Table 5.1─List of equipment and other gear for the field data collection.

2, 50 m measuring tapes

1, 100 m measuring tape

1, 3-m hand measuring tape

Range survey pins for anchoring tapes

1, Stadia rod

2, Clinometers or a laser level

Flagging

Clipboards

Pencils, pencil lead, sharpies

Field journals

File box for data sheets

Sampling Protocol & Data Sheets

Sampling protocols and data sheets for geomorphic, riparian vegetation, disturbance, and meadow data assessments

Maps and aerial images

Topographic maps for navigation to study watershed

Aerial images with dominant reach types in the upper, middle, and lower parts of the watershed delineated

GPS

Recreational grade GPS

Extra batteries and charger

Camera

Digital camera and extra data card, batteries, and battery charger

White board and markers to label photographs with date, watershed, watershed database code, and position in watershed

Species Lists

Great Basin riparian and meadow species (tables 7.3 and 9.5)

Regional floras and vegetation keys

Small rulers and hand lenses for plant identification

Plastic bags for collecting plants

Plant presses

Appendix 6─Information and Data Form for Assessing Stream Geomorphic Characteristics in the Field

This appendix includes the data form and information for collecting the stream geomorphic data. The geomorphic data are collected along the same stream reach as the riparian vegetation and disturbance data. These data are also collected when meadow complexes are sampled.

The geomorphic data are collected using form A.6.1. One form is used for each stream reach or meadow complex. At each sampled stream reach or meadow complex, identifying information is recorded on the data form. This includes the date, observer, watershed name, the watershed code in the Great Basin watershed database, location within the watershed (e.g., high, mid, low), and the reach length of the observations (typically 30 m). A GPS is used to record the UTM coordinates and elevation where the stream cross sectional profile is drawn for the sampled reach.

A complete description of the variables recorded and the specific measurements or scores used to describe each variable are in table A.6.1. The assessment involves collecting information on the current cross-sectional morphology of the valley (including the channel) and the longitudinal profile of the stream channel. Information is collected on the materials comprising the channel bed, banks, and valley fill, and the sediment mobility and availability of bed sediments. In addition, information is obtained on features that are indicative of the magnitude and rate of channel incision (e.g., knickpoints, headcuts, terraces), occurrence and amount of channel avulsion (e.g., filled or unfilled paleochannels), and the extent and mechanisms of bank erosion. Stream cross-section and bed material distribution data may be collected where more detailed data are desired.

A cross-sectional profile is drawn for each sampled reach at a representative location within the reach. An illustration of a cross-sectional profile of a stream channel is in fig. A.6.1. This drawing is used to identify the geomorphic positions used to sample riparian vegetation as described on the riparian vegetation data form A.7.1.

The data collected in the geomorphic assessment are used in the score sheets for assessing watershed sensitivity and resilience in appendix 10 and for rating ecological integrity in appendix 11.

Form A.6.1–GEOMORPHIC DATA	Date: Observer:
Watershed Name:	Database Code:
UTM Zone:	Elevation (m):
UTMs: Northing	Easting
Location in Basin: Low / Mid / High	Reach Length of Observations (m):

Definitions of terms and methods for the variables collected are in appendix A.6.2.
Use consistent units for all measurements.

Channel Character and Form

Flow Type: Perennial Ephemeral

Flow/Water Width (m): __________ **Flow Depth (m):** __________

Bankfull Channel Width (m): __________ **Bankfull Channel Depth (m):** _________

Channel Slope: distance (m): __________ clinometer height (m): __________

stadia height (m): _________ slope: __________

Sediment Size and Mobility

Bed Particle Size: approx. D_{50}: ___________ approx. max. (ave. 10 largest) _________

Bank/Valley Fill Sediment Size (%): gravel/boulders mixed gravel/fines fines (<2 mm)

Bed Clast Immobility (% of channel bed): >75% 50-75% 10-50 % <10 %

Pebble Count Taken: yes no

Cross-section Taken: yes no

Sediment Availability

Bar Frequency (# per reach in channel): none few (1-2) common (3-4) many (>4)

Bar Extent (% of channel bed): none to 10% 10-20% 20-30% >30%

Gravel Bars on Valley Floor (# per reach): none few (1-2) common (3-4) many (>4)

Evidence of Incision within the study reach

Fan Steps at the Reach: yes no If yes, range in height(s) (m): __________

Knickpoints (# per reach): none few (1-2) common (3-4) 4 = many (>4)

Knickpoint Height (cm): none 0-25 cm 25-50 cm > 50 cm

Knickpoint Composition: bedrock boulders unconsol. sediment (gravel/silt/clay) roots

Inset Terraces (#): none 1 2 3 >/=4

Incision Depth (m): none 0-1 m 1-2 m >2 m deep

Bedrock Outcrops (% of channel bed): none localized (<25 %) extensive (>25 %)

Headcuts (# per reach): none few (1-2 per reach) common (3-4) many (>4)

Headcut Height (m): no headcuts 0-1 m 1-2 m > 2 m

Evidence of Avulsion and Avulsion Channels within the study reach

Anabranching Channels (# per reach): none few (1-2) common (2-4) many (>4)

Gravel Filled Channels (# per reach): none few (1-2) common (2-4) many (>4)

Gravel Aggradation/Debris Dams (# per reach): none few (1-2) common (2-4) many (>4)

Form A.6.1–GEOMORPHIC DATA	Date:
Watershed Name:	Database Code:
UTM Zone:	Elevation:
UTMs: Northing	Easting
Location in Basin: Low / Mid / High	Reach Length of Observations:

Sketch of Stream Cross-sectional Profile: See fig. A.6.1 for an example sketch of a cross-sectional profile. Include all topographic features as well as bars, bank characteristics, and other features of geomorphic significance. Include the vertical and horizontal scale. Where sampled reaches are near fan steps, headcuts, or other significant geomorphic features, also include a longitudinal sketch. See fig. 14 for an example of a longitudinal profile illustrating a fan step downstream of a meadow.

Figure A.6.1—Example sketch of a cross-sectional profile of a stream channel.

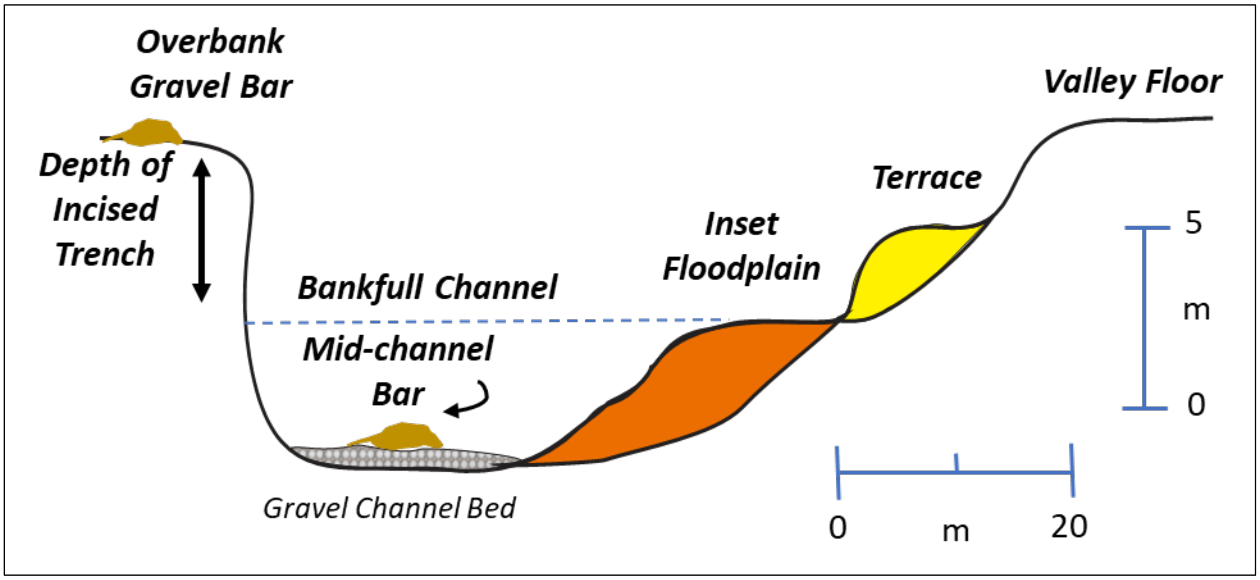


Table A.6.1—Descriptions of the variables used to assess stream reach geomorphic characteristics in the field.

- **Reach Length of Observations:** A stream reach is defined as a segment of the drainage network with homogenous channel and valley floor characteristics, including landforms (e.g., terraces, floodplains), channel bed features (pools and riffles, step and pools, bars, knickpoints, etc.), and sediment sizes. In the field, sample reaches are selected from the dominant watershed segments in the lower, middle, and higher portions of the watershed, which are predetermined in the office. The sample reach should be representative of the most common reach type within the dominant watershed segment. It should be long enough to include all valley, channel, and channel bed features that exist within the reach type. A typical study reach length is 30 m.
- **Channel Character and Form**
  - **Flow Type:** Describes the temporal variations in flow within the channel. Perennial flow – flow is present within the reach throughout the year; ephemeral flow – distinct periods of flow and dry conditions within the stream reach during the year.
  - **Flow /Water Width and Flow Depth:** The width of the water at the water's surface, and the maximum depth of the water in the channel.
  - **Bankfull:** The water level at which water is at the top of the stream bank and any further increase in water level would cause the water to "spill over" and inundate the adjacent terrace or floodplain. The bankfull channel is defined based on several parameters including: (1) the break in slope between the channel banks and the floodplain, defined as the first flat-lying, low-relief surface above the channel bed whose sediments are deposited by the modern channel; (2) the elevation of the highest depositional feature

within the channel (e.g., point bar, alternate bar, or central bar), where well-defined floodplains are absent; and (3) changes in the particle-size distribution and vegetation along the channel perimeter resulting from a change in the frequency of inundation and depositional processes.

