers to the hydrologic connectivity of contributing areas to slope waters/wetlands, and to other downgradient waters/wetlands. Slope waters/wetlands have land-dominated hydrographs so the timing, duration, and amount of water delivered to the swale is dependent upon the condition of the watershed and the buffer. The high-order seasonal and perennial streams depend upon intact connections from the upper portions of the watershed to maintain flow and sediment transport characteristics.

b. Biogeochemical Functions

1) Element and Compound Cycling

Element and compound cycling includes the abiotic and biotic processes that convert compounds from one form to another. These are primarily recycling processes wherein elements and compounds are cycled between atmosphere, water, soil and vegetation. Additionally, elements and compounds are temporarily removed from cycling processes through retention/detention in soils and sediments. The critical attributes and processes are in soil and vegetation. The buffer filters incoming surface and shallow subsurface water. Soil provides habitat for soil microorganisms that mediate the cycling processes, and also provides space where elements and compounds can be stored. Vegetation takes up, transforms, and temporarily stores elements and compounds and also provides oxygen to the rooting zone.

2) Organic Carbon Export

Organic carbon is exported from waters/wetlands in dissolved and particulate forms. Mechanisms of organic carbon export include leaching, displacement, and erosion. Sources of organic carbon include herbaceous vegetation both in the water/wetland and in the buffer, as well as organic matter incorporated into the soil profile. Export of organic carbon from the riverine water/wetland is dependent upon the condition of the hydrologic connection to down-gradient waters/wetlands.

c. Plant Community/Habitat Functions

1) Plant Community

Attributes of plant community include the species composition and physical characteristics of the living plant biomass. The emphasis is on the composition and structure of the plant community. Species composition is influenced by physical processes that maintain the characteristic hydrologic functions of slope wetlands (*e.g.*, soil structure and hydraulic conductivity) and biological processes (*e.g.*, presence of viable populations of native pollinators). In addition, because slope wetlands occur as fragmented habitat islands, the condition, areal extent and distribution of depressional/slope waters/wetlands habitat in the surrounding landscape (*i.e.*, surrounding land use and density of wetlands), which provides a regional source of colonists (propagules) to balance local extinctions within single pools, is critical to maintaining viable plant communities. Physical structure and attributes of the vegetation are also components of this function, including characteristic aerial cover, vertical and horizontal spatial distributions, and accumulation of organic matter.

2) Faunal Habitat

This function referes to the capacity of a water/wetland to support animal populations and guilds by providing heterogeneous habitats that provide food, cover, and

reproductive opportunities. The emphasis is on species that require slope waters/wetlands as an essential component for some or all parts of their life history.

3) Faunal Habitat Interspersion and Connectivity

Faunal habitat interspersion and connectivity is the capacity of a water/wetland to permit vertebrate and invertebrate aquatic organisms to enter or leave via surface or shallow subsurface connections as well as the capacity of a water/wetland to permit access of terrestrial invertebrates and vertebrates to access contiguous areas of food, cover, and reproductive opportunities.

4) Invertebrate Assemblage

This function referes to the population of terrestrial and/or aquatic invertebrates supported by the water/wetland.

5) Vertebrate Assemblage

This function refers to the population of terrestrial and/or aquatic vertebrates supported by the water/wetland.

2. Function Equations

Surface and Shallow Subsurface Water Flow and Storage

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND} + V_{LONGCON})/7$$

Sediment Retention

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{XS} + V_{SOILINT} + V_{SED} + V_{VEGABUND})/6$$

Landscape Hydrologic Connections

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON})/3$$

Element and Compound Cycling

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$$

Organic Carbon Export

$$\text{Function} = ((V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + (V_{SOILINT} + V_{OM} + V_{VEGABUND})/3 + V_{LONGCON})/3$$

Plant Community

$$\text{Function} = (V_{OM} + V_{SOILINT} + V_{VEGABUND} + V_{PRATIO} + V_{DSINDSP} + (V_{WETDEN} + V_{LANDCOND})/2/6$$

Faunal Habitat

$$\text{Function} = (V_{WSCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{SOILINT} + V_{SED} + V_{OM} + V_{VEGABUND})/6$$

Faunal Habitat Interspersion and Connectivity

$$\text{Function} = (V_{LANDCOND} + (V_{BUFFCOND} + V_{BUFFCONT} + V_{BUFFWIDTH})/3 + V_{LONGCON} + V_{WETDEN})/4$$

Invertebrate Assemblage

Direct Assessment

Vertebrate Assemblage

Direct Assessment

3. Variables

Variable: BUFFCOND

Definition: Predominant land use or condition of the area 20 feet out from the water/wetland edge or to the top of the contributing area divide whichever is less.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the water/wetland buffer in the assessment area. Compare to all the descriptions provided in the scaling for the $V_{BUFFCOND}$ variable and choose the lowest score that appropriately describes the predominant land use and/or condition of the buffer.