  - **Bankfull Channel Width and Depth:** Bankfull channel width is the width of the channel at the bankfull water stage. Bankfull depth is the maximum depth of the channel measured from the bankfull stage to the thalweg (deepest part of the channel).
  - **Channel Slope:** Gradient (rise/run) of the channel measured along the thalweg of the stream. To calculate the percent slope, divide the elevation change (stadia or level height - clinometer height) by the distance measured. Multiply the resulting number by 100 to obtain the percentage slope.

- **Sediment Size and Mobility:** Particle size and mobility influences the ease with which the channel bed can be eroded and incised by flood flows. The variables used to evaluate sediment size and mobility can be estimated. Alternatively, pebble counts can be taken. Methods for collecting and analyzing particle size are in Bunte and Abt (2001).
  - **Bed Particle Size:** Particle size D_{50} is defined based on the intermediate diameters of at least 50 particles (clasts) randomly collected from the channel bed. The approximate maximum particle size is the average intermediate diameter of the 10 largest particles (clasts) in the sample reach.
  - **Bank/Valley Fill Sediment Size (%):** Describes the percent of the bank deposits consisting of gravel/boulders, mixed gravels/fines, and fines (<2 mm). In many cases, the channel banks will be composed of multiple alluvial stratigraphic units possessing

sediments of varying size. Where multiple units are present, the percent of each particle-size range should be assessed by considering all of the units collectively.

  - **Bed Clast Immobility (% of channel bed):** Describes the approximate percentage of clasts on the channel bed that have not been transported by floods occurring at least once every 5 to 10 years. Indicators of immobility include the degree to which clasts are coated by biofilms (algae), particle imbrication (the "stacking of clasts at an oblique angle in the channel bed), and sediment sources (e.g., glacial moraines, talus cones).

- **Sediment Availability:** Describes the amount of mobile sediment that is stored within the channel and that can be entrained and transported during low to moderate flood events. Large amounts of sediment are required for channel avulsions, whereas limited sediment relative to the available discharge leads to channel incision. Sediment availability is determined from three parameters.
  - **Bar Frequency (# per reach):** Bars represent accumulations of sediment within the channel. The number of bars describes the occurrence of in-channel bars composed of mobile bed materials within the channel in the sample reach. Bar number per reach is recorded as none, few (1-2), common (3-4), or many (>4).
  - **Bar Extent (% of channel bed):** Describes the percentage of the channel bed comprised of in-channel bars in the sample reach (e.g., point bars, alternate bars, glides, etc.). Bar extent within the channel bed is recorded as 0-10 %, 10-20 %, 20-30 %, or >30%.
  - **Gravel Bars on Valley Floor (# per reach):** Gravel accumulations on the valley floor are an indicator of the movement of large amounts of sediment during overbank floods. In some cases, these deposits are associated with channel aggradation (filling), which may or may not be associated with channel avulsion initiated by a localized aggradational

event. Number of gravel bars per reach is recorded as none, few (1-2), common (3-4), or many (>4).

- **Evidence of Channel Incision:** The degree and rate to which the channel has or is currently incising provides insights into its future response.
  - **Fan Steps:** Large side-valley alluvial fans that traverse the majority of the valley floor often produce "steps" or abrupt changes in the longitudinal profile of the channel bed (fig. 14). Where these occur, they should be noted, and the approximate height of the elevation change across the fan should be estimated using a clinometer.
  - **Knickpoints (# per reach):** Knickpoints, defined as abrupt, vertical or near vertical breaks in channel slope over a distance of a few meters are a direct indicator of ongoing channel incision. Number of knickpoints is recorded as none, few (1-2 per reach), common (3-4), or many (>4).
  - **Knickpoint Height (cm):** Knickpoint height is measured as the maximum distance from the top of the knickpoint to the channel bed at the foot of the knickpoint. Knickpoint height is dependent, in part, on the composition of the materials in which the knickpoint is formed. Cohesive and/or resistant materials tend to form higher knickpoints. However, the type of channel materials is also an indicator of the magnitude to which channel incision is likely to occur. Knickpoint height is recorded as the average height of the knickpoints at the sample reach, and ranges from no knickpoints, 0-25 cm, 25-50 cm high, or > 50 cm high.
  - **Knickpoint Composition:** Refers to the predominant type of material(s) with which the knickpoint is constructed. Common materials include bedrock, boulders, unconsolidated sediments (gravel, silt/clay), and roots.

- **Inset Terraces (#):** Terraces are formed during channel incision. The number of terraces within a valley is an indicator of the number of incision events that have occurred and may help approximate the length of time over which incision has occurred and the rate and timing of incision. Inset terraces indicate a period of lateral erosion and deposition (of an inset floodplain) prior to subsequent incision. Multiple incision events may occur prior to the development of an inset floodplain, precluding the presence of an indicative inset terrace. Additionally, lateral erosion after an incision event may remove evidence of one or more inset terraces. In the Great Basin, inset terraces of differing age often correspond to high magnitude flood events that are capable of eroding channel bed sediments and are occupied by differing vegetation communities. Evidence of a given inset terrace may exist on one or both sides of a channel. Surfaces of similar height above the thalweg on both sides of a channel should be considered parts of the same inset terrace. The number of inset terraces is recorded as none, few (1), common (2-3 per reach), or many (>4).
- **Incision Depth (m):** The depth of incision, or depth of the incised trench, is a measure of depth of channel incision below the valley floor. Incision depth is measured as the distance from the valley floor to the top of the inset floodplain, if a floodplain is present. If no floodplain is present, then it is the distance from the valley floor to the highest point on the channel bed. Deep, highly incised channels are typically associated with fine-grained channel bed and bank materials, and large-scale headcuts or knickpoints. Incision depth is recorded as none, 0-1 m, 1-2 m, or >2 m.
- **Bedrock Outcrops/Exposures (% of channel bed):** Describes the presence of bedrock within the channel bed and/or banks. The rate and depth of incision can be reduced along

some reaches by the occurrence of resistant bedrock outcrops. Where present, the percent of the channel bed consisting of bedrock should be recorded. Bedrock is recorded as none, localized (<25 % of channel bed), or extensive (>25 % of channel bed).

- **Headcuts (# per reach):** Headcuts are similar to knickpoints but are commonly associated with gully systems that are developed in previously unincised alluvial valleys devoid of an existing channel (see figs. 15, 21). They often represent a significant potential change in valley conditions by means of channel incision. Number of headcuts is recorded as none, few (1-2 per reach), common (3-4), or many (>4).
- **Headcut Height (m):** Headcut height is the maximum height of the headcut as measured from the incised channel bed to the valley floor. Headcut height is recorded as none, 0-1 m, 1-2 m, or >2 m.

- **Evidence of Avulsions and Avulsion Channels:** Avulsions indicate the abrupt change in channel position from one location to another on the valley floor. Several indicators of occurrence and frequency of avulsion are used to rate geomorphic sensitivity to this process.
  - **Anabranching Channels (# per reach):** Anabranching channels are typically formed by channel avulsion and are usually associated with relatively unstable channels characterized by local channel aggradation. The number of anabranching channels per reach is recorded as none, few (1-2 per reach), common (2-4), or many (>4).
  - **Gravel Filled Channels (# per reach):** Gravel-filled channels are segments of 'old' channel reaches that have been filled with gravel and no longer transmit water. The gravel fill found in most paleo-channels are found near the surface of the valley floor. While not all gravel-filled channels are associated with channel avulsions, they are the primary evidence of avulsions, and can be found at most sites where avulsion has

occurred in the Great Basin. The number of gravel filled channels in the reach are recorded as none, few (1-2), common (2-4), or many (>4).

- **Gravel Aggradation/Debris Dams (# per reach):** Accumulation (aggradation) of gravel behind piles of wood debris or woody riparian species is common in many Type A_1 basins. Avulsions are often associated with these gravel accumulations, and they result in partial blockage of the channel, particularly during the input of sediment from debris flows, landslides, and/or upstream valley incision. The number of gravel aggradation or debris dams per reach is recorded as none, few (1), common (2-4), or many (>4).

Reference

Bunte, K.; Abt, S.R. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel-and cobble-bed streams for analyses in sediment transport, hydraulics and streambed monitoring. Gen. Tech. Rep. RMRS-GTR-74. Fort Collins: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 428 p.

Appendix 9─Information and Data Forms for Assessing Meadow Complexes in the Field

This appendix includes the data form and information for collecting the meadow geomorphic and hydrologic data and the vegetation data. The geomorphic data described in appendix 6 and disturbance data described in appendix 8 also are collected for each meadow. The geomorphic assessment is conducted for a representative reach within the meadow and should reflect the conditions observed for the meadow as a whole. The disturbance assessment characterizes the effects of disturbances in adjacent stream reaches upstream and downstream of the meadow. The sensitivity and resilience of meadow complexes within a watershed are evaluated for up to four meadows that represent the dominant meadow types and their responses to disturbance within a focal watershed.

The meadow data form A.9.1 is used to collect meadow geomorphic and hydrologic data and form A.9.2 is used to collect meadow vegetation data). At each sampled stream reach, identifying information is recorded on the data forms. This includes the date, observer, watershed name, the watershed code in the Great Basin watershed database, meadow name, location within the watershed (e.g., high, mid, low). A GPS is used to record the UTM coordinates and elevation where the stream cross section is drawn for the sampled reach.

An explanation of the variables recorded in the geomorphic and hydrologic assessment is in table A.9.1. Geomorphic and hydrologic data are collected on the geomorphic position of the meadow, groundwater sources and springs, relationship of the stream to the meadow, meadow complexity and hydrologic traits, and evidence of incision. Illustrations and descriptions of meadow hydrologic types – their hydrologic setting, hydrology, and connection of the stream to the meadow vegetation – are in table A.9.2.

An overview of the meadow vegetation types is in table A.3.1 and the dominant species within each type are in table A.9.4. The meadow vegetation types and their relative abundances within the meadow complex are determined by walking through the meadow and estimating the percentage of each vegetation type. Aerial photos of the meadow can be used delineate the different meadow types and help estimate their percentages.

The meadow vegetation is assessed by walking through each meadow type, recording the dominant indicator species within the type, and estimating the percentage cover of the species as indicated on data form A.9.2. Species vigor, mortality, successional status, and bank stability status are recorded as described in table A.9.3. Successional status and bank stability status for the dominant Great Basin meadow species are in appendix A.9.4.

The information collected for each meadow vegetation type on the relative cover, vigor, and mortality of the dominant or indicator species increases understanding of the response of the meadow vegetation to recent or ongoing disturbances affecting water availability. The information on the relative cover, successional status, and bank stability rating provide information on the longer-term responses of the meadow vegetation to a variety of different disturbances.

The watershed characteristics, stream geomorphic, and meadow vegetation data can be used to evaluate the incision and avulsion sensitivity of individual meadows as described in appendix 10. In addition, the watershed characteristics, meadow vegetation and disturbance data can be used to rate meadow ecological integrity as described in appendix 11.

Form A.9.1–MEADOW GEOMORPHIC & HYDROLOGIC DATA	Date: Observer:
Watershed Name:	Database Code:
Meadow Name:	
UTM Zone:	Elevation (m):
Coordinates (UTMs): Northing	Easting
Location in Watershed: Low / Mid / High	

Definitions of terms and methods of data collection are in appendix A.9.2 and illustrations of meadow hydrologic types are in appendix A.9.3. Definitions of the meadow vegetation types are in table A.3.1 and the species contained within each meadow vegetation type are in table A.9.5.

Meadow Size

Length parallel to valley (m): __________ Approximate area (ha): _________

Length perpendicular to valley (m): __________

Geomorphic Position (circle 1, 2, or 3)

(1) Large meadow upstream of an alluvial fan or bedrock constriction

(2) Large meadow in the valley bottom with no alluvial fan or bedrock constriction present

(3) Spring-fed meadow on part of valley floor with no stream contact

Groundwater Sources and Springs

Groundwater source is down valley; meadow gradually becomes wetter down valley: no____ yes____

Springs located along edge of valley floor (#): none ____ 1-3 ____ 4-6 ____ >6 ____

Springs not located along edge of valley floor (#): none ____ 1-3 ____ 4-6 ____ >6____

Stream Connection to Meadow (circle 1, 2, or 3):

(1) Stream bisects meadow (2) Stream on one side of meadow (3) Stream in valley but doesn't contact meadow (4) No stream in same part of valley as meadow

Stream and Groundwater Influence on Meadow Hydrology (circle 1, 2, 3, or 4)

(1) Gaining stream – dryer meadow vegetation types near stream (2) Losing stream - wetter meadow vegetation types near stream (3) No obvious pattern (4) Stream does not bisect meadow

Meadow Complexity (circle 1, 2, or 3)

(1) Simple (2) Moderate (3) Complex

Vegetation/incision Patterns Perpendicular to Stream (circle 1, 2, or 3)

(1) No change in vegetation type crossing stream (2) Minor shift from wetter to drier vegetation types adjacent to stream (3) Major shift from wetter to drier vegetation types adjacent to stream (4) N/A

Meadow Hydrologic Type (circle 1, 2, 3, 4, or 5, or describe the type)

Use answers above and information in appendix A.9.3 to determine type.

(1) Simple, not degraded by stream (2) Simple, minimally degraded by stream (3) Simple, degraded by stream (4) Complex, minimally degraded by stream (5) Complex, degraded by stream

(6) Other (describe): ____

Notes:

FormA.9.1–MEADOW GEOMORPHIC & HYDROLOGIC DATA	Date: Observer:
Watershed Name:	Database Code:
Meadow Name:	
UTM Zone:	Elevation:
Coordinates (UTMs): Northing	Easting
Location in Watershed: Low / Mid / High	

Drawing of Meadow. Stream, meadow types, relation of stream to meadow vegetation types, and locations of springs can be drawn on an aerial photograph of meadow as illustrated in fig. A.9.1. Alternatively, a sketch of the meadow can be drawn by hand. Include stream, meadow types, relation of stream to meadow vegetation types, and locations of springs. Show dimensions.

Figure A.9.1–Aerial photograph of a meadow with the stream location, meadow types, relation of stream to meadow vegetation types, and locations of springs drawn on the image. Meadow is in Kingston Canyon in central Nevada.

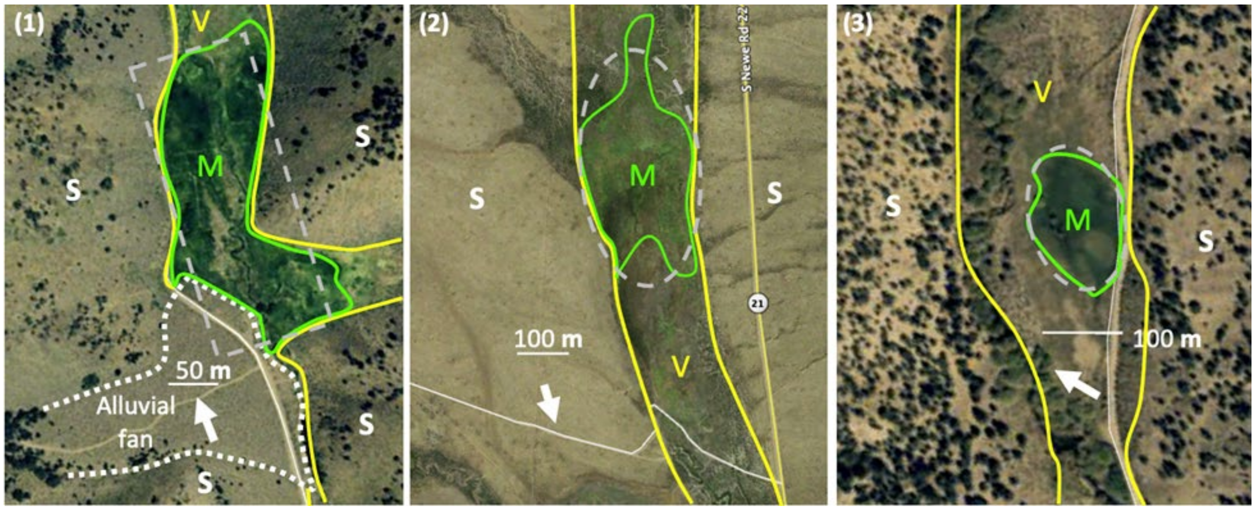


Table A.9.1– Descriptions of the geomorphic and hydrologic data needed to complete the data form for the meadow assessment (A.9.1).

- **Meadow Size:** The ecological importance and potential for impacts by natural and human-caused disturbance are often related to a meadow's size**.** The approximate length of the meadow perpendicular to the valley and width of the meadow parallel to the valley are estimated in the field or from aerial imagery. The meadow area is estimated from the product of the length and width dimensions or on a computer from aerial imagery.
- **Geomorphic Position:** The geomorphic setting of a meadow has a strong influence on its hydrology and connection to the stream and meadow vegetation types. The most common geomorphic settings in the Great Basin are: (1) large meadow upstream of an alluvial fan; (2) large meadow in the valley bottom with no alluvial fan present; and (3) spring-fed meadow on part of valley floor with no stream contact. The annotated aerial images in table A.9.3 show the three settings. In all figures, downstream is at the bottom. Arrows point north; M=meadow; V=valley floor; S=side-valley slopes.
- **Groundwater Sources and Springs:** Observations about springs (abundance and location) and general vegetation patterns can be used to infer groundwater sources for meadows and hydrogeologic conditions. An abundance of springs located at valley side margins or within the valley floor likely reflect a localized groundwater discharge area, whereas their absence may indicate that the primary source of groundwater is through upstream valley floor sediments. Areas with springs, especially on valley floors, are indicative of artesian conditions that form where fine-grained, confining sediment layers cap coarser-grained sediments. Breaching of the confining layer, whether by backhoe or stream incision, may cause significant changes in the groundwater and, therefore, vegetation. To locate springs,

walk throughout the meadow, especially in areas of wet or mesic vegetation. Note the number of springs along the edges of valley floor and in middle of the valley floor.