Scaling: The predominant use and condition of the buffer was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{BUFFCOND}$: Buffer Condition

Measurement or Condition	Index
Land condition is light or no grazing and management has explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, b) increase the abundance of native plant species, c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land use is characterized by moderate to heavy grazing. There is no management intended explicitly to: a) reduce the abundance of non-native and/or invasive plant species, b) increase the abundance of native plant species, c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
CONDITION 1: The buffer is characterized by a) maintenance plowing, disking, harrowing, or raking, **and** b) an unfractured restrictive layer. **OR** **CONDITION 2:** The buffer is characterized by a) accelerated rates of sediment deposition **and** b) an unfractured restrictive layer.	0.5
The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) cultivated crops (*e.g.*, vineyards or orchards), d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25
CONDITION 1: The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) cultivated crops (*e.g.*, vineyards or orchards), d) maintenance plowing, disking, harrowing, or raking between rows, **and** e) little to no herbaceous vegetation growing between rows. **OR** **CONDITION 2:** The buffer is characterized by a) a ripped soil profile, b) a fractured restrictive layer, **and** c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
The buffer is characterized by anthropogenic impervious surfaces (*e.g.*, roads, parking lots, buildings).	0.0

Variable: BUFFER CONTINUITY

Definition: Continuity of the buffer (20 feet out from the water/wetland edge or to the top of the contributing area divide whichever is less) around the water/wetland edge. Continuity is defined as the distance around the water/wetland edge that is bounded by a buffer divided by the total distance around the water/wetland edge times 100=%. The buffer must 1) $\geq$ one foot wide, 2) be vegetated with herbaceous species, 3) not have evidence of increased area and/or rate of sediment deposition, and 4) have an unfractured restrictive layer.

Measurement Protocol: Within the assessment area, measure the distance around the water/wetland edge that is bounded by a buffer[1]. Divide this measurement by the total distance around the water/wetland edge in the assessment area. Multiply this number by 100 to generate the percent continuity of the water/wetland buffer. Compare the percent continuity for the buffer to all the descriptions provided in the scaling for the $V_{BUFFCONT}$ variable and choose the lowest score that appropriately describes the continuity of the buffer and/or the recoverability of the buffer continuity. [1]Note: the buffer must be 1) greater than one foot wide, 2) be dominated by herbs, 3) not have evidence of increased area and/or rate of sediment deposition, and 4) have an unfractured restrictive layer.

Scaling: Buffer continuity was defined as the distance around the water/wetland edge that was bounded by a buffer divided by the total distance around the water/wetland edge (expressed as a percentage). The buffer had to 1) be greater than one foot wide, 2) be vegetated with herbaceous species, 3) not have evidence of increased sediment deposition, and 4) have an unfractured restrictive layer.

The data are bimodal. Buffer continuity tended to be 100 percent or 0 percent. The bimodal nature of the data did not allow for the determination of whether relationships between buffer continuity and ecosystem attributes and processes (*e.g.*, sediment accretion) were linear or curvilinear. Thus, the relationship was assumed to be linear.

Confidence: Medium.

$V_{BUFFCONT}$: Buffer Continuity

Measurement or Condition	Index
100% of the water/wetland edge is bounded by an intact buffer.	1.0
75% to <100% of the water/wetland edge is bounded by an intact buffer.	0.75
50% to <75% of the water/wetland edge is bounded by an intact buffer.	0.5
25% to <50% of the water/wetland edge is bounded by an intact buffer.	0.25
0% to <25% of the water/wetland edge is bounded by an intact buffer. Variable is recoverable and sustainable through natural processes and under current conditions.	0.1
0% to <25% of the water/wetland edge is bounded by an intact buffer. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: BUFFER WIDTH

Definition: Mean width of the buffer (20 feet out from the water/wetland edge or to the top of the contributing area divide whichever is less). The buffer must 1) be vegetated with herbaceous species, 2) not have evidence of increased area and/or rate of sediment deposition, and 3) have an unfractured restrictive layer.

Measurement Protocol: Within the assessment area, measure the mean width of the water/wetland buffer. A minimum of four measurements should be made to calculate the mean width. Measurements are made perpendicular from the water/wetland edge to a maximum distance of 20 feet (20 feet is the maximum width of the buffer by definition). Compare the mean buffer width to all the descriptions provided in the scaling for the $V_{BUFFWIDTH}$ variable and choose the lowest score that appropriately describes the mean width of the buffer and/or the recoverability of the width of the buffer.

Scaling: Buffer widths were defined as a 20 feet or to the top of the contributing area, whichever was the lesser distance. The buffer had to 1) be greater than one foot wide, 2) be vegetated with herbaceous species, 3) not have evidence of increased sediment deposition, and 4) have an unfractured restrictive layer. The distance to disturbance was determined by measuring from the water/wetland boundary to the nearest disturbance within the buffer. This was performed at multiple points and a mean distance to disturbance was reported.

The data are bimodal. Buffer widths tended to be greater than or equal to 20 feet or 0 feet. The bimodal nature of the data did not allow for the determination of whether relationships between buffer widths and ecosystem attributes and processes (*e.g.*, sediment accretion) were linear or curvilinear. Thus, the relationship was assumed to be linear.

Confidence: Medium.