- **Stream Connection to Meadow:** The relationship of a stream to a meadow is important because changes in stream channels (e.g., incision, avulsion, migration) can influence meadow hydrology and vegetation. One of four possible relationships is recorded: (1) stream bisects meadow; (2) stream is on one side of meadow; (3) stream is in valley but doesn't contact meadow; and (4) no stream in same part of valley as meadow.
- **Stream and Groundwater Influence on Meadow:** Hydrologic traits of meadows, such as the source of groundwater and groundwater flow directions can be assessed from vegetation patterns. For example, areas where groundwater flow is toward a stream (i.e., the stream is gaining) will have wetter vegetation types at the valley margins and drier types adjacent to the stream. In contrast, a losing stream will have wetter vegetation types adjacent to the stream. To assess whether groundwater flow in a meadow is toward a stream (gaining) or away from a stream (losing), observe the overall relationship of the groundwater-dependent vegetation from the valley side to the stream. Do not include inset stream terraces in the assessment as they do not typically reflect the same groundwater relationships as the meadow overall.
- **Meadow Complexity:** Describes the degree to which meadow vegetation types are contiguous (simple) or patchy (complex). Patchiness of vegetation types reflects underlying complexity in the hydrologic and geologic conditions. Use the following descriptions and figures of the distribution of plant types to select the complexity type that best matches the conditions within the meadow. See table A.9.3 for additional descriptions, figures, and photographs of the meadow hydrologic types.

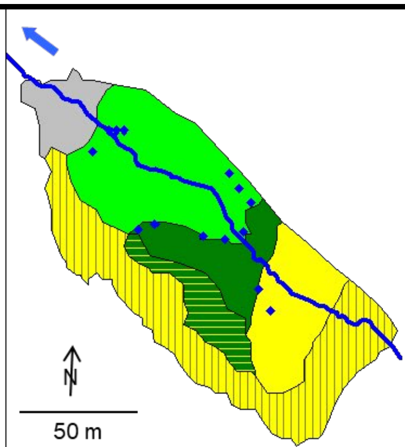
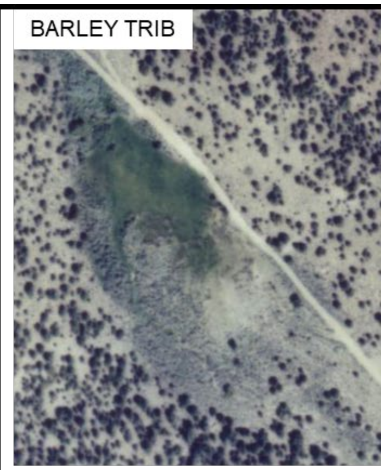
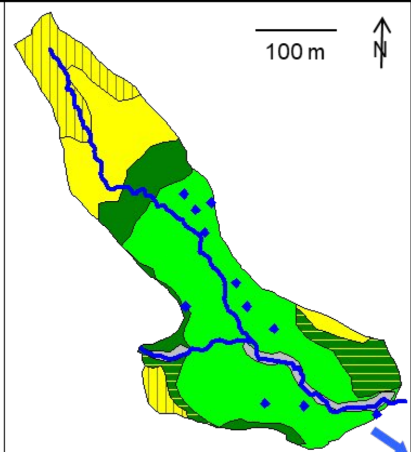
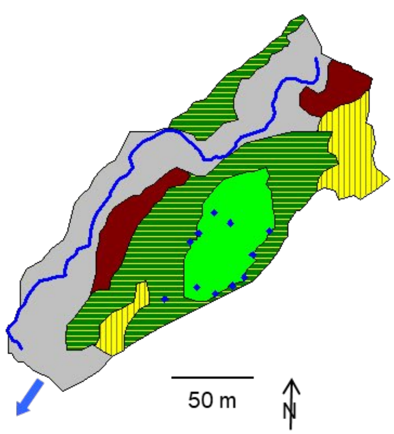
- In simple meadows, meadow vegetation types are mostly contiguous. This pattern reflects systematic shifts in the depth to the groundwater table over the meadow and low lateral variability of underlying sediments. Because of this simplicity, declines in groundwater tables and shifts in vegetation types due to stream incision have higher predictability.
- In complex meadows, meadow vegetation types occur in patches throughout the meadow. This pattern reflects high variability in depth to groundwater table and underlying sediments; some plant patches may be isolated because of dissection by past stream incision. In this setting, declines in the groundwater table and shifts in vegetation due to stream incision are difficult to predict, and may include major change with little incision. Complex meadows are common upstream of alluvial fans.
- Moderate meadows have intermediate complexity.

- **Vegetation patterns perpendicular to stream:** Assessment of impacts of stream incision on the meadow groundwater table and meadow vegetation types can be made by observing meadow vegetation type patterns associated with streams that bisect or adjoin a meadow. Stream incision causes a lowering of the groundwater table. The magnitude of the drop and the consequent shift in vegetation types is a function of the amount of incision, direction of groundwater flow, sediment permeability, and meadow vegetation types. If meadow vegetation type shows no change on either side of a stream, it typically indicates that any incision that has occurred did not cause enough of a decline in the groundwater table to cause a shift in meadow vegetation type, such as where wet meadow vegetation occurs adjacent to both sides of the stream. A meadow with moderate degradation by stream incision may show a shift in meadow type from wet to mesic or dry. In a meadow significantly degraded by incision, willows or upland vegetation may be adjacent to the stream channel. Assess the overall impact of stream incision by observing plant patterns adjacent to the stream. Do not include inset stream terraces in the assessment as they do not typically reflect the same groundwater relationships as the meadow overall. Select the incision category that best matches the distribution of plant types. See table A.9.3 for additional descriptions, figures, and photographs of types.

- **Meadow Hydrologic Type:** Use the answers in form A.9.1 "Meadow geomorphic and hydrologic data," and table A.9.3 "The meadow hydrologic types in the Great Basin" to determine the meadow hydrologic type. These are: (1) simple, not degraded by stream; (2) simple, minimally degraded by stream; (3) simple, degraded by stream; (4) complex, minimally degraded by stream; (5) complex, degraded by stream; or (6) other.

Table A.9.2–The meadow hydrologic types in the Great Basin (Lord et al. 2011).

The information in this table is used to complete the meadow geomorphic and hydrologic data form (A.7.2). The left column describes key hydrologic characteristics and the current relationship of the stream to meadow hydrology and vegetation patterns. The middle and right columns show maps of the plant communities and aerial photographs of the setting. The aerial photographs are from meadows in central Nevada. GW = groundwater.

Meadow Traits	Meadow Plant Map	Meadow Aerial Photograph
A. Simple, Not Degraded by Stream Hydrogeologic Setting • Bedrock constriction down valley • Continuous geologic units Hydrology • GW source is down-valley • Springs common in low permeability sediment layer Stream Connections • Gaining • Incision has little affect on GW and vegetation patterns		
B. Simple, Minimally Degraded by Stream Hydrogeologic Setting • Bedrock constriction • Continuous geologic units Hydrology • GW source is down and side-valley • Springs common • Perched GW table down-meadow Stream Connections • Gaining some locations; perched in others • >1 m of incision - little affect on GW and vegetation patterns		
C. Simple, Degraded by Stream Hydrogeologic Setting • Downstream valley constriction and alluvial fan Hydrology • GW source is center and down-valley • Artesian conditions and springs common Stream Connections • Gaining • Incision has likely breached confined aquifer and has affected riparian GW and vegetation patterns		

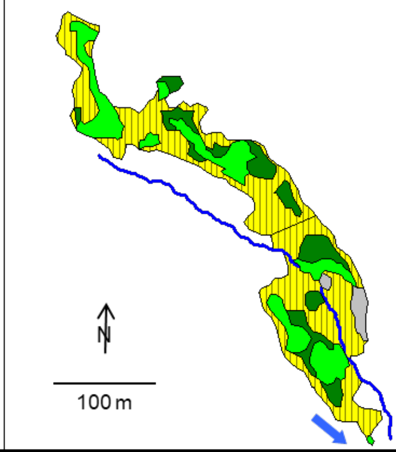
Meadow Traits | **Meadow Plant Map** | **Meadow Aerial Photograph**

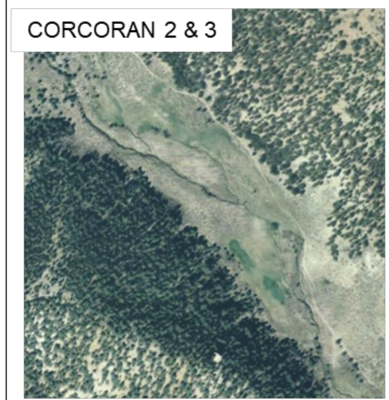
D. Complex; Minimally Degraded by Stream

Hydrogeologic Setting
- draped, old alluvial fans
- dominantly fine-grained geologic units

Hydrology
- GW source is down-valley and center-valley upwelling
- perched water tables

Stream Connections
- losing, perched
- incision has had little affect on GW and vegetation patterns



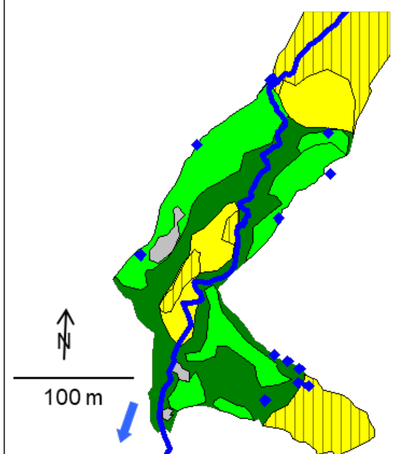


E. Complex, Stream Degraded

Hydrogeologic Setting
- upstream of alluvial fan
- complex geologic setting
- discontinuous hydrogeologic units with high variability in permeability; includes low permeability units

Hydrology
- direct GW source is valley sides and springs
- artesian conditions common

Stream Connections
- gaining overall
- incision has affected riparian GW and vegetation patterns

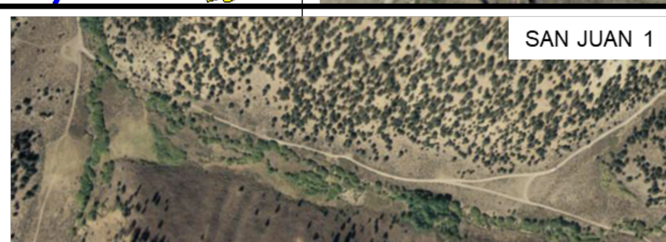


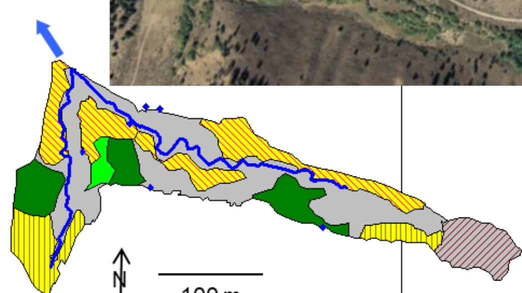
F. Complex, Degraded by Stream

Hydrogeologic Setting
- upstream of alluvial fan
- heterogeneous geologic units

Hydrology
- GW source mostly side-valley
- few springs

Stream Connections
- gaining
- incision has altered GW and vegetation patterns
- GW support for most meadows on valley floor is lost





Legend: Plant Communities and Water Features

	Wet		Mesic Shrub		Dry Shrub		Willow
	Mesic		Dry		Rose Shrub		Aspen
	Upland Plants		Spring		Stream		stream flow

Form A.9.2–MEADOW VEGETATION DATA	Date: Observer:
Watershed Name:	Database Code:
UTM Zone:	Elevation (m):
UTMs: Northing	Easting
Location in Basin: Low / Mid / High	

Record the relative aerial cover of the meadow complex by meadow type (%):
Standing Water (SW) _______ Wet Meadow ______ Mesic Meadow ______ Dry Meadow ______
Shrub Meadow ______
The meadow types are described in table A.3.1, and their characteristic species are in table A.9.6.

Record the following data for each meadow type that occurs in the meadow complex:
Dominant indicator species and aerial cover (%): record as trace < 1 (trace); 1-5; 5-25; 25-50; 50-75; 75-100.
Vigor and mortality of each species: record as high (H), moderate (M), or low (L) as described in table A.9.5.
Record the Wetland Indicator Status (WIS), successional status (Succ), and bank stability (Stab) of each species: record values for each species from the meadow species list (A.9.6). Descriptions are in table A.9.5.
Nativity of the species: record as yes (Y) or no (N) as indicated in the meadow species list (A.9.6).

Record the following data for the meadow type summaries:
Cover: estimate and record average vegetation cover for the entire meadow type.
Vigor and Mortality: record value most indicative of response to disturbance for the meadow type as described in table A.9.5.
WIS, Succ, and Stab: record most common values for the meadow type.
Native: record total number of nonnative species for the meadow type.

Meadow Type	Dominant Indicator Species	Cover (%)	Vigor H/M/L	Mort H/M/L	WIS O/F/FW /FU/U	Succ E/M/L	Stab H/M/L	Native Y/N
SW								
SW								
SW								
SW								
SW								
SW								
Standing Water Meadow Summary								
Wet								
Wet								
Wet								
Wet								
Wet								
Wet								
Wet Meadow Summary								

Form A.9.2–MEADOW VEGETATION DATA	Date: Observer:
Watershed Name:	Database Code:
UTM Zone:	Elevation (m):
UTMs: Northing	Easting
Location in Basin: Low / Mid / High	

Meadow Type	**Dominant Indicator Species**	**Cover (%)**	**Vigor H/M/L**	**Mort H/M/L**	**WIS O/F/FW /FU/U**	**Succ E/M/L**	**Stab H/M/L**	**Native Y/N**
Mesic								
Mesic								
Mesic								
Mesic								
Mesic								
Mesic								
Mesic Meadow Summary								
Dry								
Dry								
Dry								
Dry								
Dry								
Dry								
Dry Meadow Summary								
Shrub								
Shrub								
Shrub								
Shrub								
Shrub								
Shrub								
Shrub Meadow Summary								

Record the following data for the meadow summary:
Cover: estimate and record the average graminoid and forb vegetation cover for the entire meadow.
Vigor and mortality: record the value that is most indicative of the meadow response to disturbance as described in table A.9.5.
WIS, Succ, and Stab: record value most indicative of reach disturbance response as described in table A.9.5.
Native: record total number of nonnative species for the entire meadow.

Meadow Summary Values							
Indicator Species:							

Notes:

Table A.9.3—Descriptions of the variables used to assess the meadow vegetation in the field.

- **Aerial Cover of Each Meadow Type (%):** The meadow types are described in table A.3.1, and their dominant indicator species are in table A.9.6. The percentage cover of each meadow type is estimated in the field or from aerial imagery. This estimate can be made from the drawing of the meadow on form A.9.1.
- **Dominant indicator Species:** The indicator species for each meadow type are listed in table A.9.6. Meadow indicator species provide information on water availability for a particular meadow type, where water availability is determined primarily by depth to the water table. For each meadow type, record the native meadow species that indicate water availability over the duration of the growing season. No additional information is needed for the meadow type summary. For the overall meadow summary, record the species that are most indicative of the meadow's response to stream incision or avulsion. Note if the dominant indicator species also reflect anthropogenic disturbances such as livestock grazing in the notes section.
- **Aerial Cover:** The cover of meadow vegetation provides information on response to disturbance. For each meadow type, record the average aerial cover (%) for each dominant indicator species as < 1 (trace); 1-5; 5-25; 25-50; 50-75; 75-100. For the meadow type summary, estimate and record the average cover for the meadow vegetation type as a whole. For the meadow summary, estimate and record the total vegetation cover for the entire meadow.
- **Vegetation Vigor:** Provides information on potential decreases in water tables, insects, disease, weather extremes, or other disturbances such as inappropriate grazing or recreational

overuse. Reduced vigor is indicated by low height, low production (leaf area or leader growth), or signs of stress, such as chlorosis or yellowing. For each meadow type, record the vigor of each dominant indicator species as high (later successional herbaceous and woody species are vigorous), moderate (later successional herbaceous and woody species are less vigorous than appropriate), or low (vigor of later successional herbaceous and woody species is low). For the meadow type summaries and the overall meadow summary, record the value that is most indicative of the meadow's response to disturbance. Note the apparent cause of any loss in vigor in the notes section.

- **Vegetation Mortality:** Increased mortality is indicated by patches of dying or dead herbaceous and/or woody species. Mature willows with good vigor often have dead stems and this should not be interpreted as a sign of increased mortality. For each meadow type, record the mortality of each dominant indicator species as high (later successional herbaceous and woody species show no evidence of increased mortality), moderate (later successional herbaceous and woody species show evidence of increased mortality), or low (mortality of later successional herbaceous and woody species is high). For the meadow type summaries and the overall meadow summary, record the value that is most indicative of the meadow's response to disturbance. Note the apparent cause of any increases in mortality in the notes section.
- **Riparian or Wetland Indicator Status (WIS):** Descriptions of the wetland indicator status values are in table 2 and the indicator status values for the meadow species are in the table A.9.6. WIS provides general insights into flow regimes, groundwater dynamics, and the responses of the vegetation within the meadow. For each meadow type, record the WIS value of each dominant indicator species from table A.9.6. For the meadow type summaries, record

the most common values for the type. For the overall meadow summary, record wetland indicator status as high (wetland obligate, facultative wetland, and facultative upland species are found in appropriate locations and numbers within the medow), moderate (greater number of facultative upland and upland species than appropriate) or low (many more facultative upland and upland species than appropriate).