$V_{BUFFWIDTH}$: Buffer Width

Measurement or Condition	Index
Mean buffer width is greater than or equal to 20 feet **or** to top of contributing area.	1.0
Mean buffer width is between 15 and 20 feet **or** to top of contributing area.	0.75
Mean buffer width is between 10 and 15 feet **or** to top of contributing area.	0.5
Mean buffer width is between 0 and 15 feet **or** to top of contributing area.	0.25
Mean buffer width is between 0 and 5 feet **or** to the top of contributing area. Variable is recoverable and sustainable through natural processes and under current conditions.	0.1
Mean buffer width is between 0 and 5 feet **or**. Variable is not recoverable and sustainable through natural processes and under current conditions or to top of contributing area.	0.0

Variable: DEPRESSION/SLOPE INDICATOR SPECIES

Definition: The presence of plant taxa that are restricted to; indicative, characteristic or typical of; depression and slope waters/wetlands in the Sacramento Region of the Central Valley of California.

Measurement Protocol: A list of the dominant taxa (i.e. all taxa that make up > 50% of the total vegetative cover, plus taxa that make up > 20% total cover) is made from visual inspection of 1 square meter plots in the assessment area. At least 10 plots should be made at random points within the assessment area. Dominant taxa are compared with lists of restricted or associated plants compiled from the literature and the percent of taxa that are restricted or associated is calculated by dividing restricted/associated taxa by total taxa and multiplying by 100. Compare the percent indicators to all the descriptions provided in the scaling for the $V_{DSINDSP}$ or the V_{RINDSP} variable and choose the lowest score that appropriately describes the condition. This variable can be assessed when vegetation is senescent if taxa can be identified.

Scaling: The presence of indicator species was assessed by listing the dominant taxa within the assessment area and checking these taxa against lists of taxa restricted to, or typically associated with ephemeral depression or slope wetlands in the Central Valley of California. The lists were compiled from data collected in depression/slope waters/wetlands on Borden Ranch and the literature on the vegetation of vernal pools in the Central Valley. The variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

Note: Confidence in this variable is medium because due to constraints of time, $V_{DSINDSP}$ was scored during the dry stage when vegetation is senescent. Because plant identifications are more difficult at this time, some taxa could only be identified to genera. The scoring of this variable is conservative however, because taxa that could be identified only to genus level were classified as restricted or associated if any members of that genus are restricted or associated in California.

$V_{DSINDSP}$: Depression/Slope Indicator Species

Measurement or Condition	Index
> 90% of the dominant taxa present are restricted to ephemeral depression/slope wetlands in California (see attached lists).	1.0
> 50% to 90% of the taxa present are restricted to ephemeral depression/slope wetlands in California or are frequently or typically associated with depression and slope waters/wetlands in California (see attached lists).	0.75
a) at least 50% of the dominant taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) other taxa present are from the surrounding annual grasslands (*e.g.*, *Lolium*, *Hordeum*, *Briza*, *Juncus bufonius*).	0.5
a) >25% to 50% of the dominant taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) > 50% of the dominant taxa are typical of more permanently wet soils (*e.g.*, *Typha*, *Salix*, *Cyperus*, *Cynodon*, *Erodium*, *Echinochloa*, *Juncus*) or adventive annuals from more open, disturbed habitats (*e.g.*, *Atriplex*, *Rumex*, Chenopodiaceae, *Matricaria*, *Lolium*, *Polypogon*, *Malva*)	0.25
CONDITION 1: a) < 25% of the taxa present are restricted to, or are frequently or typically associated with, depression and slope waters/wetlands in California; **and** b) > 50% of the taxa are typical of more permanently wet soils (see list above) or open, disturbed habitats (see list). **OR** **CONDITION 2:** No vegetative cover, but variable is recoverable and sustainable through natural processes and under current conditions.	0.1
No vegetative cover; variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: DEPRESSION/SLOPE VEGETATION ABUNDANCE

Definition: Characteristics of vegetation abundance and structure in the waters/wetland (including height, cover, stem density, spatial distribution, and phenological sequence).

Measurement Protocol: Measurement of this variable is keyed to the different stages in the wet to dry cycle that characterizes depression, slope and riverine wetlands on Borden Ranch. Depending on the time of year the assessment is conducted, choose one of the two stages in the cycle, either Drying or Wetting/Dry (see Glossary for definitions of stages) and use the descriptions for that stage . Vegetative cover is visually estimated by assessing the percent cover of actively photosynthesizing vegetation within 1 square meter plots. At least 10 plots should be made at random points within the assessment area and an average of these 10 observations should be calculated. The vegetation within the waters/wetland is visually inspected (i.e. physiognomy, spatial distribution of species, and species composition) to determine if vegetation within the assessment area can be distinguished from the vegetation outside the assessment area. Compare percent cover, distinctness of the vegetation within the assessment area, and species composition to all descriptions provided in the scaling for the $V_{VEGABUND}$ variable and choose the lowest score that appropriately describes the condition.