- **Successional Status:** Descriptions of the successional status values are in table 4 and the successional status values for the meadow species are in the table A.9.6. Successional status ratings for individual plants provide information on the riparian ecosystems past and present responses to disturbance (table 4). Record the successional status value for each dominant indicator species from table A.9.6. For the meadow type summaries, record the most common value for the type. For the overall meadow summary, record the average successional status as high (a large number or cover of late seral species with few mid and early seral species), moderate (a reduced number or cover late seral species and increase in mid and early seral species), or low (very low numbers or cover of late seral species – dominance by mid and early seral species). Note the apparent cause of any reduction in successional status in the notes section.
- **Bank Stability Rating:** The bank stability ratings are based on table 5 and values for the meadow species are in table A.9.6. Most perennial streams require 70% to 90% stabilizing cover (vegetation, large or anchored rock, anchored wood) to buffer the erosive force of water (Winward 2000; Burton et al. 2011). Root strength and rooting depth of meadow vegetation contributes to overall stability. Record the bank stability rating for each dominant indicator species from table A.9.6. For the meadow type summaries, record the most common value for the type. For the overall meadow summary, record the bank stability

rating as high (a large proportion or cover of species with high stability ratings), moderate (a large proportion or cover of species with a medium stability rating), or low (a high proportion or cover of species with a low stability rating). Note the apparent cause of any loss of bank stability in the notes section.

- **Nativity:** Species designations as nonnative-invasive or noxious weed are in the table A.7.3. Record all nonnative-invasive species and noxious weeds as nonnative. For the geomorphic position summaries, record the total number of nonnative species on the geomorphic position. For the overall meadow summary, record the total number of nonnative species for the entire meadow.

Table A.9.4–The dominant plant species in Great Basin meadow complexes. The information in this table is used to complete the meadow vegetation data form (A.9.4). The plant species are grouped by meadow type. Included for the species in each meadow type are the scientific name, symbol, and common name (USDA 2020) of the dominant meadow species followed by their wetland indicator status, successional status, and stability index. Wetland indicator status (WIS): OBL = obligate; FAC = facultative; FACW = facultative wetland; FACU = facultative upland; UPL = upland (Lichvar and Minkin 2008). Successional status (Succ): E = early seral; M = mid-seral, L = late seral. Bank stability index (Stab): L = low stability; M = moderate stability; H = high stability (Burton et al. 2011; Swanson 2016).

*Nonnative-invasive; **Noxious weed.

Species	**Symbol**	**Common name**	**Wetland Indicator Status (WIS)**	**Successional Status (Succ)**	**Stability Rating (Stab)**
Standing Water Meadow (Depth to water table — +10 to 0 cm)					
Grasslike					
Carex aquatilis	CAAQ	water sedge	OBL	L	H
Carex utriculata	CAUT	Northwest Territory sedge	OBL	L	H
Scirpus microcarpus	SCMI2	panicled bulrush	OBL	L	H
Associated Shrubs					
Salix geyeriana	SAGE2	Geyer willow	OBL	L	H
Salix wolfii	SAWO	Wolf's willow	OBL	L	H
Forbs					
Mimulus guttatus	MIGU	seep monkeyflower	OBL	M	L
Nasturtium officinale	NAOF	water cress	OBL	M	L
Veronica americana	VEAM2	American speedwell	OBL	M	L
Disturbance Indicators					
Eleocharis quinqueflora	ELQU2	few flower spikerush		E	L
Senecio hydrophilus	SEHY2	water ragwort	OBL	E	L
Wet Meadow (Depth to water table — 0 to 30 cm)					
Grasslike					

Carex nebrascensis	CANE2	Nebraska sedge	OBL	L	H
Carex praegracilis	CAPR5	clustered field sedge	FACW	L	H
Carex scopulorum	CASC12	mountain sedge	FACW	L	H
Carex utriculata	CAUT	Northwest Territory sedge	OBL	L	H
Juncus longistylis	JULO	Longstyle rush	FACW	L	M
Juncus nevadensis	JUNE	Sierra rush	FACW	L	M
Grasses					
Deschampsia elongata	DEEL	Slender hairgrass	FACW	L	L
Glyceria striata	GLST	fowl mannagrass	OBL	L	M
Forbs					
Caltha leptosepala	CALE4	white marsh marigold	OBL	M	M
Epilobium ciliatum	EPCI	fringed willowherb	FACW	M	L
Mimulus guttatus	MIGU	seep monkeyflower	OBL	M	L
Mimulus primuloides	MIPR	primrose monkeyflower	FACW	M	L
Veronica americana	VEAM2	American speedwell	OBL	M	M
Associated Shrubs					
Salix boothii	SABO2	Booth's willow	FACW	L	H
Salix exigua	SAEX	narrowleaf willow	FACW	L	H
Salix geyeriana	SAGE2	Geyer willow	OBL	L	H
Salix lasiolepis	SALA6	arroyo willow	FACW	L	H
Salix lemmonii	SALE	Lemmon’s willow	FACW	L	H
Salix lutea	SALU2	yellow willow	OBL	L	H
Disturbance Indicators					
Agrostis stolonifera	AGST2	creeping bentgrass	FACW	E	L
Alopecurus spp.	ALOPE	foxtail		E	L
Geum macrophyllum	GEMA4	largeleaf avens	FACW	E	L
Equisetum spp.	EQUIS	horsetail		E	M
Juncus ensifolius	JUEN	swordleaf rush	FACW	E	L
Thermopsis spp.	THERM	goldenbanner		E	L
Mesic Meadow (Depth to water table – 30 to 90 cm)					
Grasslike					
Carex athrostachya	CAAT3	slenderbeak sedge	FACW	L	M
Carex microptera	CAMI7	smallwing sedge	FAC	M	M
Carex praegracilis	CAPR5	clustered field sedge	FACW	L	H
Juncus arcticus ssp. *littoralis*	JUARL	mountain rush (Baltic Rush)		L	H
Grasses					
Elymus trachycaulus	ELTR7	slender wheatgrass	FACU	E	L
Deschampsia cespitosa	DECE	tufted hairgrass		M	L
Poa pratensis	POPR	Kentucky bluegrass	FAC	E	L

Poa secunda ssp. *juncifolia*	PONE3	Nevada blue grass		E	L
Forbs					
Achillea millefolium	ACMI2	common yarrow		E	L
Potentilla gracilis	POGR9	slender cinquefoil	FAC	E	L
Stellaria longipes	STLO2	longstalk starwort	FACW	M	M
Symphyotrichum spathulatum var. *spathulatum*	SYSPS	western mountain aster		E	L
Trifolium monanthum	TRMO2	mountain carpet clover	FAC		
Trifolium wormskioldii	TRWO	cows clover	FACW	M	L
Associated Shrubs					
Ribes aureum	RIAU	golden currant	FAC	E	M
Ribes inerme	RIIN2	whitestem gooseberry	FAC	E	M
Salix boothii	SABO2	Booth's willow	FACW	L	H
Salix exigua	SAEX	narrowleaf willow	FACW	L	H
Salix geyeriana	SAGE2	Geyer willow	OBL	L	H
Salix lasiolepis	SALA6	arroyo willow	FACW	L	H
Salix lucida	SALU	Shining willow	OBL	L	H
Salix lutea	SALU2	yellow willow	OBL	L	H
Disturbance Indicators					
Agrostis stolonifera	AGST2	creeping bentgrass		E	L
Alopecurus spp.	ALOPE	foxtail		E	L
Carduus nutans	CANU4	nodding plumeless thistle	FACU	E	L
Bromus inermis	BRNI2	smooth brome	FACU	E	L
Cirsium arvense	CIAR4	Canada thistle	FACU	E	L
Erigeron divergens	ERDI4	spreading fleabane		E	L
Hordeum brachyantherum	HOBR2	meadow barley	FACW	E	L
Iris missouriensis	IRMI	Rocky Mountain iris	FACW	M	M
Poa bulbosa	POBU	Bulbous bluegrass	FACW	E	L
Rosa woodsii	ROWO	Woods' rose	FACU	E	M
Juncus arcticus ssp. *littoralis*	JUARL	mountain rush (Baltic Rush)		L	H
Rumex spp.	RUMEX	dock		E	L
Taraxacum officinale	TAOF	common dandelion	FACU	E	L
Urtica dioica	URDI	stinging nettle	FAC	E	L
Viola nephrophylla	VINE	northern bog violet	FACW	M	L
Dry Meadow (Depth to water table – 90 to 170 cm)					
Grasslike					
Carex douglasii	CADO2	Douglas' sedge	FAC	M	L
Grasses					

Leymus triticoides	LETR5	beardless wildrye	FAC	E	L
Muhlenbergia richardsonis	MURI	mat muhly	FAC	L	H
Pascopyrum smithii	PASM	western wheatgrass	FAC	M	M
Poa secunda ssp. *juncifolia*	PONE3	Nevada blue grass		E	L
Forbs					
Achillea millefolium	ACMI2	common yarrow		E	L
Erigeron divergens	ERDI4	spreading fleabane		E	L
Penstemon rydbergii	PERY	Rydberg's penstemon	FACU	M	L
Associated Shrubs					
Ribes aureum	RIAU	golden currant	FAC	E	M
Disturbance Indicators					
Bromus inermis	BRNI2	smooth brome	FACU	E	L
*Bromus tectorum**	BRTE	cheatgrass		E	L
*Cardaria draba**	CADR	whitetop		E	M
Carduus nutans	CANU4	nodding plumeless thistle	FACU	E	L
Cirsium arvense	CIAR4	Canada thistle	FACU	E	L
Cirsium scariosum	CISC2	meadow thistle	FAC	E	L
Elymus lanceolatus	ELLA3	thickspike wheatgrass	UPL	E	L
Poa bulbosa	POBU	Bulbous bluegrass	FACW	E	L
Iris missouriensis	IRMI	Rocky Mountain iris	FACW	M	M
*Iva axillaris**	IVAX	povertyweed	FAC	E	L
*Lepidium latifolium**	LELA2	broadleaved pepperweed	FAC	E	M
Taraxacum officinale	TAOF	common dandelion	FACU	E	L
Rosa woodsii	ROWO	Woods' rose	FACU	E	M
Urtica dioica	URDI	stinging nettle	FAC	E	L
Shrub Meadow (Depth to water table – 125 to 275 cm)					
Grasslike					
Carex douglasii	CADO2	Douglas' sedge	FAC	M	L
Juncus arcticus ssp. *littoralis*	JUARL	mountain rush (Baltic Rush)		L	H
Grasses					
Elymus lanceolatus	ELLA3	thickspike wheatgrass	UPL	E	L
Leymus cinereus	LECI4	basin wildrye	FAC	M	M
Leymus triticoides	LETR5	beardless wildrye	FAC	E	L
Muhlenbergia richardsonis	MURI	mat muhly	FAC	L	H
Pascopyrum smithii	PASM	western wheatgrass	FAC	M	M
Poa pratensis	POPR	Kentucky bluegrass	FAC	E	L
Poa secunda	POSE	Sandberg bluegrass	FACU	E	L

*Thinopyrum intermedium**	THIN6	intermediate wheatgrass		M	L
Forbs					
Achillea millefolium	ACMI2	common yarrow		E	L
Allium bisceptrum	ALBI2	twincrest onion		M	L
Astragalus lentiginosus	ASLE8	freckled milkvetch	UPL		
Cryptantha flavoculata	CRFL6	roughseed cryptantha		M	L
Erigeron divergens	ERDI4	spreading fleabane		E	L
Lupinus argenteus	LUAR3	silvery lupine		M	L
Penstemon rydbergii	PERY	Rydberg's penstemon	FACU	M	L
Associated Shrubs					
Artemisia tridentata ssp. *tridentata*	ARTRT	basin big sagebrush		E	L
Artemisia tridentata ssp. *vaseyana*	ARTRV	mountain big sagebrush		E	L
Chrysothamnus viscidiflorus	CHVI8	yellow rabbitbrush		E	L
Ribes aureum	RIAU	golden currant	FAC	E	M
Symphoricarpos oreophilus	SYOR2	mountain snowberry		M	M
Disturbance Indicators					
*Bromus tectorum**	BRTE	cheatgrass		E	L
*Cardaria draba**	CADR	whitetop		E	M
Carduus nutans	CANU4	nodding plumeless thistle	FACU	E	L
Cirsium arvense	CIAR4	Canada thistle	FACU	E	L
Poa bulbosa	POBU	Bulbous bluegrass	FACW	E	L
Iris missouriensis	IRMI	Rocky Mountain iris	FACW	M	M
Ericameria nauseosa	ERNA10	rubber rabbitbrush		E	L
*Iva axillaris**	IVAX	poverty weed	FAC	E	L
Taraxacum officinale	TAOF	common dandelion	FACU	E	L
Rosa woodsii	ROWO	Woods' rose	FACU	E	M
Urtica dioica	URDI	stinging nettle	FAC	E	L

References

Burton, T.; Smith, S.; Crowley, E. 2011. Multiple indicator monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737-23. Denver, CO: US Department of the Interior, Bureau of Land Management, National Operations Center. 155 p.

Lichvar, R.; Minkin, P. 2008. Concepts and procedures for updating the national wetland plant list. ERDC/CERRL TN-08-03. Handover, NH: U.S. Army Corps of Engineers, Engineer

Research and Development Center, Cold Regions Research and Engineering Laboratory. http://libweb.erdc. Usace.army.mil/Archimages/2295.pdf.

Swanson, S. 2016. Nevada plants useful for riparian condition assessment and monitoring. Special Publication 16-15. Reno, NV: University of Nevada Cooperative Extension. 8 p.

United States Department of Agriculture, Natural Resource Conservation Service. Plants Database. https://plants.sc.egov.usda.gov/java/. [Accessed 2020 August 27].

Table A.3.1—Descriptions of montane riparian and meadow ecosystems in the Great Basin.

Montane Riparian Ecosystems

Subalpine-Montane Conifer. This system occurs on stream terraces or trough-shaped floodplains. Common tree species at higher elevations with colder soils include *Pinus flexilis*, *Abies concolor*, *Abies lasiocarpa*, *Picea engelmannii*, and *Pseudotsuga menziesii*. *Pinus ponderosa* and *Juniperus scopulorum* can occur at more moderate elevations with warmer soils. *Pinus flexilis* occurs in the central part of the Great Basin, but most of these types are more common in in the eastern portion of the Great Basin. Common shrubs are *Cornus sericea*, *Rosa woodsia*, *Prunus virginiana*, and *Salix* spp. A wide variety of herbaceous species occur on these sites, with graminoids being more common on sites with finer textured soils and shallower depths to field capacity, and forbs occurring more often on site with a higher proportion of cobbles and greater depths to field capacity.

Subalpine-Montane *Populus tremuloides*. This type commonly occurs on trough floodplains but is also found on stream terraces and toe slopes. Soils are relatively cold. On sites with relatively shallow depth to field capacity (27 $\pm$ 27 cm in the eastern Sierra Nevada), graminoids occur in understory and willows and alder may be present. On sites where depth to field capacity is greater (53 $\pm$ 53 cm in the eastern Sierra Nevada) shrub species include *Salix* spp., *Alnus incana*, *Ribes* spp., and *Symphoricarpos* spp. Understory species can include *Osmorhiza* spp., *Thalictrum* spp., *Mertensia* spp., *Geranium* spp., *Ligusticum grayi*, *Aquilegia formosa*, *Aconitum columbianum*, *Poa wheeleri*, *Bromus marginatus*, and *Elymus* spp.

Subalpine-Montane Cold Willow. This ecological type typically occurs on trough floodplains or trough stream terraces but also occurs on gravelbars. These sites occur at higher elevation in areas with steeper valley slopes (2.5 to 8%). Soils are sandy and depth to field capacity is close to the soil surface (about 10 to 50 cm). The dominant willow species are *Salix boothii*, *Salix lutea* x *Salix boothii*, *Salix lucida* ssp. *lasiandra,* and *Salix geyeriana*. Sites with fewer cobbles where field capacity is close to the soil surface tend to have understories dominated by graminoids. Sites with a higher percentage of cobbles in the soil layers and greater depths to field capacity tend to have understories dominated by forbs.

Montane *Betula occidentalis*. This type typically occurs on stream terraces or trough-shaped floodplains that tend to be found in canyon constrictions. Average soil temperatures tend to be warmer but exhibit a broad range. Soils typically have a high proportion of coarse fragments (gravels, cobbles, and boulders). Sites usually have a dense overstory *of Betula occidentalis*.

Lower Montane Warm Willow. This ecological type typically occurs on gravelbars but is also found on trough-shaped floodplains, stream terraces, and incised landforms (Riverine HGM Class). These sites have a tendency to be found at lower elevations with gentler valley slopes (1-5%). Sites are associated with gravel-bed streams, and depth to field capacity is relatively close to the surface (approximately 80 cm). Warm willow species dominate (*Salix exigua*, *S. lutea*, *S. lemmoni*, or *S. lasiolepis*). On very warm sites, exotic shrub species may include *Tamarix* spp. and *Elaeagnus angustifolia.* Sites with finer textured soils where field capacity is close to the soil surface tend to have understories dominated by graminoids; those with coarser textured soils and a high percentage of cobbles in the soil layers tend to have understories dominated by forbs. This system may occur on slopes, lakeshores, or around ponds where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water and may experience overland flow but no channel formation (Slope, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches.

Lower Montane Cottonwood. This type is most commonly found on stream terraces but also occurs on trough-shaped floodplains. Soils are relatively warm. Usually no more than 15% cobbles are found in any one soil horizon. Cottonwoods, either *Populus fremontii*, *Populus balsamifera* ssp. *trichocarpa*, or *Populus angustifolia* are overstory species. Understory shrubs may include *Salix* spp., *Prunus* spp., *Rhus trilobata*, *Cornus* spp., or *Artemisia* spp. Understory grasses and forbs may include *Achnatherum* spp., *Elymus* spp., *Leymus* spp., *Bromus carinatus, Bromus marginatus, Poa fendleriana, Lupinus* spp., *Geranium* spp., *Osmorhiza* spp., *Maianthemum* spp., *Aquilegia formosa, Thalictrum* spp., and *Aconitum columbianum.* This system can also occur on lakeshores or around ponds where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Lacustrine, or Depressional HGM Classes)

Lower Montane *Artemisia tridentata* ssp. *tridentata*. This type occurs along trough-shaped drainage ways and floodplains, stream terraces and toe slopes. This type may also occur in associations with incised or avulsed landforms. Soil temperatures are relatively warm. In systems that are not incised, field capacity is typically within a meter of the surface, but in incised systems field capacity is often greater than 1 m. Coarse fragments (gravels, cobbles, and boulders) are typically less than 60% by volume for unincised systems but can be greater than 60% for incised systems. The graminoids *Achnatherum* spp., *Leymus cinereus*, *Leymus triticoides*, or *Poa secunda* ssp. *juncifolia* are the most common grasses on unincised sites. Following incision, *Poa secunda* ssp. *secunda*, *Elymus elymoides*, and *Bromus tectorum* can be the most common grasses. This type may also occur at relatively high elevations in association with *Artemisia tridentata* ssp. *vaseyana.*

Meadow Complexes

Herbaceous wetlands associated with a relatively high water table (ranges from 0 cm to about 300 cm depth to water table) that typically lack prolonged standing water These herbaceous wetlands occur in association with seeps or springs and/or montane streams, and are located in geomorphic positions that allow the accumulation of fine-textured sediments. Sites may be dominated by *natural* groundwater inputs with fairly stable hydrology. Sites may exhibit ground water sapping, lowered water tables, and changes in vegetation composition when located adjacent to incising (downcutting) streams. Sites may also be controlled by *artificial* overland flow (surface or subsurface irrigation runoff or return flow) or artificial groundwater seepage (including from leaky irrigation ditches). Sites may be small or very large. These sites may be intentionally managed for hay production or may be the result of unintentional return flows, runoff, or seepage. Vegetation is dominated by native or non-native herbaceous species; graminoids (grasses, sedges, rushes) typically have the highest canopy cover. Species composition may be dominated by non-native hay grasses. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation.