Scaling: Vegetation Abundance was assessed by measuring the percent cover and species composition of the dominant taxa, as well as describing the nature of the boundary between the vegetation of the assessment area and vegetation of the surrounding areas. This variable was scaled separately for the wet/dry and the drying stages of the seasonal wet to dry cycle, because vegetation abundance and species composition both change over time. The $V_{VEGABUND}$ variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium

$V_{DSVEGABUND}$: Depression/Slope Vegetation Abundance

Measurement or Condition	Index
Drying Stage: a) dominants are low growing (<1') native, annual forbs; **and** b) form concentric rings of different species along gradient from depression center to margin (may be one 'ring' in slopes); **and** c) boundaries between depression/slope vegetation and surrounding grassland vegetation are distinct and clear; **and** d) cover of vegetation in waters/wetlands lower (*i.e.*, 63% to 85%) than in surrounding grasslands (*i.e.*, 90% to 100%). **Dry Stage**: a) vegetative cover is <5% **and;** b) boundaries of the plant community are clear and distinct either as a water-filled depression, or as dry, open ground with a cover of senescent *Eryngium*; **and** c) no invasion by species from the surrounding annual grasslands. **Wetting/Wet Stage: Data not collected.**	1.0
Drying Stage: a) dominants are low growing, annual forbs; **and** b) form concentric rings along gradient from depression center to margin; **and** c) boundaries between depression vegetation and grassland are clear and distinct, but margins may contain increased cover from surrounding grassland plants; **and** d) cover of vegetation in the margins >85% where grassland species have invaded. **Dry Stage**: a) vegetative cover is <5%; **and** b) boundaries of plant community are clearly visible either as water-filled depression, or as dry open ground which contains mostly senescent *Eryngium*; **and** c) may contain some species from the surrounding annual grasslands. **Wetting/Wet Stage: Data not collected.**	0.75
No standard for this score.	0.5
All Stages: a) cover of spring/summer vegetation is >85% and >50% of dominants area non-native plants typical of more permanently wet soils (*e.g.*, *Echinochloa*, *Typha*, *Salix*, *Cyperus*, *Rumex*, *Lolium*), or adventives (*e.g. Chenopodium, Taraxacum, Atriplex,*); **and** b) cover/height of vegetation remains unchanged during time of year when depressions/slopes are normally dry (*i.e.*, summer); **and** c) no distinct boundary is recognizable between vegetation in depressions/slopes and surrounding area; **and** d) no clear wetting/wet stage (*i.e.*, standing water), although vegetation may be senescent during late fall/winter months.	0.25
All Stages: a) vegetative cover is <5% at all times; **and** b) during late fall/winter boundaries of original plant community may be visible with some ponding of water; **and** c) variable is recoverable and sustainable through natural processes and under current conditions.	0.1

Depression/Slope Vegetation Abundance cont.

Measurement or Condition	Index
All Stages: a) vegetative cover is <5 at all times; **and** b) boundaries of original plant community are not visible; **and** c) no short (>7 days) or very short (i.e. >1 day) ponding of water occurs during or after winter rains; **and** d) variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: LAND USE OR CONDITION

Definition: Predominant land use or condition within a 3000 foot radius of the centroid of the assessment site.

Measurement Protocol: Assess through visual observations during site review and/or by using other available information (e.g., aerial photos, maps etc.). Recent aerial photographs can facilitate the identification of land uses within the 3,000 foot radius. Compare to all the descriptions provided in the scaling for the $V_{LANDCOND}$ variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) land use within a 3,000 foot radius of the centroid of the assessment area.

Scaling: The predominant use and condition of the area within a circle with a 3000 foot radius centered on the centroid of the assessment site was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{LANDCOND}$: Land Use or Condition

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management component. The plan has the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
No standard for this score.	0.5
The area is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops that have been in place for 2 or more years (*e.g.*, vineyards or orchards).	0.25
CONDITION 1: The area is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops that have been in place for 2 or more years (*e.g.*, vineyards or orchards). OR **CONDITION 2:** The area is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) no cultivated crops (*e.g.*, vineyards or orchards), d) no disking or rolling in preparation for planting, and e) some vegetation and/or microtopographic variation exists.	0.1
The area is characterized by a) a ripped soil profile, b) a fractured restrictive layer, c) no cultivated crops (*e.g.*, vineyards or orchards), d) disking or disking and rolling in preparation for planting, and e) little to no vegetation and/or microtopographic variation exists.	0.0

Variable: LONGITUDINAL CONNECTIONS TO DOWNGRADIENT WATERS/WETLANDS

Definition: Land use or condition of the longitudinal connections to down-gradient waters/wetlands within 500 feet of the assessment area or to the next water/wetland (measurement from top of assessment are to 500' down-gradient). Flow-through depression waters/wetlands often form the headward extent of slope waters/wetlands, and slope waters/wetlands often form the headward extent of riverine waters/wetlands. The connections provide pathways for surface and shallow subsurface water flow, particulate transport, organic carbon export, and flora and fauna movement.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the longitudinal hydrologic connection(s) to down gradient waters/wetlands within 500 ft of the assessment area. Compare to all the descriptions provided in the scaling for the $V_{LONGCON}$ variable and choose the lowest score that appropriately describes the predominant land use or condition of the longitudinal hydrologic connection(s) to down gradient waters/wetlands.

Scaling: The predominant use and condition of the longitudinal connections to down-gradient waters/wetlands was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

$V_{LONGCON}$: Longitudinal Connections to Down-Gradient Waters/Wetlands

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management component. The plan has the explicit intent to a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to a) reduce the abundance of non-native and/or invasive plant species, **and** b) increase the abundance of native plant species, **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
CONDITION 1: The longitudinal connection is characterized by a) maintenance plowing, disking, harrowing, or raking **and** b) an unfractured restrictive layer. **OR** **CONDITION 2:** The longitudinal connection is characterized by a) accelerated rates of sediment deposition **and** b) an unfractured restrictive layer. **OR** **CONDITION 3:** The longitudinal connection is characterized by a) discontinuous disruptions to surface and/or shallow subsurface water flow (*e.g.*, road crossings, buried pipelines, and small ripped areas), **and** b) an unfractured restrictive layer.	0.5
The longitudinal connection is characterized by a) a ripped soil profile, **and** b) a fractured restrictive layer, **and** c) cultivated crops (*e.g.*, vineyards or orchards), **and** d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25

Longitudinal Connections to Down-Gradient Waters/Wetlands cont.

Measurement or Condition	Index
CONDITION 1: The longitudinal connection is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) maintenance plowing, disking, harrowing, or raking between rows; **and** e) little to no herbaceous vegetation growing between rows. OR **CONDITION 2:** The longitudinal connection is characterized by a) a ripped soil profile, b) a fractured restrictive layer, and c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
Longitudinal connections disconnected by anthropogenic activities and no longer exist (*e.g.*, channel bed cannot be identified).	0.0

Variable: PERCENT COVER OF ORGANIC MATERIAL IN THE WATER/WETLAND

Definition: Percent cover of the organic detrital material on the soil surface. The organic detrital material is composed of algal mats, and/or accumulated plant litter from forbs, graminoids, ferns, and fern allies.

Measurement Protocol: Make a visual assessment using 1 square meter plots of the percent cover of organic material within the assessment area. At least 10 plots should be made at random points within the assessment area and an average of these 10 observations should be calculated. Compare the average percent cover of organic material in the assessment area to all the descriptions provided in the scaling for the V_{OM} variable and choose the lowest score that appropriately describes the percent cover of organic material.

Scaling: The percent cover from organic matter in the assessment area was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High

V_{OM}: Organic Material

Measurement or Condition	Index
Depression and Slope: Cover of organic material (OM) is > 75%. **Riverine:** Cover of OM is > 50% to 70%; OM can be composed of algal and/or plant material accumulating where the kinetic energy of surface water is low.	1.0
Depression and Slope: Cover of OM is > 50% to 75%. **Riverine:** Cover of OM is > 30% to 50%; OM can be composed of algal and/or plant material accumulating where the kinetic energy of surface water is low.	0.75
Depression and Slope: Cover of OM is > 25% to 50%. **Riverine:** Cover of OM is > 20% to 30%,	0.5
Depression and Slope: Cover of OM is > 10% to 25%. **Riverine:** Cover of OM is > 5% to 20%.	0.25
Depression and Slope: **CONDITION 1:** Cover of OM is < 10%. **OR** **CONDITION 2:** Cover is high (> 90% locally) in response to irrigation return flow or in areas where irrigation has caused algal blooms in areas of ponding on the surface. **Riverine**: **CONDITION 1:** Cover of OM is <5%. **OR** **CONDITION 2:** Cover is high (> 60% locally) in response to irrigation return flow or in areas where irrigation has caused algal blooms in areas of ponding on the surface.	0.1
Depression, Slope, and Riverine: No OM. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: PERCENT OF NATIVE PLANT SPECIES

Definition: The percent of the dominant plant taxa present in the waters/wetlands that are native to California.

Measurement Protocol: A list of the dominant taxa (i.e. all taxa that make up > 50% of the total vegetative cover, plus taxa that make up > 20% total cover) is made from visual inspection of 1 square meter plots in the assessment area. At least 10 plots should be made at random points within the assessment area. Dominant taxa are recorded as either natives or non-natives using the Jepson Manual. The percent of native taxa is calculated by dividing native taxa by total taxa and multiplying by 100. Compare the percent native taxa to all the descriptions provided in the scaling for the V_{PRATIO} variable and choose the lowest score that appropriately describes the condition. This variable can be assessed when senescent vegetation is present if taxa can be identified.

Scaling: The percent of native species was assessed by listing the dominant taxa within the assessment area and checking these taxa against the Jepson Manual to determine native/non-native status in California. The variable was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium

Note: Confidence in this variable is medium because due to constraints of time, V_{PRATIO} was scored during the dry stage when vegetation is senescent. Because plant identifications are more difficult at this time, some taxa could only be identified to genera. The scoring of this variable is conservative however, because taxa that could be identified only to genus level were classified as native if any members of that genus are native to California.

V_{PRATIO}: Percent of Native Plant Species

Measurement or Condition	Index
Depression, Slope, and Riverine: > 90% of the taxa are native.	1.0
Depression and Slope: a) >70% to 90% native taxa; **and** b) individuals from surrounding non-native annual grasslands may be present. **Riverine**: a) >50% to 75% of the taxa are natives; **and** b) individuals from surrounding non-native annual grasslands may be present.	0.75
Depression and Slope: a) >50% to 70% native taxa; **and** b) non-native taxa are from the surrounding annual grasslands (*e.g., Lolium, Briza, Aira, Hordeum, etc.*). **Riverine**: a) >25% to 50% native taxa; **and** b) non-native taxa from surrounding annual grasslands (*e.g., Lolium, Hordeum, Briza, Aira*), or non-native adventives (*e.g., Taraxacum, Atriplex, Salsola, Rumex*) are present.	0.5
Depression and Slope: a) >20% to 50% are natives; **and** b) >50%of taxa are either non-natives typical of more permanently wet habitats (*e.g., Echinochloa, Erodium, Ranunculus, Cyperus*), or taxa typical of open, disturbed habitats (*e.g., Chenopodium, Rumex, Salsola, Taraxacum*). **Riverine**: a) >5% to 25% native taxa; **and** b) >75% are non-native taxa typical of more permanently wet habitats (*e.g., Echinochloa, Cynodon, Erodium, Ranunculus, Cyperus*) or taxa typical of open, disturbed habitats (*e.g., Chenopodium, Rumex, Salsola, Taraxacum*).	0.25
Depression and Slope: CONDITION 1: <20% native taxa. **OR** CONDITION 2: No vegetation present. Variable is recoverable and sustainable through natural processes and under current conditions. **Riverine**: CONDITION 1: <5% native taxa. **OR** CONDITION 2: No vegetation present. Variable is recoverable and sustainable through natural processes and under current conditions	0.1

Percent Cover of Native Plant Species cont.

Measurement or Condition	Index
Depression, Slope, and Riverine: There is no vegetation present. Variable is not recoverable and sustainable through natural processes and under current conditions.	0.0

Variable: SEDIMENT DEPOSITION

Definition: Area and/or rate of sediment deposition in the water/wetland.

Measurement Protocol: Make a visual assessment of the area and/or rate of sediment delivery to the water/wetland within the assessment area. Compare to all the descriptions provided in the scaling for the V_{SED} variable and choose the lowest score that appropriately describes the condition/status of sediment delivery to the water/wetland within the assessment area.

Scaling: The approximate area and volume of fill in the assessment site was determined by field measurements. Approximate areas of fill were determined through measurements of aerial coverage. The approximate depths of fill were measured in a few areas, and a mean depth of fill was calculated. The approximate volumes were determined by multiplying the aerial coverage of fill by the mean depth of fill.

This scaling for this variable was based upon the V_{SED} variable from the *Operational Draft Guidebook to HGM Functional Assessments in Temporary and Seasonal Depressional Waters/Wetlands in the Northern Prairie Pothole Region* (*The Northern Prairie Depressional HGM Guidebook*)(Lee *et al.* 1997). *The Northern Prairie Depressional HGM Guidebook* has been through peer review, and is one of the most mature HGM guidebooks in the nation. The scaling was modified by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High.

V_{SED}: Sediment Deposition

Measurement or Condition	Index
No evidence of increased area or rate of sediment deposition in the water/wetland from anthropogenic sources.	1.0
Historical evidence suggests that the area and/or rate of sediment deposition in the water/wetland increased in the past. a) Evidence may include, but is not limited to, stabilized fans and/or sediment layering on the soil surface; **and** b) The current condition is stable as evidenced by intact plant communities and/or the development of distinct soil structural and morphological features in the sediment layers.	0.75
The area and/or rate of sediment deposition in the water/wetland has slightly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, discontinuous bank shear, a veneer of fine sediment located where kinetic energy of surface water is low (*e.g.*, small pits), and/or sediment staining on detritus and/or plant materials; **and**. b) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.5
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently developed and/or developing fans and sediment layering on the soil surface; **and** b) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.25
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently ripped soil profiles; **and** b) 100% of the assessment site ***area*** is filled; **and** c) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.1
The area and/or rate of sediment deposition in the water/wetland has greatly increased due to current anthropogenic activities. a) Evidence may include, but is not limited to, recently ripped, disked, and rolled soil profiles; **and**. b) 100% of the assessment site ***volume*** is filled **and** c) Current conditions are not stable as evidenced by perturbed plant communities and/or the lack of development of distinct soil structural and morphological features in the sediment layers.	0.0

Variable: SOIL PROFILE INTEGRITY

Definition: Presence and condition of the soil profile in the assessment area.

Measurement Protocol: Excavate a representative soil pit in the assessment area. Characterize the soil pit consistent with NRCS protocols (USDA 1993). Compare to all the descriptions provided in the scaling for the $V_{SOILINT}$ variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) soil condition of the water/wetland within the assessment area.

Scaling: Soil pits were excavated to practicable depths, usually to the depth of the restrictive layer. Identification and nomenclature of the soil horizons were consistent with NRCS guidance. Colors were determined from wet samples and were reported as Munsell Soil Colors. The $V_{SOILINT}$ variable was scaled by the interdisciplinary team and is based upon the soil pit data and best professional judgment.

Confidence: High.

$V_{SOILINT}$: Soil Profile Integrity

Measurement or Condition	Index
Depression and Slope: a) Soil profile is intact and undisturbed. Typically, the soil profile has a thin O horizon over well-developed A (and/or E), B, and C horizons. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile is intact and undisturbed. Typically, the soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured.	1.0
Depression and Slope: a) Soil profile is truncated due to compaction by domestic livestock. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** **CONDITION 1:** a) Soil profile is truncated due to compaction by domestic livestock. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **CONDITION 2:** a) Soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured; **and** c) A veneer of fine sediment is present. Typically, the veneer of fine sediment is located where kinetic energy of surface water is low (*e.g.*, small pits).	0.75
Depression and Slope: a) Soil profile has an Ap horizon due to plowing, disking, harrowing, or raking. Restrictive layers, where present, occur in the B and/or C horizon(s) **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile consists of Entisols that are fluvial in origin. Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured; **and** c) Soil profile altered by discontinuous disruptions (*e.g.*, road crossings and/or small ripped areas).	0.5
Depression and Slope: a) Soil profile has not been ripped, but it is buried under recently deposited sediment (*e.g.*, silt, sand, gravel, and/or cobble). Restrictive layers, where present, occur in the B and/or C horizon(s); **and** b) Restrictive layers, where present, are unfractured. **Riverine:** a) Soil profile plowed, disked, harrowed, or raked. An Ap horizon may be present.. Restrictive layer(s), where present, occur in the B and/or C horizons; **and** b) Restrictive layer(s), where present, are unfractured.	0.25

Soil Profile Integrity cont.

Measurement or Condition	Index
Depression, Slope, and Riverine: a) Soil profile has been ripped and, possibly, disked, rolled, or excavated. C horizons dominate throughout the soil profile.; **and** b) Restrictive layers, where present, are fractured.	0.1
Depression, Slope, and Riverine: The substrate is anthropogenically-derived impervious surface (*e.g.*, roads, parking lots, buildings).	0.0

Variable: WETLAND DENSITY

Definition: The percent of the total area that is occupied by depressional, slope, and riverine waters/wetlands within a 3000 foot radius of the centroid of the assessment site.

Measurement Protocol: Measurement Protocol - First determine which geomorphic surface the assessment area is located on (*e.g.,* High Terrace, Terrace Dissection, Holocene Alluvium etc.). This will determine which set of variable scaling scores to use for the assessment area water/wetland. Next determine the density of waters/wetlands through visual observations during site review and/or by using other available information (e.g., aerial photos, maps etc.). Recent aerial photographs can facilitate the identification of wetland types within the 3,000 foot radius. Compare the density to all the descriptions provided in the scaling for the V_{WETDEN} variable and choose the lowest score that appropriately describes the density of waters/wetlands within a 3,000 foot radius of the centroid of the assessment area.

Scaling: The percent of the total area within a 3000 foot radius of the assessment area was determined by measuring the area covered by depressions/slopes/riverine waters/wetlands from 1:6000 scale aerial photographs taken of the Borden Ranch site at the time of the assessment, in August 1997. The variable was scaled separately for each geomorphic surface because densities of the different waters/wetland classes differ among High Terrace, Dissected Terrace Face and Holocene Terrace and Floodplain. The variable was scored according to the disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: High

V_{WETDEN}: Wetland Density

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >50% to 75% of the total area, with large depressions/complexes of depressions present; Slope waters/wetlands: >50% to 75% of the total area; with large complexes of slopes/depressions Riverine waters/wetlands: >5% to 10% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >15% to 25% of the total area, with depressions smaller than on high terrace, often isolated; Slope waters/wetlands: >30% to 50% of the total area Riverine waters/wetlands: >10% to 20% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >20% to 30% of the total area Slope waters/wetlands: >40% to 60% of the total area Riverine waters/wetlands: >40% to 50% of the total area **AND** No fragmentation due to anthropogenic activities	1.0
High Terrace: Depressional waters/wetlands: >40% to 50% of the total area Slope waters/wetlands: >40% to 50% of the total area Riverine waters/wetlands: >5% to 10% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >10% to 15% of the total area Slope waters/wetlands: >20% to 30% of the total area Riverine waters/wetlands: >5% to 10% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >10% to 20% of the total area Slope waters/wetlands: >30% to 40% of the total area Riverine waters/wetlands: >30% to 40% of the total area **AND** Fragmentation by fencing, roads and activities associated with moderate to heaving grazing.	0.75

V_{WETDEN}: **Wetland Density** cont.

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >20% to 40% of the total area, with few large, connected complexes Slope waters/wetlands: >20% to 40% of the total area Riverine waters/wetlands: >1% to 5% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: >5% to 10% of the total area Slope waters/wetlands: >10% to 20% of the total area Riverine waters/wetlands: > 1% to 5% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: >5% to 10% of the total area Slope waters/wetlands: >20% to 30% of the total area Riverine waters/wetlands: >20% to 30% of the total area **AND** Fragmentation due to large areas with fractured restrictive layers (*e.g.* ripped and disked or ripped, disked and cultivated)	0.5
High Terrace: Depressional waters/wetlands: >10% to 20% of the total area, with no large connected complexes Slope waters/wetlands: >10 to 20% of the total area Riverine waters/wetlands: <1% of the total area **Dissected Terrace Face**: Depressional waters/wetlands: > 1% to 5% of the total area Slope waters/wetlands: >5 to 10% of the total area Riverine waters/wetlands: <1% of the total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: <5% of the total area Slope waters/wetlands: >10% to 20% of the total area Riverine waters/wetlands: >10% to 20% of the total area **AND** Fragmentation due to large areas with fractured restrictive layers (e.g. ripped and disked or ripped, disked and cultivated)	0.25

V_{WETDEN}: Wetland Density (cont)

Measurement or Condition	Index
High Terrace: Depressional waters/wetlands: >5% to 10% total area Slope waters/wetlands: > 5% to 10% total area Riverine waters/wetlands: < 1% total area **Dissected Terrace Face**: Depressional waters/wetlands: < 1% total area Slope waters/wetlands: < 5% total area Riverine waters/wetlands: < 1% total area **Holocene Terrace and Floodplain**: Depressional waters/wetlands: > 1% to 5% total area Slope waters/wetlands: > 5% to 10% total area Riverine waters/wetlands: > 5% to 10% total area **AND** Fragmentation due to large areas with fractured restrictive layers (*e.g.,* ripped and disked or ripped, disked and cultivated)	0.1
High Terrace: Depressional waters/wetlands: < 5% Slope waters/wetlands: < 5% Riverine waters/wetlands: none present **Dissected Terrace Face**: Depressional waters/wetlands: none present Slope waters/wetlands: none present Riverine waters/wetlands: none present **Holocene Terrace and Floodplain**: Depressional waters/wetlands: none present Slope waters/wetlands: none present Riverine waters/wetlands: none present	0.0

Variable: WATERSHED CONDITION

Definition: Predominant land use or condition of the contributing area.

Measurement Protocol: Make a visual assessment of the predominant (*i.e.*, >50%) land use and/or condition of the watershed/contributing area. Compare to all the descriptions provided in the scaling for the V_{WSCOND} variable and choose the lowest score that appropriately describes the predominant land use or condition of the watershed/contributing area.

Scaling: The predominant use and condition of the contributing area was scored according to a disturbance scale. The disturbance scale was developed by the interdisciplinary team and is based upon field observations and best professional judgment.

Confidence: Medium.

V_{WSCOND}: Watershed Condition

Measurement or Condition	Index
Land is subject to a management plan that includes either light grazing or no grazing with a fire management. The plan has the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species; **and** b) increase the abundance of native plant species; **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	1.0
Land is subject to a management plan that includes either moderate to heavy grazing or no grazing and no fire management. The plan does not have the explicit intent to: a) reduce the abundance of non-native and/or invasive plant species; **and** b) increase the abundance of native plant species; **and** c) protect sensitive plant species, **and** d) manage fire fuel loads.	0.75
The watershed is characterized by a) maintenance plowing, disking, harrowing, or raking **and** b) an unfractured restrictive layer.	0.5
The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) no maintenance plowing, disking, harrowing, or raking between rows, **and** e) abundant herbaceous vegetation growing between rows.	0.25
CONDITION 1: The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer; **and** c) cultivated crops (*e.g.*, vineyards or orchards); **and** d) maintenance plowing, disking, harrowing, or raking between rows, **and** e) little to no herbaceous vegetation growing between rows. **OR** **CONDITION 2:** The watershed is characterized by a) a ripped soil profile; **and** b) a fractured restrictive layer, **and** c) no cultivated crops (*e.g.*, vineyards and orchards).	0.1
The watershed is characterized by anthropogenic impervious surfaces (*e.g.*, roads, parking lots, buildings).	0.0

Variable: SWALE OR CHANNEL CROSS-SECTION

Definition: Condition of the swale or channel cross-section in terms of widths, depths, cross-sectional areas, and width:depth ratios. NOTE: This variable should not be used to assess isolated depressions; for use in slope, riverine, or flow through depressions.

Measurement Protocol: Make a visual assessment of the channel cross-section/outlet swale. Compare to all the descriptions provided in the scaling for the V_{XS} variable and choose the lowest score that appropriately describes the predominant (*i.e.*, >50%) land use and/or condition of the channel cross-section/outlet swale.

Scaling: Microtopography was measured by surveying changes in ground surface elevation with a laser level. Microtopography transects were established as typical cross-sections in pools and riffles and typical longitudinal profiles. Stations were surveyed at intervals that allowed accurate description of the ground surface. There were no fixed intervals specified. Cross-sectional transects encompassed the width of the water/wetland and 20 foot buffers on each side. Data were plotted and assessed in the context of field notes and photographs.

Confidence: High.

V_{XS}: Swale or Channel Cross-Section

Measurement or Condition	Index
Swale or channel cross-section unaltered as evidenced by intact soil profiles and plant communities.	1.0
Swale or channel cross-section altered by portions of the swale margin/channel bank that have been pushed or pulled in by ripping and/or disking operations and/or cattle grazing (*e.g.*, bank trampling, shear).	0.75
Swale or channel cross-section altered by discontinuous entrenchment (*i.e.*, small areas that are incipient headcuts).	0.5
CONDITION 1: Swale or channel cross-section altered by continuous entrenchment. **OR** **CONDITION 2:** Swale or channel cross-section altered by discontinuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, road crossings and small ripped areas).	0.25
a) Swale or channel cross-section altered by continuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, entirely ripped and/or disked); **and/or** b) Discontinuous areas with poorly-developed channel cross-sections occur; **and** c) May include areas with infrequent or no maintenance cultivation (*i.e.*, disking, mowing, etc.)	0.1
Swale or channel cross-section altered by continuous surface disruptions to surface and/or shallow subsurface water flow (*e.g.*, entirely ripped and/or disked). No areas with channel cross-sections can be identified.	0.0