Montane Meadow - Herbaceous wetlands associated with a high water table or overland flow. Sites are typically associated with snowmelt or elevated groundwater. Sites associated with the Flats or Slope HGM class are rarely subjected to high disturbance events such as flooding. Those associated with a stream channel are more tightly connected to overbank flooding from the stream channel (Riverine HGM Class) and may be affected by avulsion and/or incision. Sites vary in size; montane meadow vegetation may occur on stream terraces with elevated water tables. Vegetation is dominated by herbaceous species; graminoids typically have the highest canopy cover. Different plant community types are associated with different groundwater levels and are indicated by species with different physiological tolerances for depth to water table (Castelli et al. 2000; Chambers et al. 2004; Lord et al. 2011).

- ***Meadows with perennial standing water* —** Depth to water table is +10 to 0 cm. Characteristic species include *Carex aquatilis*, *Carex utriculata*, *Scirpus microcarpus*, and *Senecio hydrophilus.*
- ***Wet meadow* —** Depth to water table is 5 to 30 cm. Characteristic species include *Carex nebrascensis*, *Deschampsia elongata,* and *Deschampsia cespitosa*.
- ***Mesic meadow* —** Depth to water table – 30 to 90 cm. Characteristic species include *Carex microptera*, Carex praegracilis, *Poa secunda juncifolia*, *Juncus arcticus* ssp. *littoralis*, and *Deschampsia cespitosa*. *Poa pratensis* is common; it is an indicator of historical heavy grazing and may not reflect the current grazing regime.
- ***Dry meadow* —** Depth to water table – 90 to 170 cm. Characteristic species include *Leymus triticoides*, *Elymus trachycaulus*, *Poa secunda juncifolia*, and *Muhlenbergia richardsonis*. *Poa pratensis* is common; it is an indicator of historical heavy grazing and may not reflect the current grazing regime.
- ***Dry shrub meadow* —** Depth to water table is 125 to 275 cm. Characteristic species include *Artemisia tridentata* ssp., *Carex douglassi,* and *Leymus cinereus*.

Irrigated Wet Meadow - Large herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water, but may have standing water early in the season if water levels are very high. Vegetation is dominated by native or nonnative herbaceous species; graminoids have the highest canopy cover. Species composition may be dominated by non-native hay grasses such as *Poa* spp*., Alopecurus* spp*.*, *Phleum pratense*, and *Bromus inermis* spp. *inermis*. There can be patches of emergent marsh vegetation and standing water less than 0.1 ha; these are not the predominant vegetation.

REFERENCES

Castelli, R.M.; Chambers, J.C.; Tausch, R. 2000. Soil-plant relations along a soil water gradient in Great Basin riparian meadows. Wetlands. 20:251-266.

Comer, P.; Menard, S.; Tuffly, M.; Kindscher, K.; Rondeau, R.; Jones, G.; Steinuaer, G.; Schneider, R.; Ode, D. 2003. Upland and Wetland Ecological Systems in Colorado, Wyoming, South Dakota, Nebraska, and Kansas. Report and Map to the National Gap Analysis Program. (U.S. Geological Survey, Department of Interior). NatureServe, Arlington, Virginia. 18 p. plus appendices.

Lemly, J.; Giligan, L.; Wiechman, C. 2016 Ecological Integrity Assesment (EIA) for Colorado Wetlands Field Manual, Version 2.1. Fort Collins, CO: Colorado Natural Heritage Program Colorado State University,

Lord, M.L.; Jewett, D.W.; Miller, J.R.; Germanoski, D.; Chambers, J.C. 2011. Hydrologic processes affecting meadow ecosystems. In: Chambers, J.C.; Miller, J.R. (eds). Geomorphology, Hydrology and Ecology of Great Basin Meadow Complexes: Implications for Management and Restoration. Gen. Tech. Rep. RMRS-GTR-258. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 44-66.

Manning, M.E.; Padgett, W.G. 1995. Riparian community type classification for Humboldt and Toiyabe National Forests, Nevada and Eastern California. Gen Tech. Rep. R4-Ecol-95-01. Ogden, UT; U.S. Department of Agriculture, Forest Service, Region 4. 306 p.

Weixelman, D.A.; Zamudio, D.C.; Zamudio, K.A. 1996. Central Nevada riparian field guide. Publication No. 22.09.417.01/96. Sparks, NV: U.S. Department of Agriculture, Forest Service, Toiyabe National Forest.

Weixelman, D.A.; Zamudio, D.C.; Zamudio, K.A. 1999. Eastern Sierra Nevada riparian field guide. Publication No. 22.09.417.07/99. Sparks, NV: U.S. Department of Agriculture, Forest Service, Toiyabe National Forest.

Appendix 8─Information and Data Form for Assessing Disturbance in the Field

This appendix provides the data form for the disturbance assessment. Disturbance data are collected for assessments of both riparian and meadow ecosystems using the form A.8.1. One form is used for each reach. At each sampled stream reach, identifying information is recorded on the data form. This includes the date, observer, watershed name, the watershed code in the Great Basin watershed database, location within the watershed (e.g., high, mid, low), and the reach length of the observations (typically 30 m). A GPS is used to record the UTM coordinates and elevation where the stream cross section is drawn for the sampled reach.

Common disturbances in the Great Basin are described in the section on "What are the Effects of Human-caused Disturbances?" in Part 1 of this report. Disturbances that are not in the list provided as well as those present in the sample reach and adjacent upstream and downstream reaches are recorded. Any negative effects of the disturbance on the stream channel, stream bank, or riparian vegetation of the sample reach are then recorded. The effects of the disturbance are recorded as none (no negative effect); low (the disturbance is having a minor negative effect on the stream channel, stream banks, or vegetation); moderate (the disturbance is having a clear negative effect on geomorphic processes or riparian vegetation); and high (the disturbance has significantly altered geomorphic processes or the riparian vegetation in a negative way).

The disturbance data collected in the field are summarized for the sampled stream reaches in the ecological integrity form in appendix 11. Combining summaries of disturbance data with those for the geomorphic and vegetation data can provide a clear picture of the type and magnitude of disturbances and, thus, the types of management actions needed to improve the ecological conditions or integrity of the stream reach.

Form A.8.1– DISTURBANCE DATA	Date: Observer:
Watershed Name:	Database Code:
UTM Zone:	Elevation (m):
UTMs: Northing	Easting
Location in Basin: Low / Mid / High	Reach Length of Observations (m):
Camera ID and Nos.	

Yes/No: enter **Y** if the disturbance is present in the sample reach or in adjacent upstream and downstream reaches and **N** if it is not.
Location of disturbance: record as sample reach/meadow (**SR/SM**), upstream (**UPS**), or downstream (**DST**).
Component(s) affected by disturbance: record as stream channel (**SC**), stream bank (**SB**), and/or riparian/meadow vegetation (**RV/MV**).
Negative effects of disturbance on sample reach: record as none (**N**), low (**L**), moderate (**M**), or high (**H**).

Other: list other disturbances affecting the stream reach, their location, and their relative effect.

Disturbance Type	Yes / No	Location	Component	Effect
Road in the valley bottom				
Road channel in-stream crossings				
Culverts				
Road captures (stream diverted onto road)				
Developed campsites				
Undeveloped campsites				
Human developments (houses/cabins)				
Mining activity on hillslopes (circle: historic, active)				
Mining activity in valley bottom (circle: historic, active)				
Surface water manipulation (ditches, spring boxes, etc.)				
Groundwater extraction (wells)				
Water diversion (dams/canals)				
Inactive beaver dams (erosion, low water quality, etc.)				
Active beaver dams (appropriate channel location, continued maintenance, redundant structures, etc.)				
Wildfire - Fire name/ date if known:				
Prescribed fire				
Livestock effects on vegetation (circle: sheep, cattle)				
Livestock effects on bank and channel				
Wild horse effects on vegetation				
Wild horse effects on bank and channel				
Other disturbances:				

Notes: