Oklahoma Rapid Assessment Method (OKRAM)

User Manual - Version 1.1

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Oklahoma State University and Oklahoma Conservation Commission

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Acknowledgements

The Oklahoma Rapid Assessment Method (OKRAM) was created and developed as a collaboration between Oklahoma State University (OSU) and the Oklahoma Conservation Commission (OCC). OKRAM was first conceptualized in 2011 and has only been able to be realized in it's current form due to continued support from the U.S. Environmental Protection Agency (USEPA). Wetland Program Development Grants [104(b)(3)] have provided the critical funding needed to test, validate and refine the method at the diverse wetland types across Oklahoma over the last decade. We thank Joe Bidwell and Chris DuBois for critical insights into OKRAM during early stages of development. Numerous graduate students and technicians at OSU have been instrumental in collecting the data needed to ensure OKRAM scores accurately reflect wetland condition. We thank Bill Hiatt, Cameron Sherbon, Anthony Thornton, Matt Walters, Jeff Tibbits, Morgan Noland, and Brent Fetting for their tireless efforts during hot Oklahoma summers.

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Rapid assessment methods (RAMs) have been recognized for their utility within state and federal wetland programs because they provide a consistent, affordable approach for ambient monitoring and prioritization of wetland conservation efforts (USEPA 2006). RAMs use metrics that record observable field indicators such as vegetation, topography, and alterations to the wetland's hydrology (e.g., sedimentation, dikes, ditches, etc.) to define wetland condition. Individual metric scores are aggregated into an overall condition score, which represents the relative degree of deviation in condition from least-disturbed wetlands (i.e., reference standard condition).

RAMs fit within the three-tiered framework for wetland monitoring and assessment (Figure 1) established by the United States Environmental Protection Agency (USEPA 2006). RAMs are considered Level 2 assessments, and they provide consideration for local factors that may be overlooked by coarse Level 1 landscape assessments but are less time-consuming compared to Level 3 intensive site assessments. As a result, they have become an important element of wetland monitoring programs for applications including evaluating the performance of compensatory mitigation projects and producing regional wetland condition estimates. RAM utility for these functions is predicated on four characteristics (Fennessey et al. 2004, Fennessey et al. 2007): (1) wetland condition is reflected by a single score, (2) the assessment can be completed rapidly (one day in the office and field for two staff members), (3) the assessment is completed on-site, and (4) the method is validated with Level 3 intensive data.

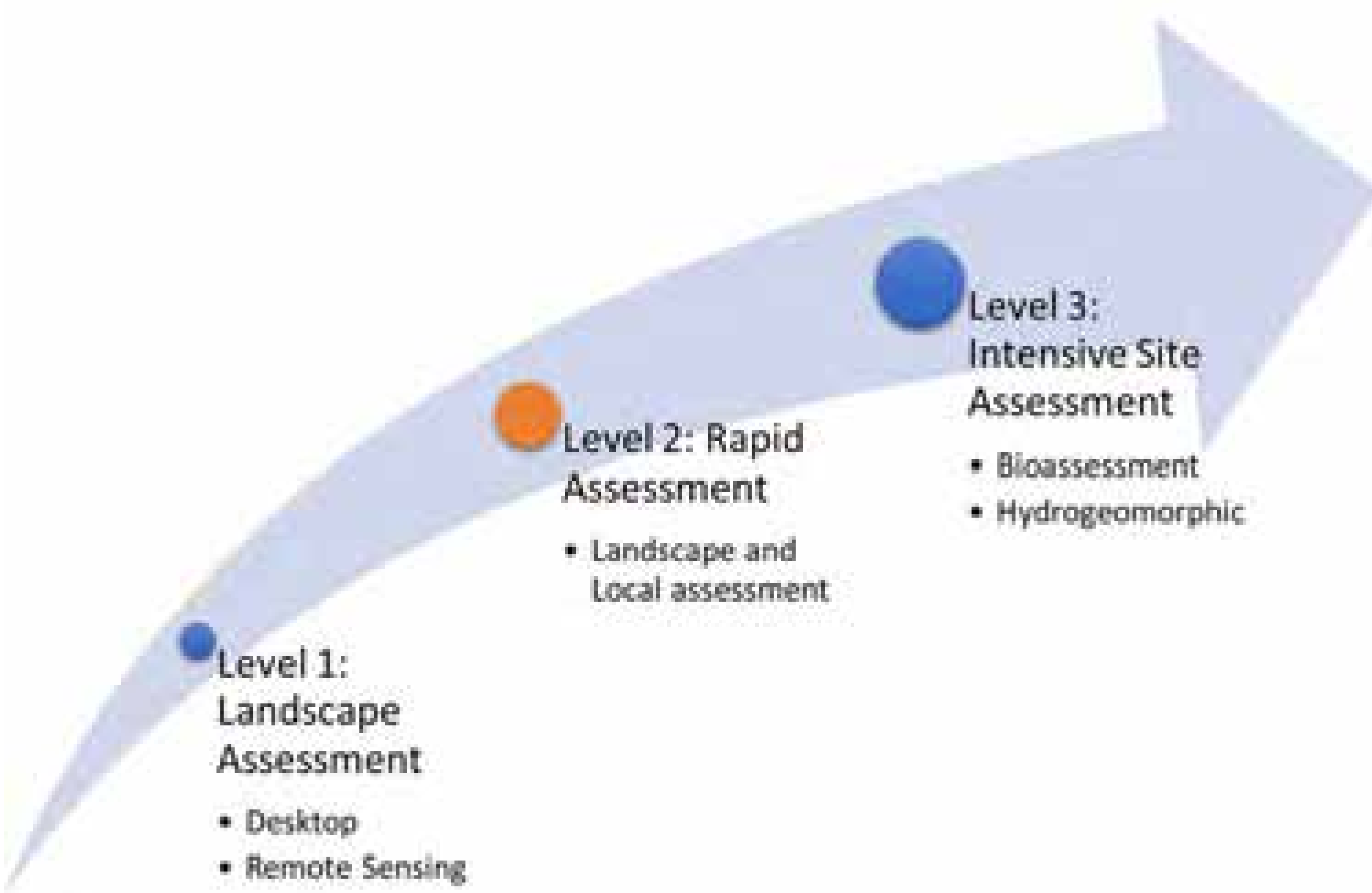


Fig 1. USEPA three-tiered framework for wetland monitoring and assessment. Arrow indicates increase in time required for assessment and technical expertise required.

Background and Conceptual Framework

Oklahoma Rapid Wetland Assessment (OKRAM)

The first draft of the Oklahoma Rapid Assessment Method (OKRAM) was conceived in 2012 with the goal of creating a single-score wetland assessment that was truly rapid and fully validated. The assessment framework was designed following an extensive literature review of existing state RAMs (Collins et al. 2008, Jacobs 2010, Johnson et al. 2011, Kutcher 2010, Kutcher 2011, Mack 2001, Miller and Gunsalus 1997, NCWFAT 2010, Peterson and Niemi 2007, Reiss and Brown 2007, Sifneos et al. 2010, Stein et al. 2009) as well as primary literature regarding the effects of anthropogenic stressors on wetland function, structure and condition (Brazner et al. 2007, Castelle et al. 1994, Euliss and Mushet 1996, Fairbairn and Dinsmore 2001, Gleason 2003, Gray 2004, Lehtinen et al. 1999, Luo et al. 1997, Rickerl et al. 2000,Voldseth et al. 2007). The theoretical underpinning of OKRAM is similar to that of the Functional Assessment of Colorado Wetlands (FACWet) and the Delaware Rapid Assessment Protocol (DERAP) in which the presence of stressors causes ecosystem condition to deviate from condition at undisturbed sites (Jacobs 2010, Johnson et al. 2013). When stressors are not identified, the wetland is assumed to maintain the best possible ecological condition (Johnson et al. 2013).

Since its inception, OKRAM has consisted of metrics, aggregated into three attribute scores and finally combined to give one overall condition score (Figure 2). The metrics included in OKRAM are based on metrics from the California Rapid Assessment Method (CRAM) and FACWet but are adjusted based on regionally important stressors according to the primary literature and best professional judgment of project staff. Metrics are divided into three attributes (hydrologic condition, water quality condition, and biotic condition) with each attribute representing fundamental physical, chemical and biological components of wetland condition. Individual metrics and the overall score are scaled from 0 to 1, with 1 representing ideal or least disturbed conditions and 0 representing complete degradation resulting from anthropogenic activities.

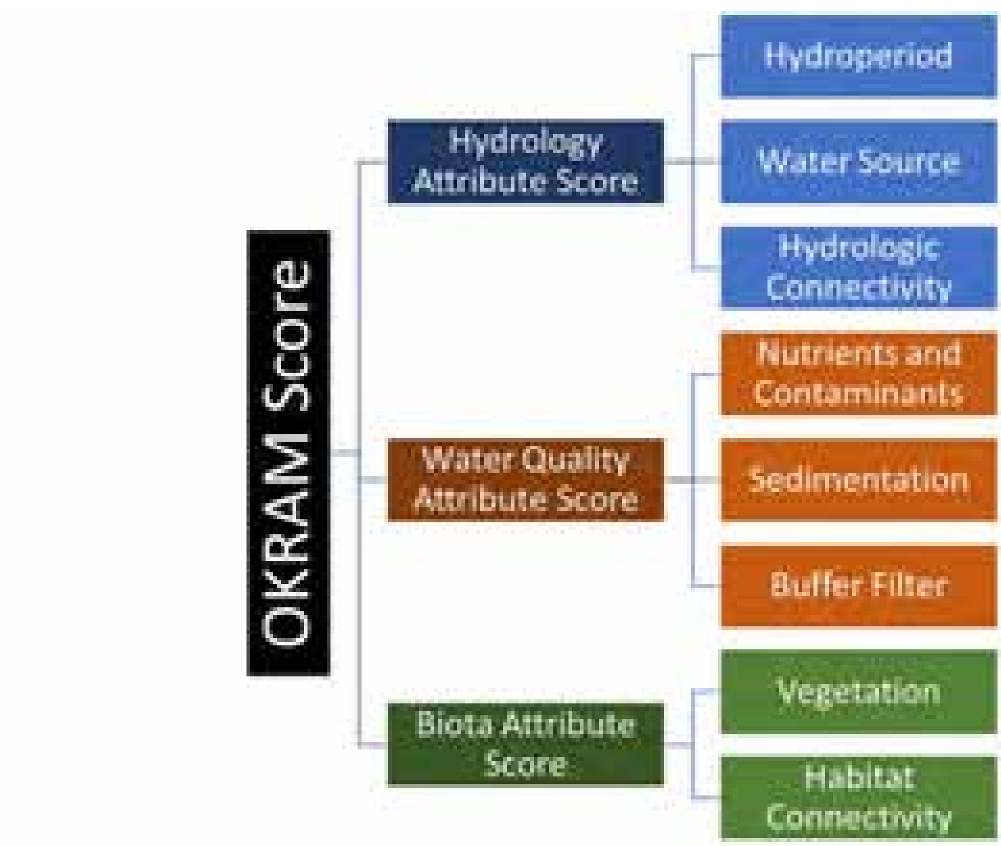


Fig 2. Structure of OKRAM assessment. Metrics (rightmost column) are aggregated into attributes (center column), which are subsequently averaged to provide an overall OKRAM score. Metrics, attributes and overall score range from 0 to 1.

Background and Conceptual Framework

Between 2012 and 2022, OKRAM has been applied at over 250 wetlands across Oklahoma (Fig. 3) in an effort to refine, calibrate and validate the method (Dvorett et al., 2014, Gallaway et al. 2016, Gallaway et al. 2019, Gilmer et al. 2020, OCC 2019) with intensive site data (i.e., biological community and water/soil chemistry). Through these efforts, the effectiveness of OKRAM at assessing the condition of depressional and floodplain (riverine) wetlands in Oklahoma has been confirmed. However, OKRAM has yet to be validated for other wetland types in Oklahoma, though conceptually the method should be appropriate for assessing slopes, flats and additional riverine wetland subclasses. Currently, we do not recommend applying OKRAM to lacustrine fringe wetlands, as it has been difficult to adequately account for the highly manipulated hydrology of wetlands associated with reservoirs (Gallaway et al. 2016). OKRAM may have applicability to wetlands outside of Oklahoma that exist in similar landscapes and climate; however, we have not completed validation of OKRAM outside Oklahoma.

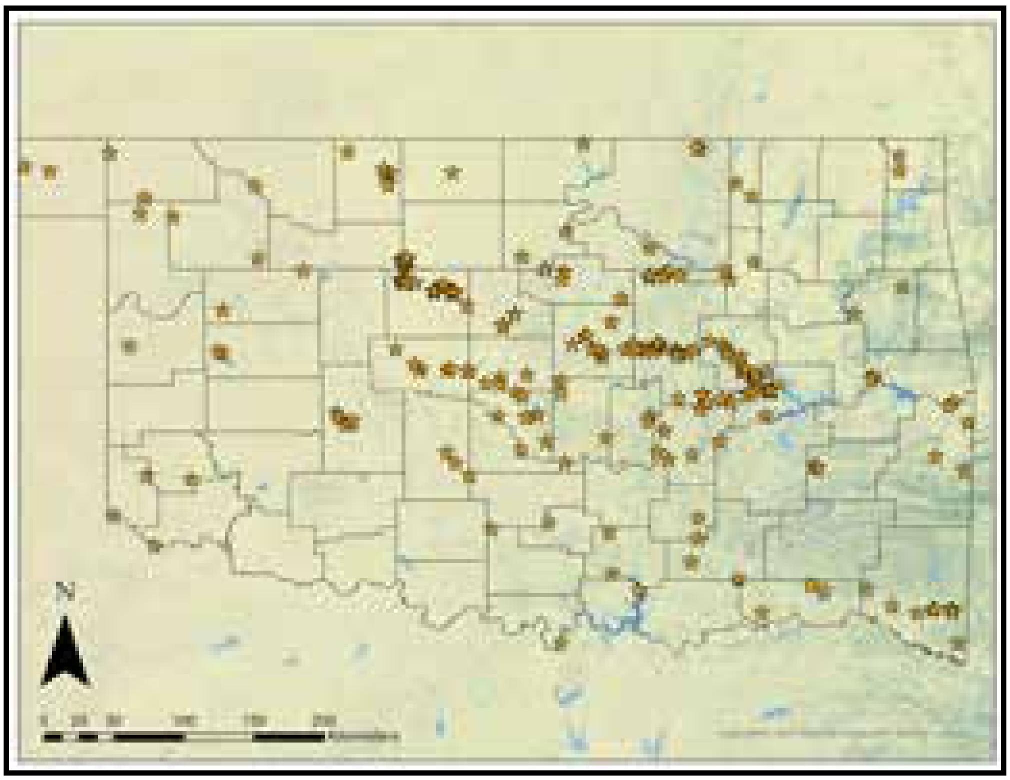


Fig 3. Location of OKRAM assessments completed since 2011

The extensive validation over the last decade provides support that OKRAM provides a repeatable, rapid and accurate method to assess wetland condition at a variety of scales ranging from individual site characterizations to statewide estimates of wetland quality. As a result, the method is appropriate for a variety of applications including prioritizing wetland restorations, identifying high quality wetlands for protection, ambient monitoring, and tracking Clean Water Act mitigation projects.

Application of OKRAM

Completion of an OKRAM Assessment requires office preparation and a field assessment. In most cases, OKRAM can be completed by two people in less than one day (one half-day in the office and one half day in the field). Adequate office preparation is necessary to ensure accurate completion of worksheets in the field. The next two sections, Office Preparation Checklist and Field Assessment Checklist provide an overview of the steps required to complete an OKRAM assessment. More details on how to complete each of these steps are then presented in the subsequent sections of this document. Throughout this document, suggestions are provided for how to process data in Geographic Information Systems (GIS). In most cases it is also possible to complete metrics by manually annotating aerial imagery and topographic maps that are printed to scale.

Office Preparation Checklist

For each OKRAM assessment, the following steps (Fig. 4) should be completed in the office prior to visiting the wetland. Additional details needed to complete these steps are provided in this document.

- Compile necessary frame materials in GIS, including:
    - USGS topographic maps,
    - Digital Elevation Models (DEMs),
    - National Land Cover Dataset (NLCD),
    - National Wetlands Inventory (NWI) maps,
    - High-resolution aerial imagery (e.g., National Agriculture Imagery Program (NAIP)), and
    - Watershed boundaries (Hydrologic Unit Code 12 (HUC12) and Hydrologic Unit Code 8 (HUC8)).

- Delineate approximate wetland boundary in GIS using the NWI maps, aerial photograph interpretation or any other local knowledge of the site.

- Generate preliminary Assessment Areas (see Section: Assessment Area Creation and Adjustment).

- Print aerial photographs at multiple scales with necessary graphical overlays for completion of metrics in the field:
    - Wetland with 100 meter buffer for Hydroperiod, Excess Nutrients/Contamination, and Sedimentation,
    - Wetland with eight 250 m buffer transect lines for the Buffer Filter metric,
    - Wetland with 500 meter buffer for the Hydrologic Connectivity, and Hydroperiod metrics,
    - Wetland with 1 km buffer for the Habitat Connectivity metric, and
    - Wetland with delineated catchment for the Water Source metric.

- Complete preliminary assessment of metrics following metric specific instructions:
    - Hydroperiod (see Section: Hydroperiod),
    - Hydrologic Connectivity (see Section: Hydrologic Connectivity)
    - Water Source, (see Section: Water Source– Depressional or Water Source– Riverine),
    - Buffer Filter (see Section: Buffer Filter), and
    - Habitat Connectivity metrics (see Section: Habitat Connectivity).

- Print a complete datasheet packet for the expected wetland type (i.e., Depressional or Riverine).
    - If the wetland type is unknown, bring datasheets for both wetland types.
    - For a site-specific assessment, bring enough datasheets to complete multiple assessment areas.

Fig 4. Office preparation steps for completion prior to visiting wetland for OKRAM assessment

Field Assessment Checklist

At each OKRAM site, the following steps (Fig. 5) should be completed in the field. Further detail on each of these steps is provided in this document.

- Establish the Assessment Area (AA) for the first portion of the wetland to be assessed (see Section: Assessment Area Creation and Adjustment):
    - Navigate to the randomly generated point,
    - Determine if AA is valid, and
    - Adjust AA as needed.

- Determine wetland HGM class and regional subclass(es) (see Section: OKRAM Wetland Classes).

- Complete Site Description Form (see Section: Site Description):
    - General site information,
    - Location information,
    - Assessment Area information,
    - HGM Classification, and
    - Additional Site Characteristics.

- Complete OKRAM assessment:
    - Hydroperiod (see Section: Hydroperiod),
    - Water source (see Section: Water Source-Depressional or Section: Water Source-Riverine),
    - Hydrologic Connectivity (see Section: Hydrologic Connectivity),
    - Excess Nutrients and Contaminants (see Section: Excess Nutrients and Contaminants),
    - Sedimentation (Depressional only; see Section: Sedimentation),
    - Buffer Filter (see Section: Buffer Filter),
    - Vegetation Condition (see Section Vegetation Condition), and
    - Biotic Connectivity (see Section: Biotic Connectivity).

- Calculate OKRAM score for AA (See Section: Final Scoring).
    - If the site requires only one AA, this is the final score.
    - If the site requires multiple AAs, continue to the next step

- Repeat the previous steps for any additional AAs, replacing the Site Description form with the Additional Assessment Area Form (see Section: Site Description).
    - Continue until all possible AAs are completed OR at least 3 AAs have been completed and the most recent OKRAM score was <15% different from the average of all previously completed AAs (see Section: Assessment Area Creation and Adjustment).
    - Average all AA scores together to determine final OKRAM score for the site.

Fig 5. Steps to be completed in the field for an OKRAM assessment

OKRAM Wetland Classes

In Oklahoma and across the world, wetlands exist under a variety of hydrologic and geomorphic conditions that drive ecosystem structure and function, and as a result, wetlands are susceptible to unique anthropogenic stressors. Therefore, OKRAM has been developed as a modular assessment, with the goal of maximizing consistency across wetland types, but also accounting for important differences between wetlands. During method development and validation, study wetlands were classified, according to the Hydrogeomorphic Classification system (HGM) to determine where modifications for wetland type were necessary. HGM categorizes wetlands based on three components: (1) geomorphic setting or topographic position in the landscape, (2) water source, and (3) hydrodynamics or the direction and strength of water flow (Brinson 1993). HGM Classification has seven national classes, of which five can be found in Oklahoma: depressional, lacustrine fringe, riverine, slope, and mineral soil flats. To date, OKRAM modules have been developed and validated for depressional and riverine wetlands.

Depressional Wetlands

Depressional wetlands (Fig. 6) occur in topographic depressions that accumulate water from precipitation, surface flows, and groundwater discharge (Smith et al. 1995). Depressional wetlands may function as an open wetland with numerous inlets or outlets or as a closed wetland (Brinson 1993). Hydrodynamics are dominated by vertical fluctuations in water level with water loss via outlets, evapotranspiration, or groundwater recharge (Smith et al. 1995). Depressional wetlands are highly dynamic systems with hydroperiods that vary based on climate and geographic location, and as such, these wetlands can range from highly ephemeral to semi-permanent.

Fig 6. Depressional (Closed Surface-Water) Wetland in Kingfisher County

OKRAM Wetland Classes

Riverine Wetlands

Riverine wetlands (Fig. 7) occur in floodplains and riparian corridors adjacent to stream channels, where the dominant water source is overbank flooding or subsurface hydraulic connections between the stream channel and wetlands (Smith et al. 1995). Additional water sources include interflow, return flow, overland flow from adjacent uplands, tributary inflow, and precipitation (Smith et al. 1995). In addition to floodplain wetlands, riverine wetlands include beaver complexes and in-channel wetlands such as vegetated sandbars and islands. Riverine wetlands also exist in geomorphologies that grade into other wetland classes. In the context of OKRAM, topographic depressions within floodplains, where the dominant hydrologic influence is overbank flooding (i.e., 5 year return interval), are considered riverine wetlands. These riverine wetlands may be swales, back channels, or oxbows that are still connected to the river of origin. Additionally, in impounded lotic systems such as reservoirs, riverine wetlands often grade into lacustrine fringe wetlands. In these impounded systems, riverine wetlands are those that are directly adjacent to a distinct channel and/or receive overbank flooding from the channel, even if the flooding is a result of water backing up from the downstream lake.

Fig 7. Riverine Wetlands (In-Channel and Floodplain Lower Perennial) on North Fork of the Red River in Kiowa County

OKRAM Wetland Classes

Lacustrine Fringe Wetlands

Lacustrine fringe wetlands (Fig. 8) are adjacent to lakes where the water table is maintained by water elevation. Additional water sources are precipitation and groundwater recharge (Smith et al. 1995). Hydrodynamics consist of bidirectional flow from water level fluctuations and wave action. Water is lost via evapotranspiration and receding floodwaters (Smith et al. 1995). Lacustrine wetlands provide a variety of functions and services, including breeding and foraging habitat for various wildlife species, reducing the direct input of sediment into lakes, and filtering nutrients within the lake water. The majority of lacustrine wetlands in Oklahoma are located along the numerous reservoirs created by the Army Corps of Engineers, U.S. Bureau of Reclamation, and Grand River Dam Authority (Johnson 1998). Most of the reservoirs located on public land serve as recreational lakes and sources of drinking water. Wetlands associated with large oxbow lakes that are disconnected from river inputs and maintain permanent water >2 meters deep are the only natural lacustrine wetlands in the state.

Fig 8. Lacustrine Fringe Wetland in Logan County

OKRAM Wetland Classes

Slope

Slope wetlands (Fig. 9) typically occur on sloping land, such as hillsides, where there is discharge of groundwater to the land surface (Smith et al. 1995). The primary water source is groundwater, but slope wetlands may be influenced by return flow and interflow from surrounding uplands, as well as precipitation. Hydrodynamics are dominated by downslope unidirectional water flow (Smith et al. 1995). Although normally occurring on sloping land, slope wetlands can also occur in nearly flat landscapes where groundwater discharge is the dominant water source.

Fig 9. Slope (Headwater) Wetland impounded by American beaver

Mineral Soil Flats

Mineral soil flats (Fig. 10) are found on interfluves, extensive relic lake bottoms, or large historic floodplain terraces where the dominant water source is precipitation (Smith et al. 1995). Flats can be distinguished from depressional based on topography, and slope wetlands because they receive no groundwater. Hydrodynamics are dominated by vertical fluctuations and water loss is due to evapotranspiration, saturation overland flow, and seepage to underlying groundwater (Smith et al. 1995). Mineral soil flats are distinguished from flat upland areas based on their poor drainage and low lateral drainage.

Fig 10. Mineral Flat Wetland in McCurtain County

HGM Subclasses

HGM wetlands are further divided into subclasses based on hydrogeomorphic characteristics to reduce natural variability in expected function and structure among grouped wetlands. A key to HGM classes and subclasses is provided in Figure 11. It is critical to complete HGM classification prior to conducting OKRAM assessments because several metrics vary based on HGM class (i.e., Water Source and Sedimentation). However, OKRAM assessment metrics designed for each class are applicable at all subclasses within that class.

Dichotomous Key for HGM Wetland Classification in Oklahoma

1. Wetland is within the 5 year floodplain of a river but not fringing an impounded water body.	*Riverine(5)*
1. Wetland is associated with a topographic depression, flat or slope.	2
2. Wetland is located on a topographic slope (slight to steep) and has groundwater as the primary water source. Wetland does not occur in a basin with closed contours.	*Slope* (15)
2. Wetland is located in a natural or artificial (dammed/excavated) topographic depression or flat.	3
3. Wetland is located on a flat without major influence from groundwater.	*Flat* (**Hardwood Flat**)
3. Wetland is located in a natural or artificial (dammed/excavated) topographic depression.	4
4. Topographic depression has permanent water greater than 2 meters deep and wetlands are restricted to the margin of the depression.	*Lacustrine Fringe (10)*
4. Topographic depression does not contain permanent water greater than 2 meters.	*Depression (11)*

Dichotomous Key for Riverine Wetland Subclassification in Oklahoma

5. The wetland is a remnant river channel that is periodically hydrologically connected to a river or stream every 5 years or more frequently.	**Connected Oxbow**
5. The wetland is not an abandoned river channel.	**6**
6. The hydrology of the wetland is impacted by beaver activity.	**Beaver Complex**
6. The hydrology of the wetland is not impacted by beaver activity.	**7**
7. The wetland occurs within the bankfull channel (includes vegetated ephemeral channels, bars and islands).	**In-channel**
7. The wetland is directly adjacent to the river channel or occurs on a topographic floodplain (may include back-channels, swales or other topographic relief).	**8**
8. Stream is intermittent or ephemeral	**Floodplain (Non-perennial)**
8. Stream is perennial	**9**
9. Stream is a 1st or 2nd order	**Floodplain (Upper Perennial)**
9. Stream is a 3rd order or higher	**Floodplain (Lower Perennial)**

Dichotomous Key for Lacustrine Wetland Subclassification in Oklahoma

10. Wetland is associated with a remnant river channel that is hydrologically disconnected from the stream or river of origin.	**Disconnected Oxbow**
10. Wetland is associated with a reservoir or pond created by impounded or excavation.	**Man-made Lacustrine Fringe**

Dichotomous Key for Depressional Wetland Subclassification in Oklahoma

11. Wetland was created by human activity.	12
11. Wetland was not created by human activity.	13
12. Wetland does not have discernible water outlets.	**Closed Impounded Depression**
12. Wetland has discernible water outlet.	**Open Impounded Depression**
13. Wetland primary water source is groundwater.	**Groundwater Depression**
13. Wetland primary water source is surface water.	14
14. Wetland does not have any discernible water outlets.	**Closed Surface Water Depression**
14. Wetland has discernible water outlets.	**Open Surface Water Depression**

Dichotomous Key for Slope Wetland Subclassification in Oklahoma

15. Wetland is hydrologically connected to a low order (Strahler <=4), high gradient, or ephemeral stream.	**Headwater Slope**
15. Wetland is hydrologically connected to a high order (Strahler >=5), low gradient river. Slope may be imperceptible or extremely gradual (includes wet meadows).	**Low Gradient Slope**

Fig 11. Keys to the HGM wetland classes and subclasses of Oklahoma

Assessment Area Creation and Adjustment

Background: An Assessment Area (AA) is a portion of a target wetland where OKRAM is applied. To minimize selection bias, OKRAM utilizes a standardized protocol for randomly locating and adjusting AA boundaries. AA creation is based on National Wetland Condition Assessment (NWCA) protocols (USEPA 2021).

Valid AAs have the following attributes:

1. Contain only one HGM class. However, multiple HGM subclasses of the same class are acceptable within one AA (e.g., In-Channel and Floodplain Non-Perennial subclasses from the Riverine class),
2. Contain collectively no more than 10% upland and water deeper than 1 m (Though project specific goals may demand that 100% of the AA is wetland), and
3. Does not overlap any other AAs.

The first step in AA creation is to randomly locate a point within the wetland from which to generate an AA. The preferred AA is a 40 m radius circular AA (Standard AA), with the point at the center. Instructions for creating an initial AA are provided for Ambient Monitoring (page 12) and Site-Specific Monitoring (page 13). Standard AAs centered on a randomly generated point can be adjusted if a valid AA was not created. In addition to a Standard AA, Polygon AAs and Site-Boundary AAs are also acceptable. AA types are displayed in Figure 12 and more detailed instructions for AA adjustment are provided (page 18). Ideally an AA will be 0.5 ha (Standard or Polygon AA), but can be smaller if the target wetland is less than 0.5 ha in size (Site-Boundary AA).

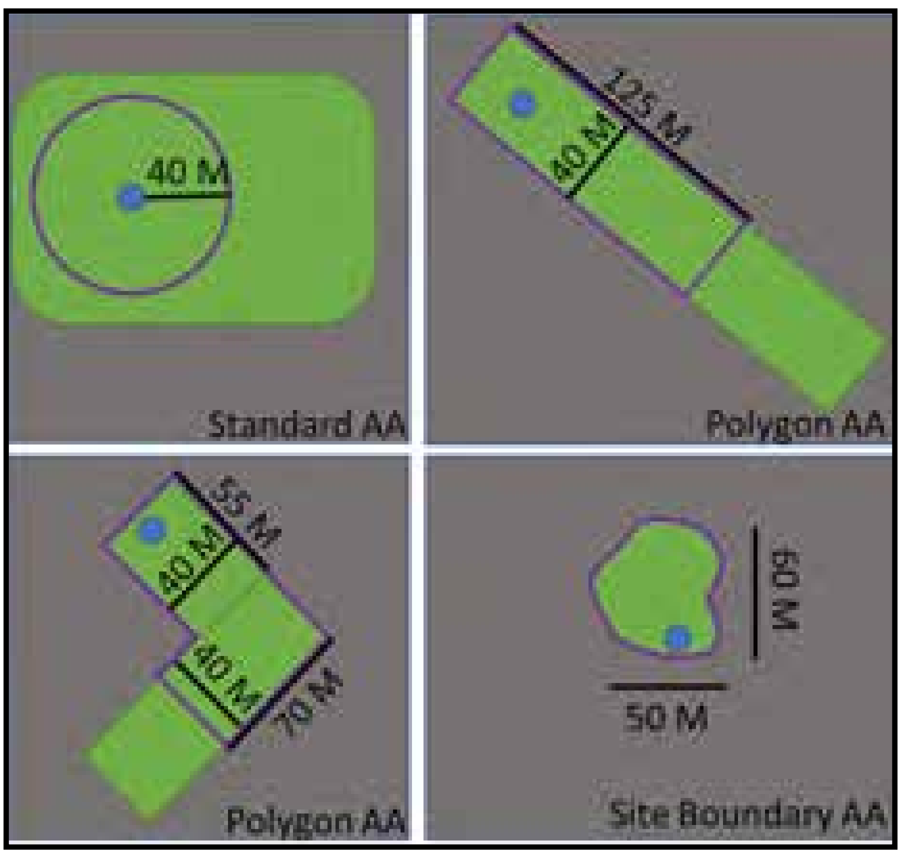


Fig 12. Examples of acceptable AA boundaries. Wetland is represented by green. Upland is represented by gray and AA boundaries are represented by purple lines. The Standard AA (40 m radius circular AA) is the preferred AA (upper left). If a valid Standard AA cannot be created, the next preferred AA is a Polygon AA. Polygon AAs can be a rectangle (preferred; upper right) or irregularly shaped (lower left) as needed to create a 0.5 ha AA. Finally if the wetland is less than 0.5 ha, a Site-Boundary AA is used (lower right).

Assessment Area Creation: Ambient or Population

Ambient monitoring and population condition assessments are completed to assess the condition of the wetland resource in a region. Generally, a random sample of monitoring locations is created to ensure an unbiased population is assessed. Regardless of wetland size, one AA is generally used to represent the condition of a wetland. The following steps describe how to create assessment areas for these broader-scale study designs.

Step 1:

Delineate the boundaries of the study wetlands (Fig. 13). Often the sample population for ambient monitoring will be the National Wetlands Inventory (NWI) but other datasets may be substituted as project goals dictate.

Step 2:

Generate points within the study wetlands (Fig. 13). The project goals will dictate the spatial frame of the wetland dataset used, sample strata, and number of sampling points generated. Most often the sample locations should be chosen randomly; however, project goals may dictate a targeted approach to site selection.

Data Processing Tips:

The spsurvey package in program R or the Create Spatially Balanced Points tool in ArcGIS (requires Geostatistical Analyst) can be used to generate a spatially balanced random sample of points from a sample population of polygons.

Step 3:

Generate 40-m radius circular AAs (Standard AAs) centered on each randomly selected sampling point (Fig. 14). Upon site-visit, if the standard AA contains one HGM class, and collectively <10% upland and deepwater (≥1 m in depth), a valid AA is created, otherwise continue to Step 1 of AA Adjustment (page 18).

Data Processing Tips:

Use the Buffer tool in ArcGIS to create 40-m radius circular AAs.

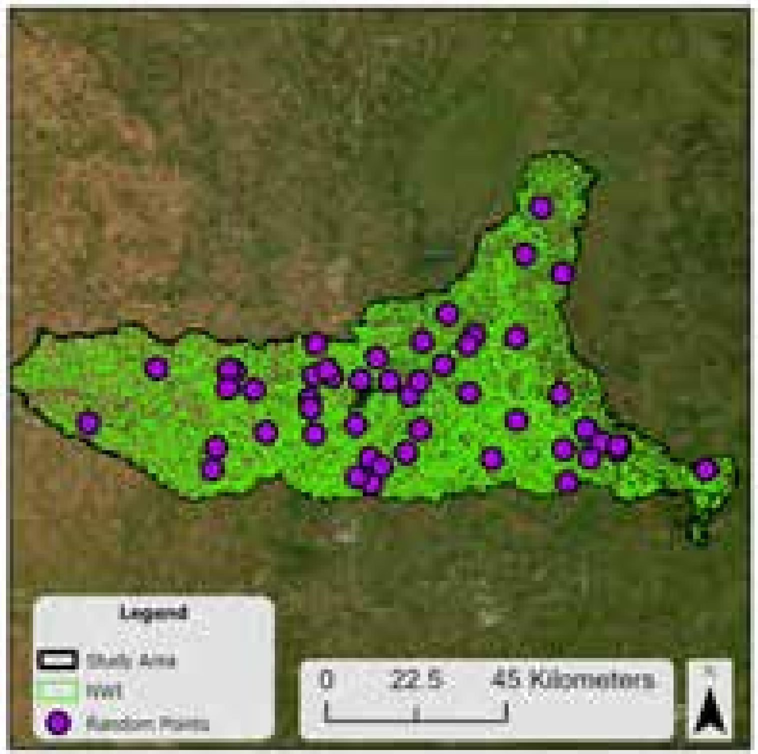


Fig 13. Step 1 and 2: Example population study within the Black Bear—Red Rock Watershed upstream of Keystone Lake. In program R the spsurvey package (GRTS function) was used to create a spatially balanced sample of 50 study wetlands.

Fig 14. Step 3: The buffer tool was used in ArcGIS to create Standard AAs (40 m radius circular AAs) at all randomly generated points

Assessment Area Creation: Site-Specific Assessment

Site-Specific Assessments are completed to evaluate the condition of one wetland. Site-Specific Assessments are conducted for a variety of applications, but they are often completed to assess the condition of a wetland impacted by a project, and/or assess the condition of a restoration project before and after restoration has been completed. Unlike broader scale assessments used to assess the condition of a wetland population, Site-Specific Assessments are designed to characterize the condition of one study wetland. Therefore, more than one AA may be necessary when the wetland (or project) boundary is large and or contains more than one HGM class.

Step 1:

Delineate the boundary of the wetland. Boundary delineation can be completed through a variety of methods depending upon the application of OKRAM, but it is critical to begin with an accurate boundary for Site-Specific Assessment.

Step 2: If the wetland is ≤0.5 ha (or 5,000 square meters), the entire wetland is the AA (Site-Boundary AA, Fig. 15).

In the rare case a small wetland includes multiple HGM classes, adjust the Site-Boundary AA to include only the dominant HGM class. Then, establish one Site-Boundary AA in the largest contiguous area of at least 0.1 ha for all other HGM classes. Multiple HGM subclasses within the same class can be contained in the same AA (e.g., In-Channel and Floodplain Non-Perennial subclasses in the Riverine class).

If the wetland is >0.5 ha, continue on to step 3.

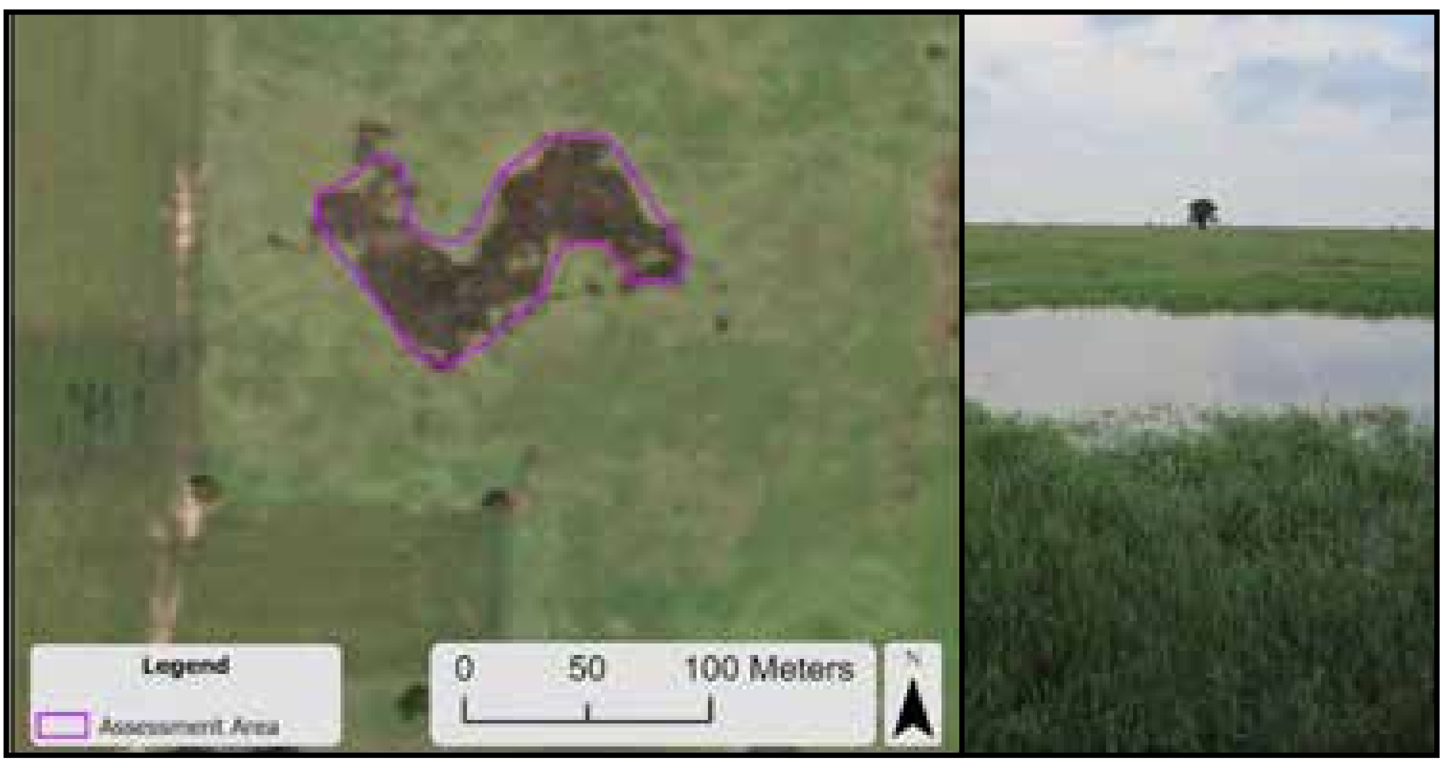


Fig 15. Wetland that is 0.4 ha (<0.5 ha) has an assessment area that encompasses the entirety of the wetland

Assessment Area Creation: Site-Specific Assessment

Step 3:

If the AA is >0.5 ha but <1.5 ha, create one random point within the largest contiguous area of each HGM class (minimum 0.1 ha) and generate a Standard AA centered around all points (Fig. 16). Then, for each point where a valid AA (one HGM class, 90% wetland, no AA overlap) was not created, adjust as needed following guidance starting on Step 1 of AA Adjustment (Page 18). If the AA is ≥1.5 ha, continue on to Step 4 of AA Creation.

Data processing Tips:

In most cases, only one HGM class will be present within a wetland <1.5 ha.

Use the Create Random Points tool in ArcGIS to place a random point within the AA.

Use the Buffer tool in ArcGIS to place a 40-m circular AA around each point.

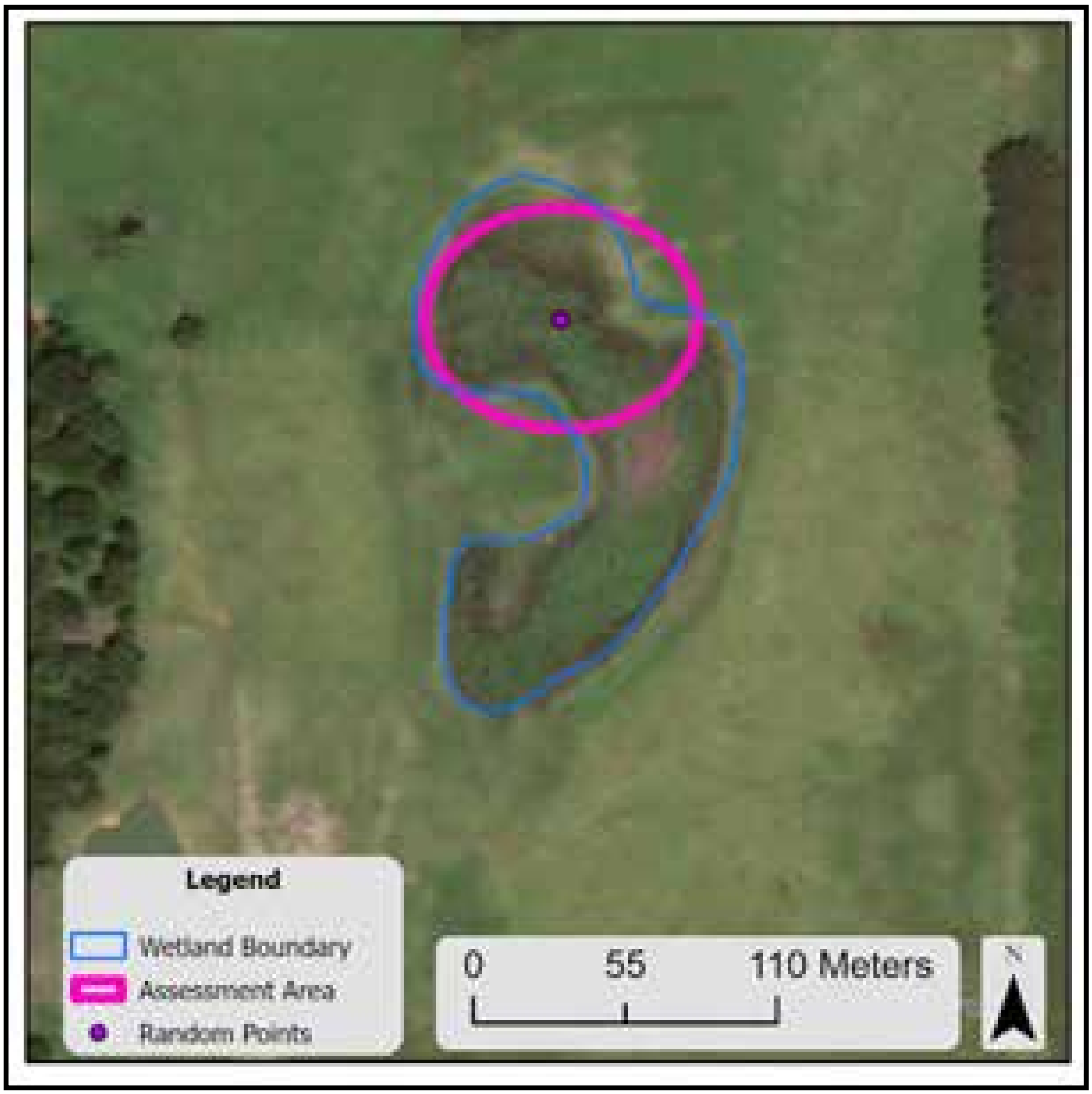


Fig 16. One hectare wetland. A random point was generated and a Standard AA was generated using the Create Random Pont and Buffer tools in ArcGIS.

Assessment Area Creation: Site-Specific Assessment

Step 4:

If the AA is ≥1.5 ha, the AA should be systematically divided with the goal of generating one AA per 0.5 ha of wetland area rounded down, but at minimum one AA per ha of wetland area (rounded up) should be possible (Fig. 17). For example, ideally a 1.9 ha wetland will have three divisions in which an AA could be located but should have two possible AA locations at a minimum.

To avoid bias in AA selection, each division that overlaps at least 0.5 ha of the study wetland should receive a random number, starting with 1 and continuing sequentially. Following assigning a number to all possible divisions of at least 0.5 ha, assign the next sequential random numbers to all remaining divisions, passing over any divisions with <0.1 ha of wetland area.

Starting with the division assigned the value of one, place a point in the center and generate a 40-m radius circular AA centered around that point. In divisions where a valid AA was not created (one HGM class, 90% wetland, no AA overlap) adjust as needed treating each division as a wetland boundary, starting with Step 1 of AA adjustment (page 18). Continue creating and assessing AAs in sequentially numbered divisions until one of the following conditions are met:

1. **All valid AAs have been assessed, OR**
2. **At least 3 AAs have been completed and the most recently completed AA's OKRAM score differs by ≤15% from the average of all previously completed AAs.**

Data Processing Tips:

The generate tessellation tool in ArcGIS can be used to systematically grid a wetland into squares with 80 m length and width (6,400 sqm area) in which standard circular AAs can be centered. For long narrow wetlands, alternative methods of wetland division will be required. In all events, the subdivision should occur following a documented procedure to avoid sample bias.

In practicality, it may be impossible to achieve the number of hypothetical AAs dictated by the wetland size because of irregular wetland shape. However, a valid subdivision will create at least one division per 1 ha of wetland (rounded up) at a minimum. If this minimum number of divisions has not been achieved, another method of subdivision is required.

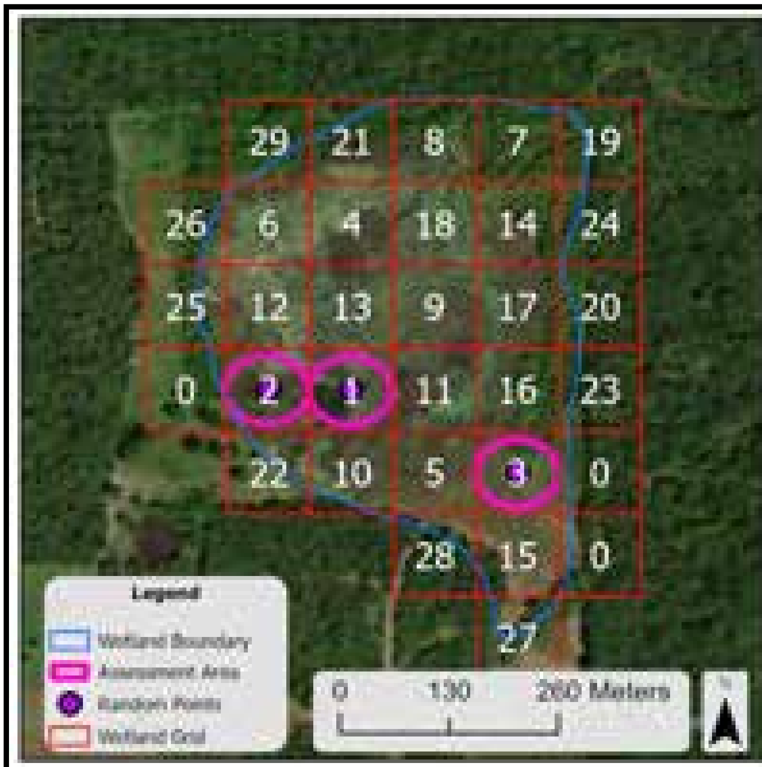


Fig 17. Large wetland (~17 ha) that was gridded using the generate tessellation tool in ArcGIS (6,400 sqm squares). Grids were then randomly assigned a number, with first priority given to grids with at least 0.5 ha of wetland area (Grids 1– 18). Grids 19-29 were then randomly assigned to divisions with less than 0.5 ha of wetland area. Grids assigned a 0 were removed because the wetland area present was <0.1 ha. Standard AAs were generated for grids 1, 2, and 3 because a minimum of 3 AAs would be assessed. Additional AAs could be generated subsequently if a completion criterion was not met..

Assessment Area Creation: Site-Specific Assessment

Additional notes on assessing pre-restoration and post-restoration conditions:

OKRAM can be used to evaluate the condition of project areas proposed for restoration. Often pre-restoration conditions will be assessed at sites that no longer maintain wetland hydrology, vegetation and/or soils. Additionally, post-restoration assessment may occur in upland areas, where restoration is unsuccessful.

When OKRAM is applied at non-wetland sites, an accurate project boundary is critical. Random points and AAs are then generated within project boundaries (Fig. 18). Follow the guidance for AA creation for Site-Specific Assessment starting on page 13.

However, **a Valid AA to assess pre– or post-restoration conditions has the following requirements**:

1. Contains only one HGM class. However, multiple HGM subclasses of the same class are acceptable within one AA (e.g., In-Channel and Floodplain Non-Perennial subclasses from the Riverine class),
2. Contains 90% project area proposed for restoration, and
3. Does not overlap any other AAs

Subsequently, AAs may need to be adjusted following the guidelines in this document (page 18), using the above criteria for a valid AA.

Each time a specific project is assessed, new AAs should be randomly generated. For example, for pre-restoration condition, AAs will be randomly generated independently from post-restoration AAs.

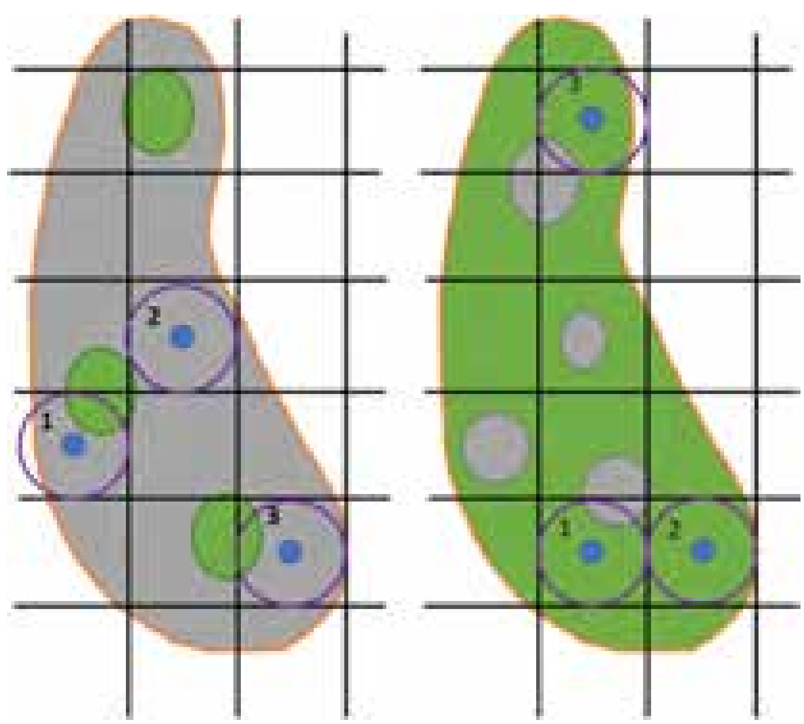


Fig 18. AA creation for pre-restoration (left) and post-restoration (right). Project area boundary is denoted with orange lines. Upland (non-wetland) areas are denoted in gray and wetland areas are denoted in green. Project area is greater than 1.5 ha so it is systematically divided and the first 3 AAs (purple circles) are assigned randomly . Pre– and post–restoration AAs may include any amount of upland habitat as long as it was proposed for restoration. Pre– and post-restoration AAs are randomly generated independently.

Assessment Area Creation: Site-Specific Assessment

Fig 19. Flow chart for OKRAM AA creation for Site-Specific assessments of wetland condition . For pre– and post–restoration assessment replace all instances of the word "wetland" above with the words "project boundary".

Assessment Area Adjustment

Step 1:

Remotely generated AAs may be inaccurate. If the standard circular AA is not valid (≥10% upland and water deeper than 1 m collectively, or 2 HGM classes), the AA needs to be moved (Figs. 20 and 21).

The first preference is to move the point the minimum distance to create a valid 40-m circular AA that contains the point. The maximum distance the point should ever be moved is 60 m.

The point DOES NOT need to be at the center of the new AA. It is therefore acceptable to keep the point in the same location and shift the location of the circular AA, as long as it includes the original point and is valid (See Figure 21(left)). If the point cannot be moved ≤ 60 m to create a valid 40 m-radius circular AA, continue to Step 2.

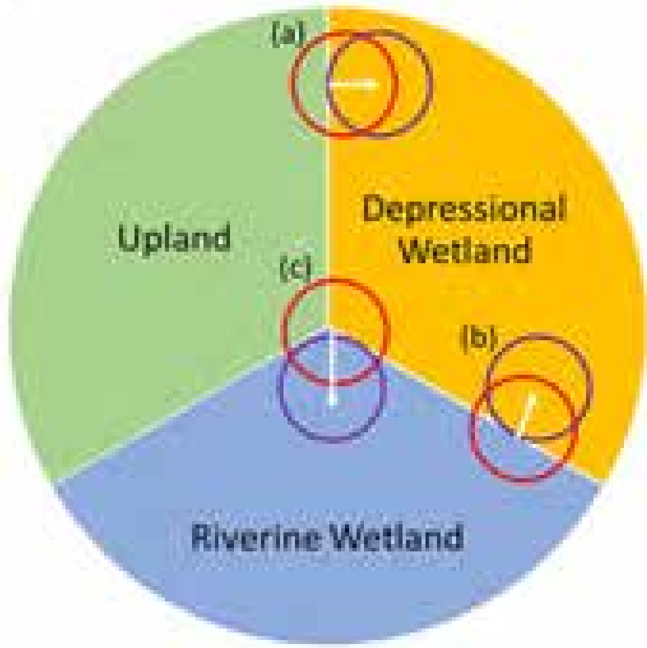


Fig 20. Conceptual diagram indicating how AAs should be shifted in the field. Red circles indicate original AA, purple circles are shifted AAs and white arrows indicate the direction the AA is moved. (a) AA includes 30 percent upland and is shifted to include only depressional wetland. (b) AA includes 35% Riverine Wetland and 65 percent Depressional Wetland and is shifted to include only Depressional Wetland. (C) Includes 30% upland, 30% Depressional Wetland and 40% Riverine Wetland and is shifted to only include Riverine Wetland.

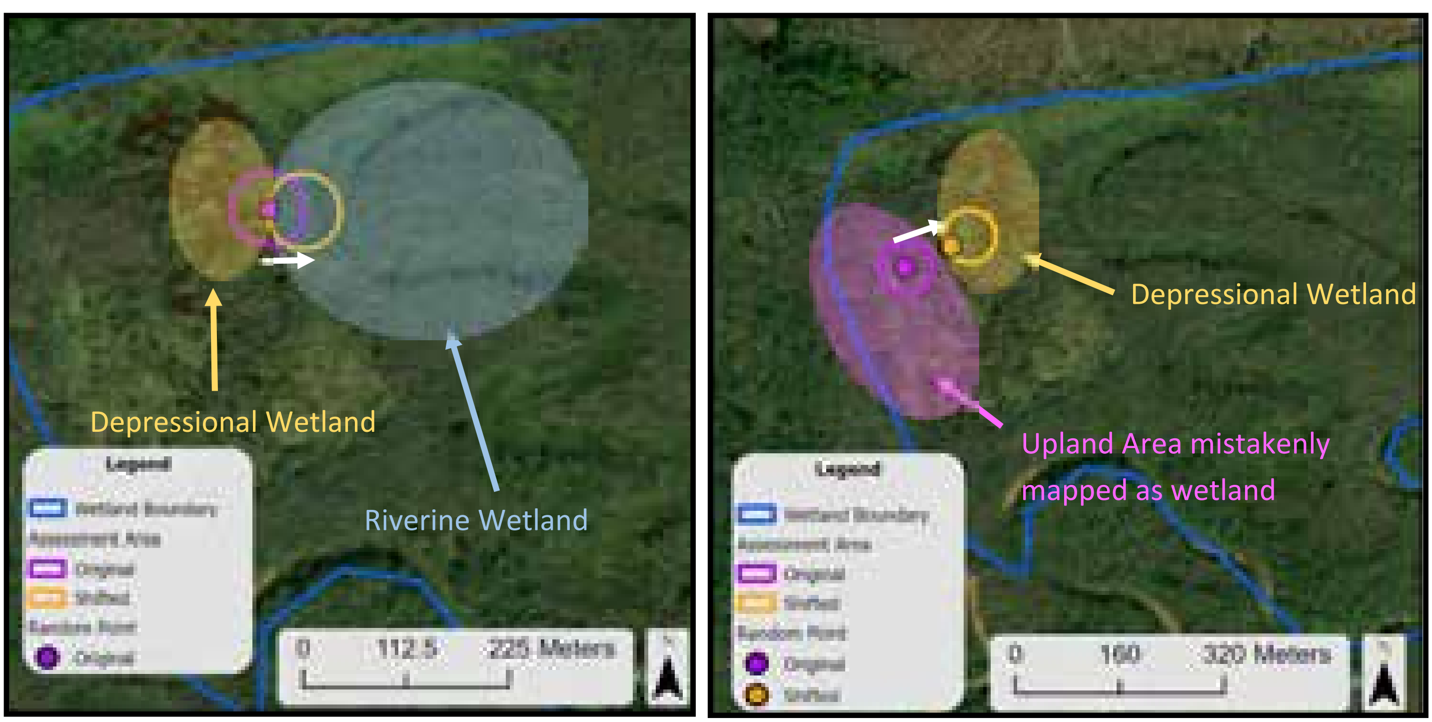


Fig 21. Step 1: Point shifted minimum distance (0 m) to create a new standard AA that contains one HGM class (left) and point shifted minimum distance (60 m) to create a new standard AA that includes no more than 10% upland (right). White arrows denote the direction the AA is shifted.

Assessment Area Adjustment

Step 2:

If the shape of the wetland does not allow for the placement of a Standard AA (e.g., long narrow wetland or small wetlands) within 60 m of the random point, the AA shape may be adjusted (Fig. 22). Again, the maximum distance a point should ever be moved is 60 m.

If the contiguous wetland area is ≥0.5 ha, create a polygon AA, taking care to minimize the distance the point is moved. Preference is given to rectangular AAs if possible, but irregular shapes are acceptable, if needed.

If there is contiguous wetland area within 60 m of the point that is <0.5 ha, create a site-boundary AA.

For Ambient Monitoring, if the point cannot be moved to a wetland area within 60 m, do not assess.

For Site-Specific Monitoring, if the point cannot be moved to a wetland with 60 m, revise site boundaries and generate new random points and AAs.

Fig 22. Step 2: Narrow wetland with an average 30 meter width, where a 40-m radius circular AA will not fit (top and bottom right). A 30-meter wide polygon, 166 meters long is created to retain a 0.5 ha. A polygon AA can be created that contains the original point, which minimizes the distance the point is moved (top right). Site boundary AA is used on a wetland that is smaller than 0.5 ha (bottom left).

Assessment Area Adjustment

Fig 23. Flow chart for generating and adjusting AAs for OKRAM application at wetlands. If the purpose of the assessment is to evaluate pre– or post-restoration conditions, replace all instances of the word "wetland" with the words "project area".

Site Description

Recording general site information is important to document personnel involved, reason for the assessment and wetland classification to ensure the usage of appropriate metrics. The Site Description form can be found in Figure 24 and should be used to characterize the HGM class and subclasses present within the wetland. Each AA should only include one HGM Class but may include multiple subclasses. When multiple assessment areas are needed, each AA should be given a unique ID (Assessment Area ID), and separate OKRAM assessments should be completed for each AA. Each AA beyond the first, should have Additional AA Description forms completed.

Site Description							
Site Name							
Date of Assessment							
Assessor Name(s)							
Assessor Affiliation(s)							
Location Information							
Site Latitude							
Site Longitude							
Coordinate System							
Level III Omernik Ecoregion							
Directions/Access Notes							
Assessment Area Information							
Size of Wetland							
# of Assessment Areas							
Assessment Area ID		**AA Type**			**AA size**		
Reason for Assessment							
HGM Classification (circle one class and any relevant subclasses)							
HGM Class	**Depression**		**Flat**	**Slope**	**Lacustrine**		**Riverine**
Regional Subclass	*Closed Impounded*		*Hardwood*	*Headwater*	*Disconnected Oxbow*		*Connected Oxbow*
	Open Impounded			*Low-gradient*	*Man-made Lacustrine*		*Beaver Complex*
	Groundwater						*In-Channel*
	Open Surface Water						*Floodplain (non-perennial)*
	Closed Surface Water						*Floodplain (upper perennial)*
							Floodplain (lower perennial)
Additional Site Characteristics (circle dominant condition)							
Hydrologic Condition at time of assessment	Ponded/inundated		Saturated Soil (no surface water)				Dry
Hydroperiod	Temporary *(inundated for <1 month)*		Seasonal *(inundated for extended periods of growing season)*		Semi-permanent/ Permanent *(inundated except during drought years)*		
Dominant Vegetation	Forested	Scrub/Shrub	Emergent	Submergent/ Floating Leaved			Unvegetated
Management	Unmanaged		Agriculture	Stormwater	Water treatment	Water supply	Widllife
Site Notes							

Fig 24. Site Description Form

Site Description

Descriptions of the fields recorded on the Site Description form are provided below. Italicized fields are recorded again for each additional AA in the Additional AA Description form:

General Information

Site Name: *A unique identifier created for the site.*

Date of Assessment*: The date the field portion of the assessment is completed.*

Assessor(s) Names: List all personnel involved, with the project lead first.

Assessor Affiliation(s): List all affiliations of all personnel involved, with the project lead affiliation first.

Location Information

Site Latitude*: The latitude of the randomly generated point for the AA, after any adjustments have been made in the field.*

Site Longitude*: The longitude of the randomly generated point for the AA, after any adjustments have been made in the field.*

Coordinate System: The coordinate system of the Site Latitude and Site Longitude.

Level III Omernik Ecoregion: The Level III Omernik Ecoregion where the site occurs

(https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/ok/ok_eco_lg.pdf).

Directions/Access Notes: Any relevant information regarding how to access site, and any potential access obstacles.

Assessment Area Information

Size of the Wetland: The approximate size of the contiguous wetland area that contains the AA(s).

# of Assessment Areas: The number of AAs needed to complete the assessment.

Assessment Area ID*: A sequential number, starting with 1, assigned to all AAs that are assessed at a site.*

AA Type*: The type of AA utilized (i.e., Standard, Polygon or Site-Boundary).*

AA Size*: The size of the AA in hectares.*

Reason for assessment: The purpose of the assessment. Examples include ambient monitoring, impact assessment, pre-restoration condition assessment etc.

HGM Classification

HGM Class*: Circle the HGM class within the AA.*

Regional Subclass*: Circle all regional subclasses within the AA.*

Additional Site Characteristics:

Hydrologic Condition*: Circle the dominant hydrologic condition at the time of assessment.*

Hydroperiod*: Circle the presumed hydroperiod using any available evidence (e.g., NWI Cowardin classification, landscape position, vegetation and soils).*

Vegetation*: Circle the dominant vegetation class. Starting with the tree layer (forested) circle the vegetation type where a cumulative 30% cover has been reached. For example, if a wetland had 20% tree cover and 10% shrub cover, Scrub/Shrub would be circled.*

Management*: Circle the primary management type for the AA.*

Metric 1a. Hydroperiod (Depressional and Riverine)

Background: Hydroperiod refers to the duration and frequency of inundation. Deviation from natural conditions can obviously impact the hydrologic functions that wetlands provide such as flood abatement, water storage and groundwater recharge. However, deviation can also alter biogeochemical processes and biological communities (Mitsch and Gosselink 2007).

Assessment Methods: The hydroperiod metric is scored by assessing the severity and areal extent of hydrologic stress that will cause the duration and frequency of inundation to shift away from reference conditions. Some common hydroperiod stressors include water pumping into or out of a wetland, sedimentation resulting in basin volume loss, and drainage ditches.

Step 1:

In the office, mark potential hydroperiod stressors that occur within 500 meters of the AA on aerial imagery for further inspection in the field (Fig. 25).

Data Processing Tips:

Use the buffer tool in ArcMap to create a 500 m boundary around the AA to review for hydroperiod alterations.

Drainage ditches and excavation are the primary hydroperiod stressor that will be visible from aerial imagery.

High resolution LiDAR imagery can be useful for identifying ditches (Fig. 26) and excavation (Fig. 27), and can even be processed using standard protocols to aid in ditch visualization (Vaughn 2017).

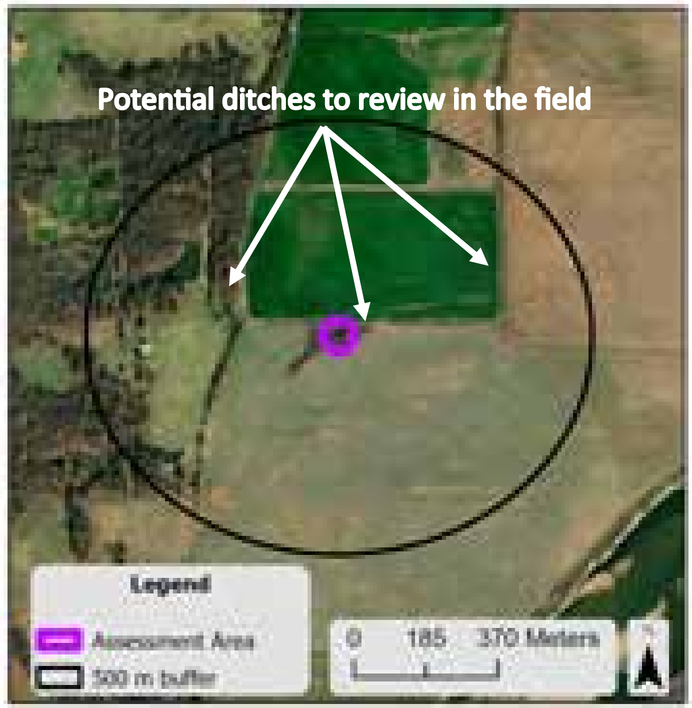


Fig 25 Step 1– Identify potential hydroperiod stressors

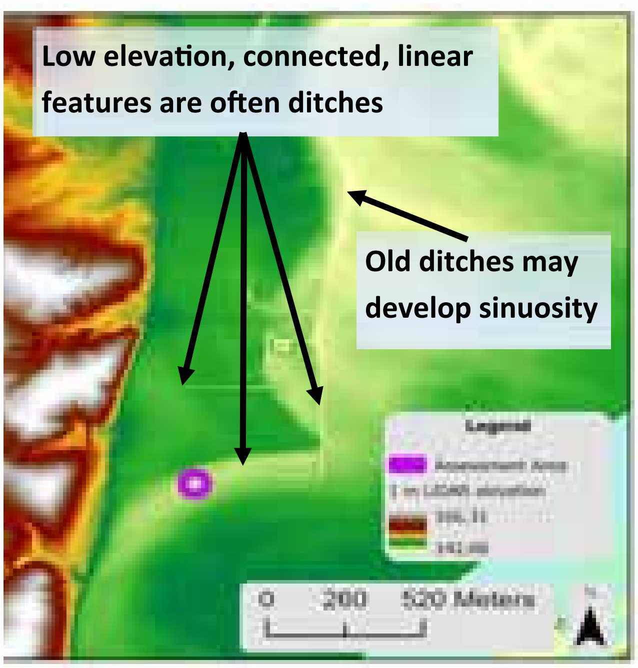


Fig 26. High resolution LiDAR elevation data can make identification of ditches easier.

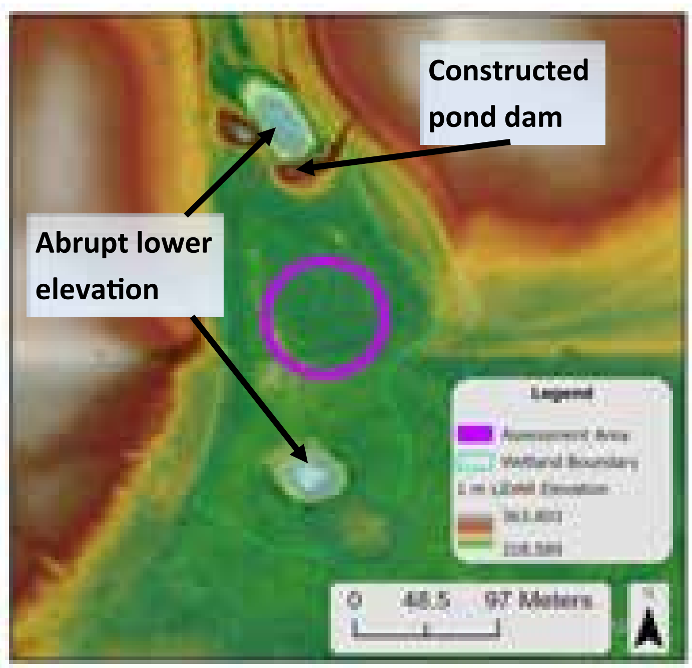


Fig 27 Abrupt changes in elevations with ponded water within a wetland may indicate excavation.

Metric 1a. Hydroperiod (Depressional and Riverine)

Step 2:

In the field, confirm hydroperiod stressors identified in the office (Fig. 28), as well as any other hydroperiod stressors, matching the alteration to the indicator and the severity from Table 1. Annotate an aerial image with the areal extent of impact from all identified indicators.

Data Processing Tips:

The areal extent of impact will not necessarily match the physical extent of the indicator. For example, a ditch occupying 2% of the AA, or even falling outside the AA, will likely impact 100% of the AA. In most cases, hydroperiod stressors will impact the entirety of the AA. Examples of hydroperiod stressors that impact a portion of the AA are presented in Figure 33.

If potential hydroperiod stressors within 500 m are inaccessible (e.g., access restrictions, difficult terrain), impact may be inferred based on aerial imagery and best professional judgment.

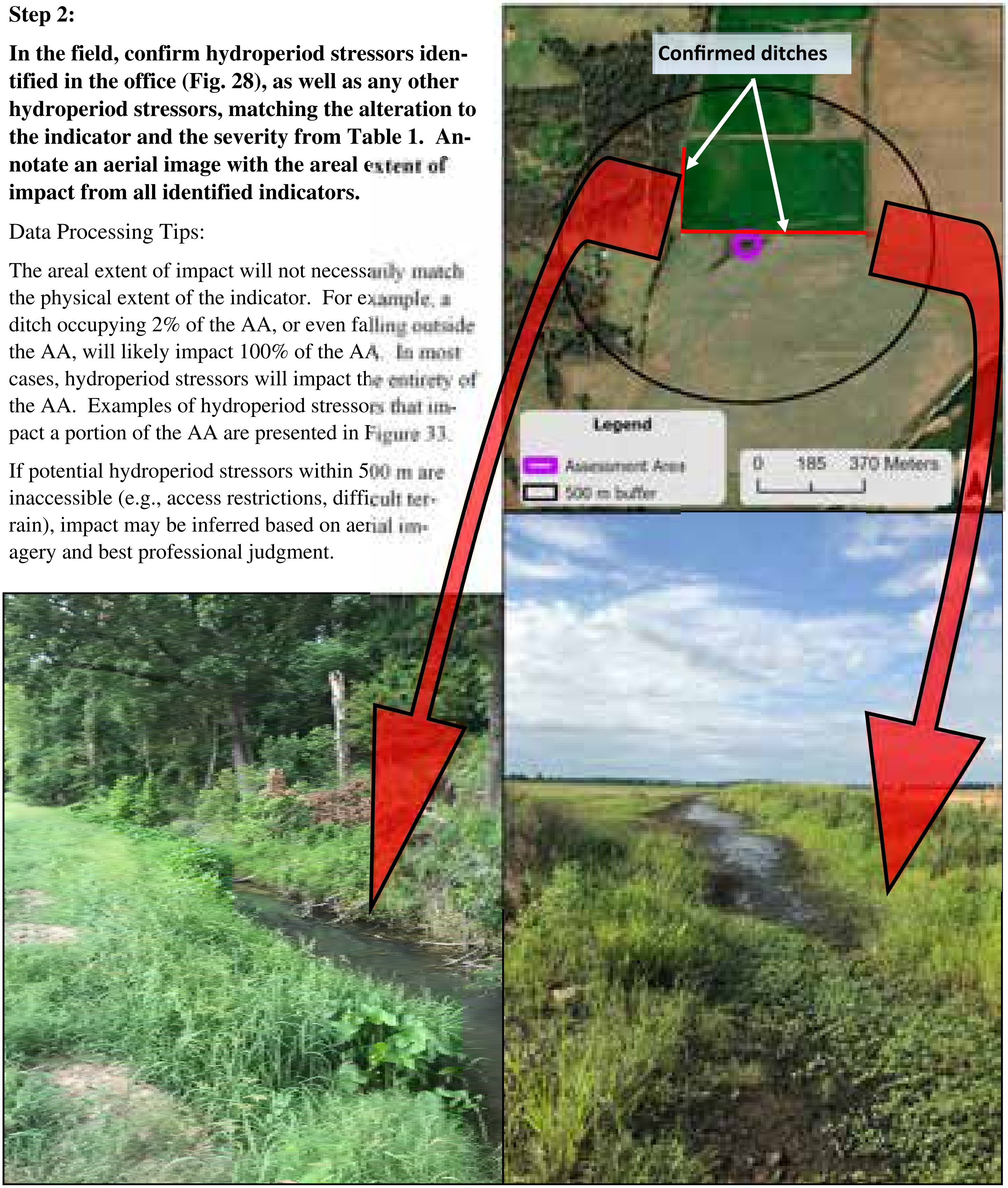


Fig 28. Step 2– Confirm and identify all hydroperiod stressors within 500 meters of AA and annotate aerial imagery.

Metric 1a. Hydroperiod (Depressional and Riverine)

Table 1. Indicators of hydroperiod alteration and severity descriptions

	Severity			
Indicators of altered hydroperiod	**Minor**	**Moderate**	**Major**	**Complete Loss**
1. Fill/sedimentation	Silt covered vegetation, extremely turbid water, AND/OR rills on adjacent uplands	Sediment splays, completely buried vegetation, AND/OR silt deposits around trees	Silt deposits or fill that have greatly reduced wetland volume	Complete loss of basin
2. Water pumping into our out of the wetland	Water level is properly manipulated for wetland management activities including slow, cool-season drawdowns. Desirable annual moist soil plants present.	Water is pumped out of the wetland for agricultural or other human uses OR water level is poorly manipulated for wetland management activities including rapid, warm-season drawdowns. Undesirable weedy plants present (e.g. cocklebur).	n/a	n/a
3. Water control structures	Water level is properly manipulated for wetland management activities including slow, cool-season drawdowns (desirable annual moist soil plants present) OR water is passively managed to mimic natural wetland filling and drawdown.	Water level is poorly manipulated for wetland management activities including rapid, warm-season drawdowns. Undesirable weedy plants present (e.g. cocklebur).	Water control structures are derelict or no longer maintained, resulting in substantial lengthening or shortening of hydroperiod.	Water control structures are derelict or no longer maintained, resulting in complete wetland drainage or permanent deep water.
4. Culverts, discharges, ditches or tile drains in to or out of the wetland	Old drainages present that appear to have minor influences on current wetland hydrology (e.g. old ditches that have sedimented in or tile drains that have been damaged)	Water drained from wetland only during high water events AND/OR water enters wetland from culverts, diversions or ditches only during large storm events AND/OR water is consistently discharged into wetland from irrigation (e.g., agricultural or residential).	Water is drained from wetland at all times of the year but still retains wetland hydrology AND/OR water from culvert, diversion, irrigation or ditch is the dominant water source for the wetland.	Wetland completely dried OR Wetland completed converted to permanent deepwater
5. Beaver dam removal (excludes maintenance of restoration/ mitigation sites and activity in control structures/ infrastructure)	Beaver activity not a major driver of wetland hydrology and removal caused minimal changes in area, depth and duration of ponding.	n/a	Beaver activity was the primary source of wetland hydrology and removal caused major changes in area, depth and duration of ponding.	Wetland completely dried as a result of dam removal.
6. Excavation/ Dredging/ Mining/ Impoundment (excludes sediment removal to restore hydrology resulting from human-induced sedimentation)	Small areas of excavation within the AA to deepen water for habitat improvement that has minimal impact on the hydrology of the wetland.	n/a	Wetland excavated or impounded but still retains wetland hydrology. Hydroperiod substantially lengthened.	Wetland converted to permanent deepwater OR center of the wetland excavated to permanently dry remainder or wetland.

Metric 1a. Hydroperiod (Depressional and Riverine)

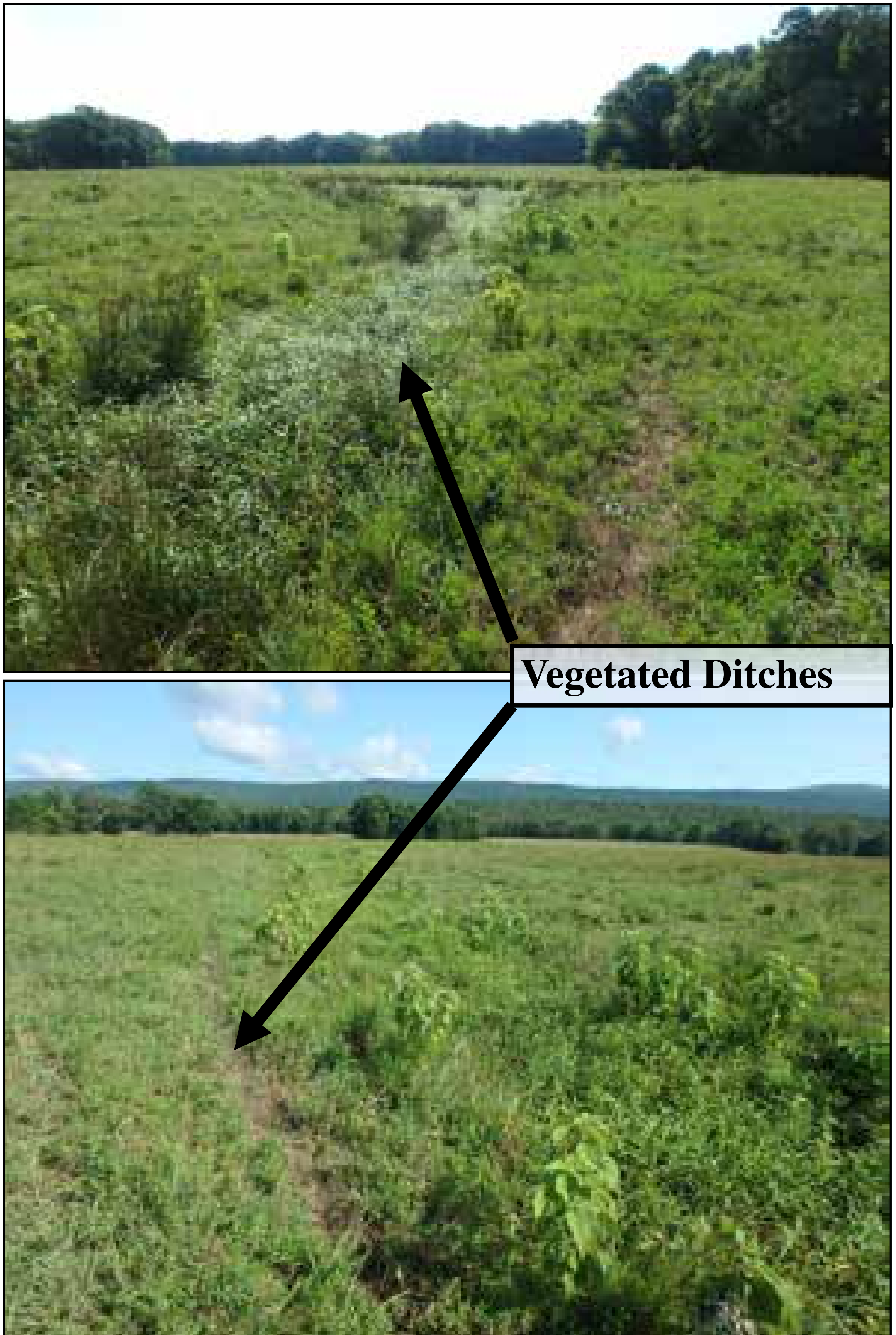


Fig 29. Ditches are one of the most common hydroperiod stressors. Old Ditches may fill in over time and become vegetated.

Metric 1a. Hydroperiod (Depressional and Riverine)

Fig 30. Common stressors that increase hydroperiod: active culvert causing unnatural patterns of filling–major (top left), old pipe culvert that fills wetland during large storm events–moderate (top right), wetland filled by center pivot irrigation (CP) with CP tire track–major (bottom)

Metric 1a. Hydroperiod (Depressional and Riverine)

Fig 31. Common stressors that decrease hydroperiod: center of wetland is excavated, which dries remaining wetland area–major (top left), water pumping out of the wetland for agricultural use–moderate (top right), rills on adjacent uplands–minor (bottom left), sedimentation from surrounding tillage has filled in basin volume–major (bottom right)

Metric 1a. Hydroperiod (Depressional and Riverine)

Fig 32. Common water control structures used for wetland creation and hydrologic manipulation. Water control structures are a minor stressor if wetlands are managed well, and a moderate stressor if they are poorly managed.

Fig 33. While most hydroperiod stressor indicators impact the entire AA, above are examples of stressors that impact portions of the AA. Fill material from oil and gas exploration placed in a small portion of a depressional wetland –major stressor with 20% areal extent (left). Sediment covered vegetation at channel input at downstream edge of AA–moderate stressor with 30% areal extent (right).

Metric 1a. Hydroperiod (Depressional and Riverine)

Step 3:

If no hydroperiod stressors are identified, select the "No Indicators of Altered Hydroperiod Present" button. This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if indicators of alteration are present, ensure the "Hydroperiod is impacted" button is selected (Fig. 34) and continue on to Step 4.

Step 4:

Record the percentage (0-100) of the AA impacted by each indicator in the appropriate severity column (Fig. 34). Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore the total percent cover of indicators cannot exceed 100. The metric is autocalculated in the worksheet.

Data Processing Tips:

Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore, the total percent cover of indicators cannot exceed 100.

The metric is autocalculated in the worksheet but can be calculated with he following equation:

$$\text{Hydroperiod Score} = 1-((MiE * 0.25) + (MoE * 0.5) + (MaE * 0.75) + CL)$$

Where, MiE= extent of minor stressor indicators, MoE = extent of moderate stressor indicators, MaE= extent of major stressor indicators, and CL = extent of complete loss of wetland function from stressors.

Completing the description fields in the worksheet for indicators is helpful but not required.

◉ Hydroperiod is impacted	○ No Indicators of Altered Hydroperiod Present			○ AA is not a Wetland	
Indicators of Altered Hydroperiod	**Minor**	**Moderate**	**Major**	**Complete Loss**	**Indicator Description**
Fill/sedimentation					
Water being pumped into or out of the wetland					
Water control structures					
Culverts, discharges, ditches or tile drains into our out of the wetland			100		AA ditched for improved agricultural production
Beaver dam removal					
Excavation/Dredging/Mining/ Impoundment					
TOTAL IMPACTED AREA			**100**		
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	**1**	
SEVERITY WEIGHTED AREA			**75**		
METRIC SCORE 1A					**0.25**

Fig 34. Steps 3 and 4– Record hydroperiod stressor indicators in the worksheet. The data provided are based on the example hydroperiod stressors presented in steps 1 and 2.

Metric 1b. Water Source (Depressional)

Background: The water source metric assesses the degree of landscape alteration in the watershed (i.e., catchment) surrounding the wetland. Land-use change from native vegetation to impervious surface and agricultural land can alter the movement of water from the uplands into a wetland ecosystem. Impervious surfaces prevent the infiltration of water into the soil and can create "flashier" drainage patterns, increasing the frequency of inundation in aquatic systems and wetlands (Scheuler 1992, Allan 2004). Agricultural land, when irrigated can increase the surface water present in a watershed and also increase the movement of water from uplands into wetlands. Furthermore, rain events during post-harvest when agricultural lands are barren can alter the ability of uplands to retain precipitation through decreased plant interception and uptake (Euliss and Mushet 1996).

Assessment Methods: The water source metric is scored by quantifying the amount of anthropogenic alteration to the land-use in the watershed of the wetland.

Step 1:

In the office, delineate the catchment for the entire wetland that contains the Assessment Area (Fig. 35).

Data Processing Tips:

Create a polygon shapefile in ArcMap for digitizing the catchment.

The preferred method for catchment delineation is through visual interpretation of USGS topographic maps. Mark the lowest point or outlet of the study wetland, then mark all of the highest locations around the wetland. Starting with the wetland outlet, systematically connect all the highest points, crossing the contours perpendicularly.

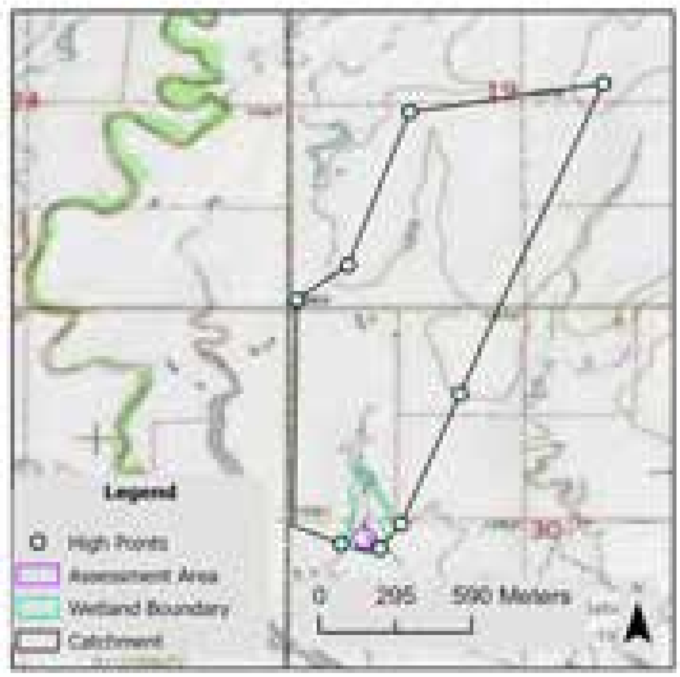


Fig 35. Step 1– Delineate the catchment.

Step 2:

In the office, identify indicators of altered water source within the catchment (Fig. 36).

Data Processing Tips:

Aerial imagery and the National Land Cover Dataset (NLCD) are helpful to identify indicators of altered water source.

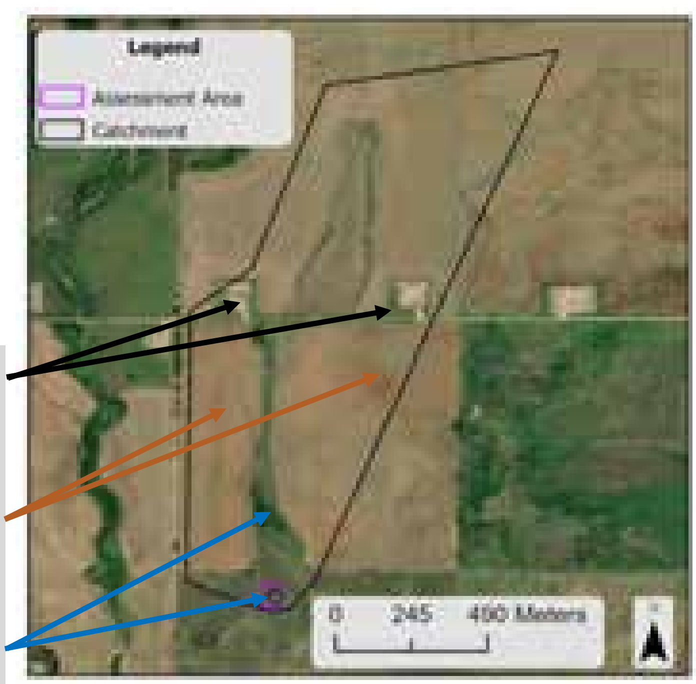


Fig 36. Step 2– Identify indicators of altered water source.

Metric 1b. Water Source (Depressional)

Step 3:

Where possible, confirm indicators of altered water source in the field (Fig. 37).

Data Processing Tips:

Consider distance, access restrictions and confidence in desktop indicator identification. Places of high uncertainty with easy access should be visited and photographed. Metric calculation can be adjusted upon return to the office if field verification identifies differences from the desktop metric application.

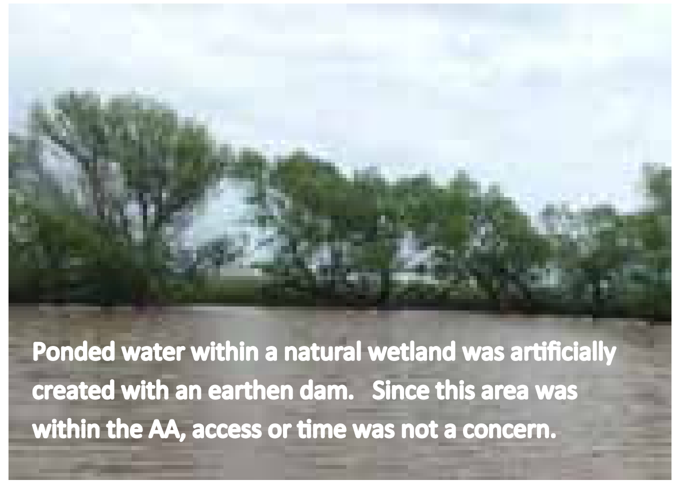


Fig 37. Step 3– Confirm indicators in field where feasible

Step 4:

In the Water Source worksheet, record the percent cover (0-100) of each indicator of altered water source identified within the catchment (Fig. 38). If the catchment's water source is completely unaltered, select the box labeled, "No Indicators of Altered Water Source Present". The metric is autocalculated in the worksheet.

Data Processing Tips:

Percent cover for each indicator of water source is calculated by dividing the total area of that indicator within the catchment by the total catchment area. The metric is scored by subtracting the sum of all severity weighted covers from 1, using the following equation:

$$Water\ Source = 1 - \sum_{1}^{i}(C_i * W_i)$$

Where, C_i is the cover stressor i and W_i is the severity weight for cover i.

Because some indicators have severity weights greater than 1, metric scores less than 0 are possible. Scores less than 0 are automatically converted to 0.

Completing the description fields in the worksheet for indicators is helpful but not required.

No Indicators of Altered Water Source Present: ☐			
Catchment Indicators of altered water source	**% Cover**	**Severity Multiplier**	**Description**
Impervious surface (paved roads and ditches, parking lots, structures and roof tops, and compacted gravel and dirt roads)	9	1.5	
Irrigated agricultural land (center pivot, ditch, flood etc.)		1.5	
Dryland agricultural land that is tilled	82	0.5	
Woody encroachment (e.g., eastern red cedar (*Juniperus virginiana*) and salt cedar (*Tamarix sp.*))		0.5	
Impounded water	0.25	2	
Topographic alteration (leveling, excavation, mining)		1	
Total Altered Cover			55
METRIC SCORE 1b			0.45

Fig 38. Step 4– Record the percent cover of each indicator of altered water source. The data provided are based on the example presented in steps 1 through 3.

Metric 1b. Water Source (Depressional)

Notes on catchment delineation:

1. In extremely flat landscapes it can be a challenge to identify topographic breaks between catchments. Additionally, distinguishing isolated basins from upstream basins that are connected via outflows is difficult. Digital Elevation Models (DEMs) may provide an additional line of evidence to help delineate the most accurate catchment boundary (Fig. 39). However, OKRAM is designed to be a rapid assessment and utilizing best professional judgement within the constraints of the methods is expected.
2. To maximize consistency, topographic map delineation is the preferred method for catchment delineation. However, where topographic breaks can not be manually determined, watershed delineation tools in ArcMap may provide a viable alternative. However, in most cases, the boundaries and metric score should be similar regardless of method.

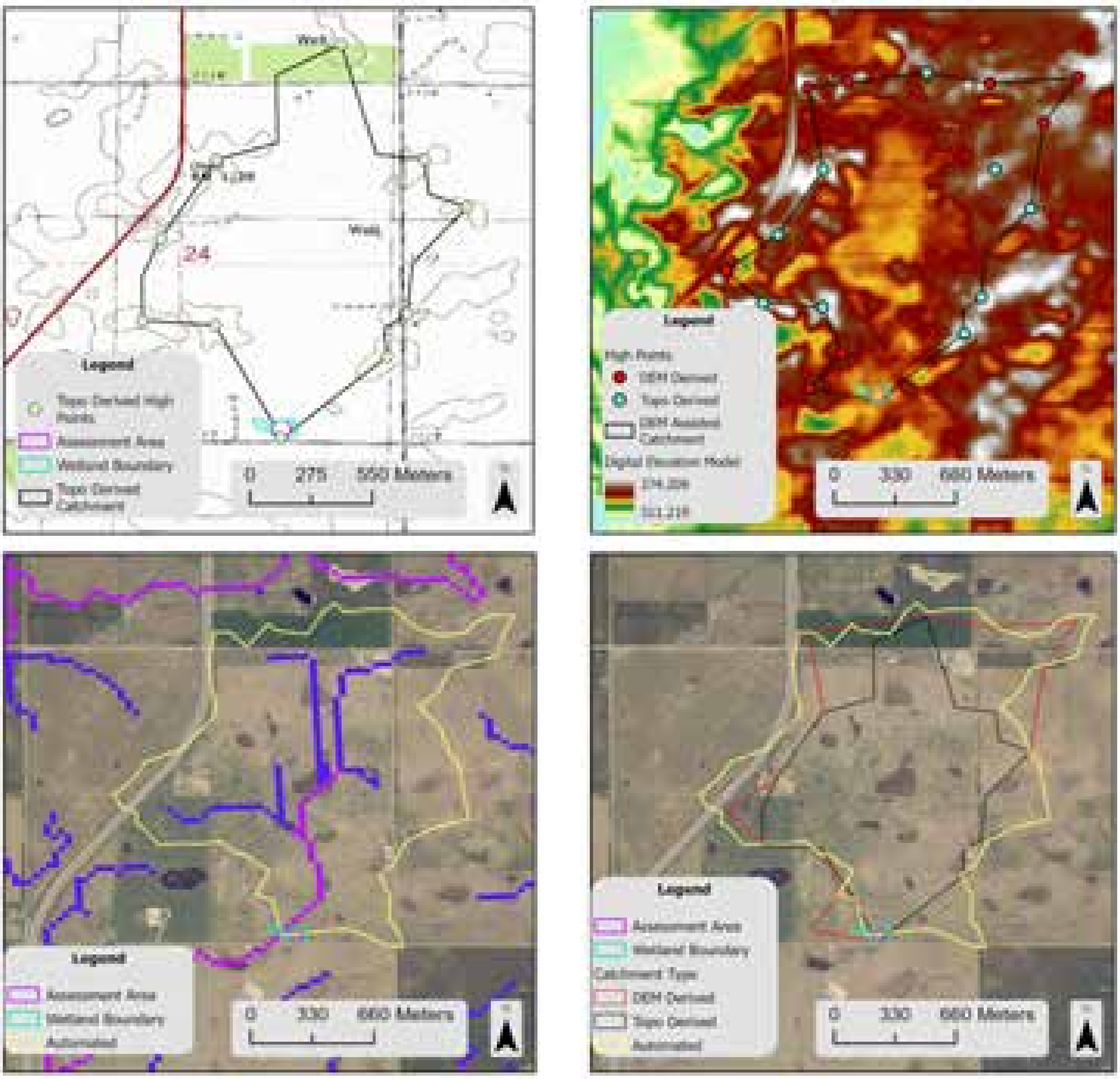


Fig 39. Comparison of manual and automated methods used to generate wetland catchment: Topographic map delineation (top left), DEM enhanced topographic delineation (top right), automated catchment in ArcMap (bottom left), and comparison of all boundary methods (bottom right). All watershed types received a score of 0 for the water source metric.

Metric 1b. Water Source (Riverine)

Background: The water source metric assesses the degree of landscape alteration in the watershed surrounding the wetland. Land-use change from native vegetation to impervious surface and agricultural land can alter the movement of water from the uplands into a wetland ecosystem. Impervious surfaces prevent the infiltration of water into the soil and can create "flashier" drainage patterns, increasing the frequency of inundation in aquatic systems and wetlands (Scheuler 1992, Allan 2004). Agricultural land, when irrigated can increase the surface water present in a watershed and also increase the movement of water from uplands into wetlands. Furthermore, rain events during post-harvest when agricultural lands are barren can alter the ability of uplands to retain precipitation through decreased plant interception and uptake (Euliss and Mushet 1996). Since the primary water source for riverine wetlands is overbank flooding, the water source metric for riverine wetlands includes presence of upstream and downstream impoundments. Upstream impoundments can impact riverine wetlands by reducing stream flow and thereby decreasing flooding potential for adjacent floodplain wetlands. Downstream impoundments can also impact riverine wetlands by slowing streamflow resulting in nearby backwaters.

Assessment Methods: The water source metric is scored by quantifying the amount of anthropogenic alteration to the land-use in the watershed of the wetland and determining distance to upstream and downstream impoundments.

Step 1:

In the office, identify the stream or the river that serves as the primary water source for the study wetland and follow it upstream. Record the distance (in meters) to the first upstream impoundment encountered in the 'Distance' field next to 'Upstream Impoundment' (Fig. 40). If no impoundment is reached within 100 km (of stream distance) or before reaching the headwaters of the stream, leave this field blank.

Data Processing Tips:

The distance to the upstream impoundment is generally the distance to the impounding feature (i.e., dam).

Stream distance can be measured by adding the length of relevant NHD segments or by manually estimating distance using the measurement tool in ArcMap.

The upstream impoundment score reduction is autopopulated in the worksheet based on the distance to the impoundment (Table 2).

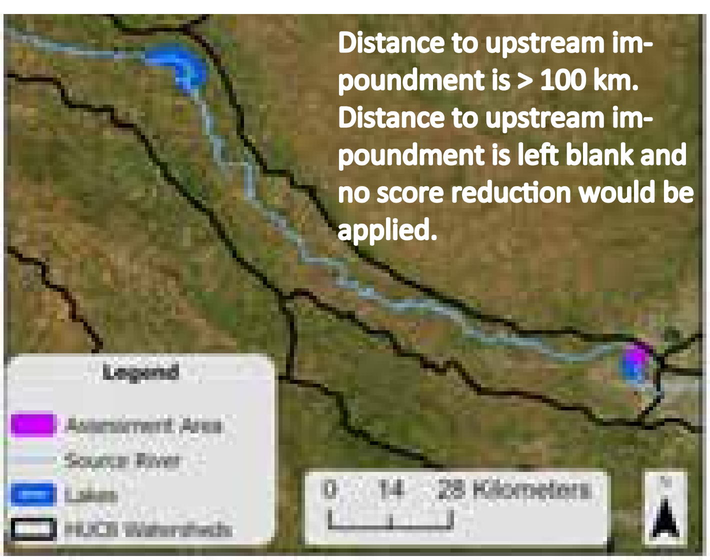


Fig 40. Step 1– Identify distance to upstream impoundment

Table 2. Score reduction based on distance to upstream or downstream impoundment

Distance	Score reduction
≤ 500 m	0.3
>500 m but ≤ 5 km	0.2
≥ 5 km but ≤ 100 km	0.1

Metric 1b. Water Source (Riverine)

Step 2:

In the office, follow the source river downstream. Record the distance (in meters) to the first downstream impoundment encountered in the 'Distance' field next to 'Downstream Impoundment' (Fig. 41). If no impoundment is reached within 100 km (of stream distance) or before reaching the downstream confluence (i.e., stream changes name), leave this field blank.

Data Processing Tips:

The distance to the downstream impoundment should be recorded to the first indicator of impounded water (e.g., channel widening, deeper water, or lack of flow).

The downstream impoundment score reduction is autopopulated in the worksheet based on the distance to the impoundment (Table 2).

Fig 41. Step 2– Identify Distance to Downstream Impoundment

Additional Notes on Steps 1 and 2

Watershed boundaries do not impact area of observation (Fig. 42).

If there is evidence of channel widening at downstream confluence, record distance to downstream confluence (Fig 43).

Fig 42. Upstream HUC8 does not impact score reduction.

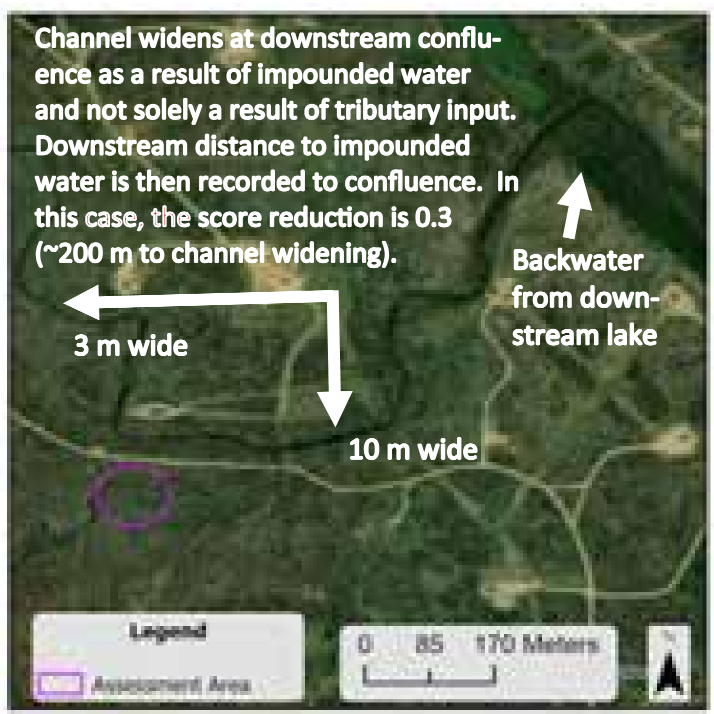


Fig 43. Channel widening at downstream confluence

Metric 1b. Water Source (Riverine)

Step 3:

In the office, delineate the catchment for the entire wetland that contains the AA (Fig. 44).

Data Processing Tips:

Create a polygon shapefile in ArcMap for digitizing the catchment.

The preferred method for catchment delineation is visual interpretation of USGS topographic maps and HUC 12 boundaries. Mark the lowest point or the outlet of the study wetland, then mark the highest locations around the wetland. Starting with the wetland outlet, systematically connect all the highest points, crossing the contours perpendicularly. When the HUC 12 boundary is encountered, utilize the watershed boundary to continue delineating the catchment.

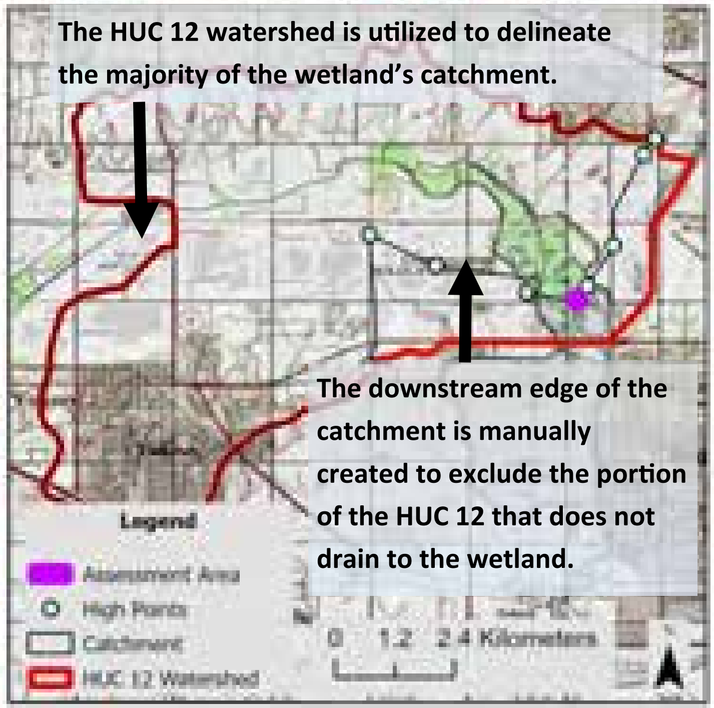


Fig 44. Step 3– Delineate the Catchment

Additional Notes on Step 3

If the HUC 12 boundary is encountered within 2 km upstream and the source river continues, delineate the entirety of the wetland's catchment within the next upstream HUC 12 as well (Fig. 45). This should only occur when the river at the output of the upstream HUC 12 is also the study wetland's source river.

Similar to depressional wetlands, in relatively flat landscapes, National Hydrography Dataset (NHD) flowlines, flow accumulation layers and digital elevation models can help delineate catchment boundaries. Where topographic breaks cannot be determined manually, watershed delineation tools in ArcMAP may provide a viable alternative. (Fig. 46).

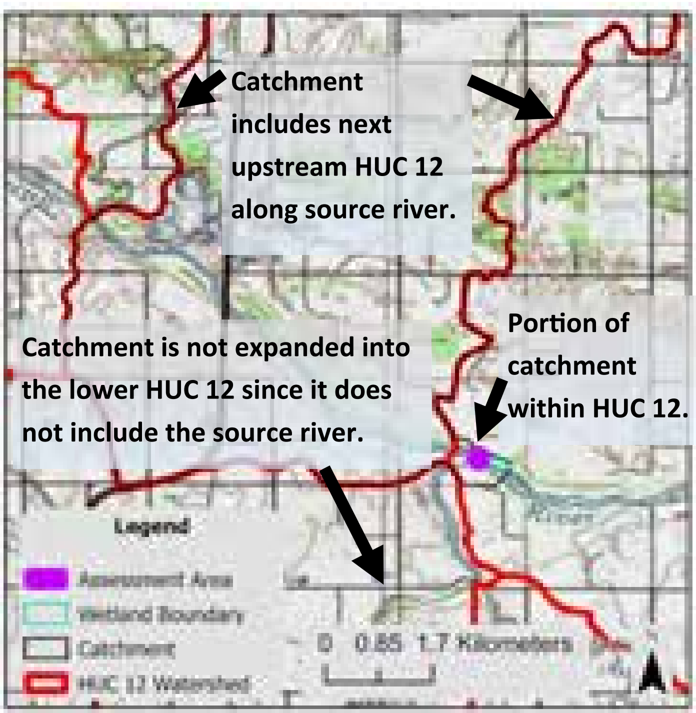


Fig 45. Wetland with 2 km of upstream HUC 12 boundary; catchment is expanded to upstream HUC12 of source river

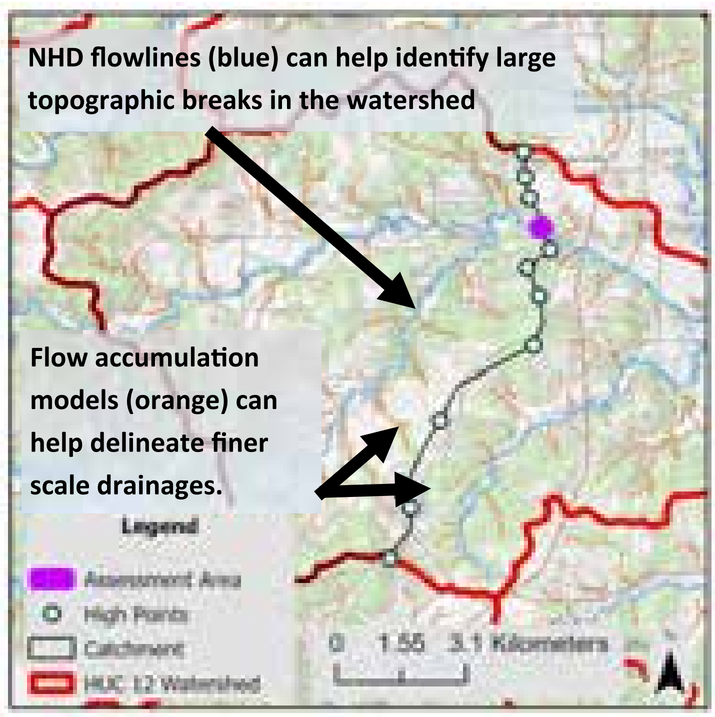


Fig 46. NHD and flow accumulation models can help delineate wetland catchment boundaries.

Metric 1b. Water Source (Riverine)

Step 4:

In the office, identify indicators of altered water source within the catchment (Fig. 47).

Data Processing Tips:

Aerial imagery and the National Land Cover Dataset (NLCD) are helpful to identify indicators of altered water source.

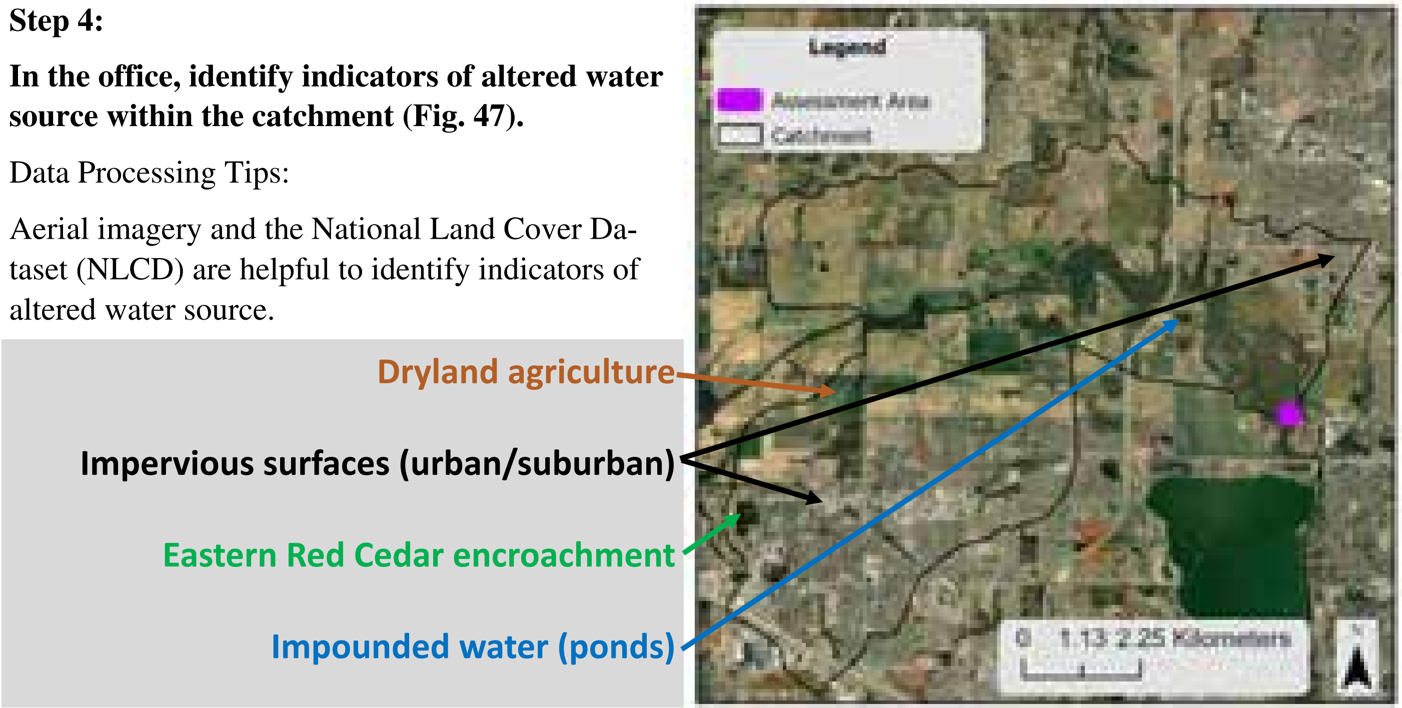


Fig 47. Step 4– Identify indicators of altered water source

Step 5:

Where possible, confirm indicators of altered water source in the field (Fig. 48).

Data Processing Tips:

Consider distance, access restrictions and confidence in desktop indicator identification. Places of high uncertainty with easy access should be visited and photographed. Metric calculation can be adjusted upon return to the office if field verification identifies differences from the desktop metric application.

Fig 48. Step 5– Confirm indicators of altered water source: Tilled crop field observed from road is an indicator of altered water source (left), but improved pasture identified observed from road is not an indicator of altered water source (right).

Metric 1b. Water Source (Riverine)

Step 6:

In the Water Source worksheet, record the percent cover (0-100) of each indicator of altered water source identified within the catchment (Fig. 49). If the catchment's water source is completely unaltered and there are no upstream or downstream impoundments, select the box labeled, "No Indicators of Altered Water Source Present". The metric is autocalculated in the worksheet.

Data Processing Tips:

Percent cover for each indicator of water source is calculated by dividing the total area of that indicator within the catchment by the total catchment area.

The metric is autocalculated in the Water Source Worksheet but can be calculated by subtracting impoundment score reductions and the sum of all severity weighted cover types from Step 1, using the following equation:

$$Water\ Source = (1 - UsI - DsI) - \left(\left(\sum_{i}^{i} \frac{(C_i * W_i)}{100}\right) * (1 - UsI - DsI)\right)$$

Where, *UsI*= upstream impoundment score reduction (according to table 3), *DsI*= downstream impoundment score reduction (according to table 3), C_i is the cover stressor *i* and W_i is the severity weight for cover *i.*

Because some indicators have severity weights greater than 1, metric scores less than 0 are possible. Scores less than 0 are automatically converted to 0.

Completing the description fields in the worksheet for indicators is helpful but not required.

No Indicators of Altered Water Source Present: ☐			
HUC 8 Indicators of altered water source	**Distance (m)**		**Score Reduction**
Upstream Impoundment			0
Downstream Impoundment	0		0.3
Catchment Indicators of altered water source	**% Cover**	**Severity Multiplier**	**Description**
Impervious surface (paved roads and ditches, parking lots, structures and roof tops, and compacted gravel and dirt roads)	35	1.5	
Irrigated agricultural land (center pivot, ditch, flood etc.)		1.5	
Dryland agricultural land that is tilled	10	0.5	
Woody encroachment (e.g. eastern red cedar (*Juniperus virginiana*) and salt cedar (*Tamarix* sp.))	0.25	0.5	
Impounded water	0.02	2	
Topographic alteration (leveling, excavation, mining)		1	
Total Altered Cover			57.67
METRIC SCORE 1b Alternate			**0.30**

Fig 49. Step 6– Record the percent cover of each indicator of altered water source. The data provided are based on the example presented in steps 1 through 5.

Metric 1c. Hydrologic Connectivity (Depressional and Riverine)

Background: Hydrologic connectivity refers to the ability of water to move between the wetland and adjacent ecosystems. The inability of water to leave a wetland can alter the depth of inundation which can stress the biotic communities present as well as alter the movement of materials such as sediment, nutrients, and detritus. Common barriers to hydrologic connectivity include road grades and levees.

Assessment Methods: The metric is scored by quantifying the percentage of the wetland boundary that has been altered.

Step 1:

On an aerial image, in the office, denote any potential barriers to hydrologic connectivity around the boundary of the wetland that contains the AA (Fig. 50). In larger wetlands, the assessment of the Hydrologic Connectivity metric should be restricted to the portion of the wetland within 500 meters of the AA boundary. In the field, confirm and identify any additional connectivity alterations (Fig. 51), and record barriers on the aerial imagery.

Data Processing Tips:

A preliminary assessment can be completed in the office in ArcMap, particularly in larger wetlands, so potential connectivity alterations can be targeted for inspection in the field (Fig 51).

In large wetlands where access to portions of the boundary is restricted, hydrologic connectivity alterations can be inferred from aerial imagery.

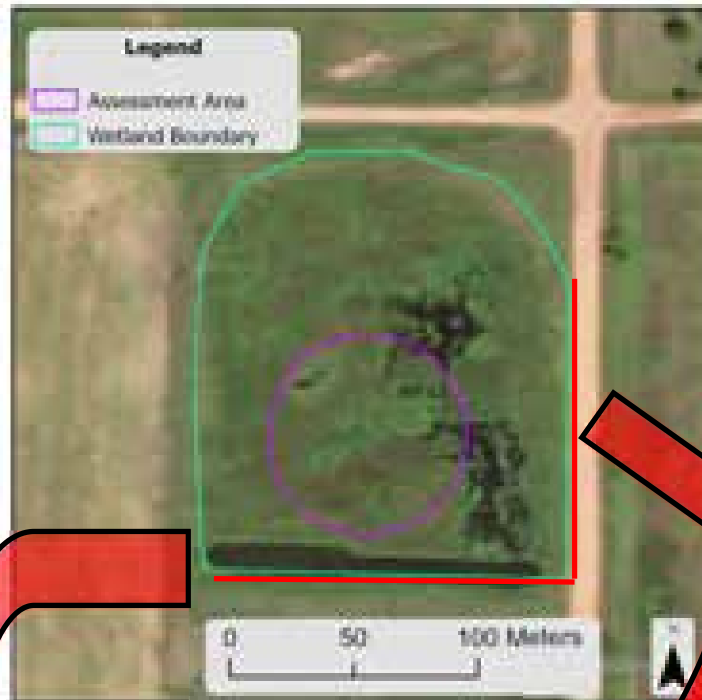


Fig 50. Step 1– Outline boundary of wetland where hydrologic connectivity is altered

Fig 51. Confirm and Identify Hydrologic connectivity alterations in the field

Metric 1c. Hydrologic Connectivity (Depressional and Riverine)

Step 2:

If no connectivity stressors are identified, select the "No Indicators of Altered Connectivity Present" button (Fig. 52). This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if indicators of alteration are present, ensure the "Connectivity is impacted" button is selected and continue on to Step 3.

Step 3:

Record on the worksheet the percentage (0-100) of the perimeter where hydrologic connectivity is impaired (Fig. 52).

Data Processing Tips:

Estimates of alteration percentage are most accurately calculated after returning to the office and using ArcMap by dividing the length of each alteration by the perimeter of the wetland.

The metric is autocalculated in the worksheet as a percentage of unimpacted wetland perimeter or (100– altered perimeter)/100.

Completing the description fields in the worksheet for indicators is helpful but not required.

◉ Connectivity is Impacted ○ No Indicators of Altered Connectivity Present ○ AA is not a Wetland

Indicators of altered connectivity	Perimeter Percentage	Description
Levees, Berms, Dams, Weirs, or other artificially steep grades	22	
Road Grades	23	
METRIC SCORE 1C		0.55

Fig 52. Step 2– Record the percentage of perimeter with altered hydrologic connectivity. The data provided are based on the example presented in step 1.

Additional notes on large wetlands:

In large wetlands, extend the boundary of the AA until the edge of the wetland is encountered or 500 meters is reached. Hydrologic connectivity alterations beyond 500 m from the AA boundary are not included in metric calculations (Fig. 53).

The 500 m limit beyond the AA for the hydrologic connectivity metric is established for both logistical (e.g., observation time) and functional (e.g., reduced impact of distant connectivity barriers) reasons.

The buffer tool in ArcMap can create a 500 m boundary around the AA, that can be intersected with the wetland boundary to identify the portion of the wetland that should be used for the hydrologic connectivity metric.

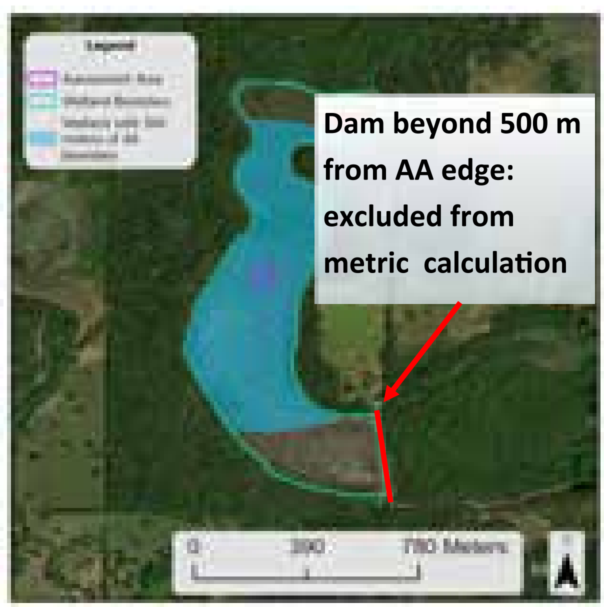


Fig 53. Entirety of large wetland not assessed for hydrologic connectivity

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Background: The excess nutrients and contaminants metric assesses the intensity and areal coverage of contaminant and excessive nutrient inputs to a wetland. Many wetlands, due to their low topographic position on the landscape are natural sinks for materials and nutrients from the surrounding uplands (Zedler and Kercher 2004). Wetlands naturally transform these nutrients through normal hydrologic processes that shift conditions from aerobic to anaerobic (Mitsch and Gosselink 2007). However, unnatural inputs of nutrients can overwhelm the capacity of wetlands to perform natural nutrient cycling processes and ultimately alter the chemistry of the system. This metric also assesses any other contaminant such as salt or petroleum products that may alter natural wetland processes.

Assessment Methods: The excess nutrient and contaminant metric is scored by assessing the severity and areal extent of stress that will cause the biogeochemical cycling to shift away from reference conditions. Common indicators of altered nutrient inputs are unnatural discharges, excessive algal growth and livestock/animal waste. Common indicators of other chemical contaminants include point source discharges, oil sheen and salt crust.

Step 1:

When in the field, outline on an aerial photograph all areas within the AA where nutrient cycling has been altered (Fig. 54), matching the alteration to the indicator and the severity from Table 3. Complete the same assessment, marking areas where chemical contaminants have been observed, matching the alteration to the indicator and the severity from Table 4.

Data Processing Tips:

The areal extent of impact will not necessarily match the areal extent of the stressor. For example, livestock waste covering 5% of the ground surface should be recorded for the area where cattle have access and utilize the wetland, which may be up to 100%.

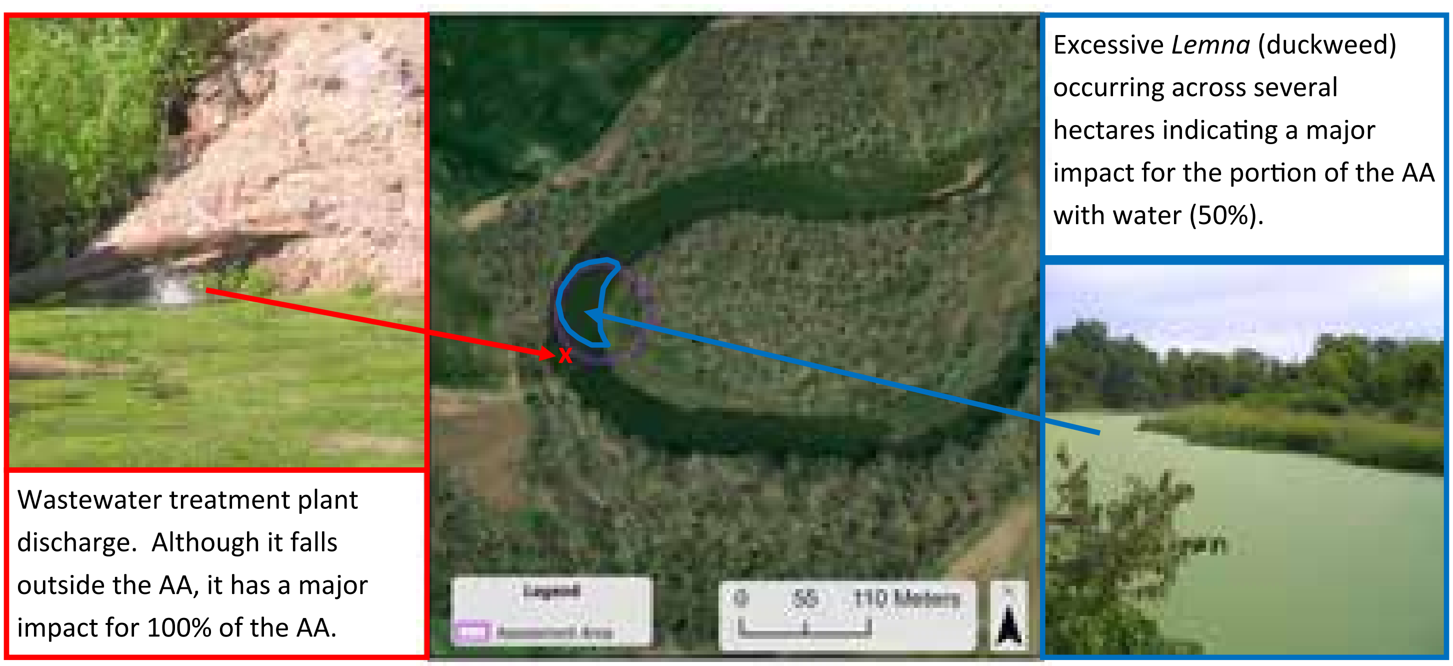


Fig 54. Step 1– Identify nutrient and contaminant stressor indicators in the field.

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Table 3. Indicators of altered nutrient cycling and severity descriptions

	Severity		
Indicators of Altered Nutrient Cycling	**Minor**	**Moderate**	**Major**
Livestock/animal waste	Sparse domestic animal feces (e.g., cow pies), evidence of sparse feral pig activity (rooting, wallows, feces)	High concentration of domestic animal feces (e.g., cow pies), evidence of large scale feral pig activity (rooting, wallows, feces)	Runoff from wastewater lagoons into wetland, evidence of manure piles, poultry litter piles draining to wetland
Residential Runoff and Septic/sewage discharge	Residential dwellings within 200 meters of wetland	Residential dwellings within 50 meters of wetland	Discharge from wastewater/sewage treatment plant
Crop Production	n/a	n/a	Land within the AA has been converted to agricultural production, including both dryland and irrigated crops.
Excessive algae or Lemna sp. (Do not count this metric if algae or Lemna blooms are a result of evapoconcentration of nutrients as wetland is drying.)	Sparse mats or blooms of filamentous algae, Lemna, or cyanobacteria. Small contiguous patches are less than 200 square meters	Mats or blooms of filamentous algae, Lemna, or cyanobacteria may cover large areas but will not be contiguous for more than 0.1 hectares and will contain intermittent gaps where no mats or blooms or present.	Mats or blooms of filamentous algae, Lemna, or cyanobacteria that are contiguous for areas larger than 0.1 hectares.

Fig 55. Livestock are one of the most common sources of nutrient inputs into wetlands in Oklahoma. Indicators include cattle actively using wetland and feces– moderate (left), as well as high density of hoof action and discolored water– moderate (right).

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Fig 56. *Lemna* (duckweed) and algal blooms are a common indicator of excess nutrients in a wetland. The severity of the indicator is based on the size and density of the vegetation or algae– top left (minor), top right (moderate), bottom (major)

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Table 4. Indicators of chemical contaminants and severity descriptions

	Severity		
Indicators of Chemical Contaminants	**Minor**	**Moderate**	**Major**
Point source discharge other than wastewater treatment (ditch or pipes from industrial sources, etc.)	n/a	Discharge from industrial point source to adjacent water body that is intermittently connected to wetland	Direct discharge from industrial point source to the wetland
Stormwater inputs (ditches, discharge pipes, culverts, adjacent impervious surface or railroad tracks)	Adjacent impervious surfaces such as paved roads or railroads (within 10 meters of wetland)	Stormwater inputs from culverts or discharge pipes	n/a
Increased salinity (e.g., salt crust, excessively high conductivity)	Oil and gas exploration/ extraction within 30 meters of AA (e.g., pumpjacks, tank batteries)	Salt crust present on soil surface (excludes saline wetlands such as those in the Great Salt Plains of Alfalfa County)	n/a
Industrial spills or dumping	Few small containers (5 gallons or less) scattered in the wetland with no signs of chemical contamination AND/OR evidence of limited dumping of trash	55 gallon drums or large industrial containers present, and signs of limited chemical contamination (e.g., sterile ground, dead vegetation) AND/ OR construction/demolition debris, appliance/automotive parts AND/OR Evidence of drilling mud application.	Knowledge or evidence of industrial spill within or directly adjacent to the wetland AND/OR Mine tailings draining to wetland.
Oil sheen (sheen that breaks apart or fractures into platelets upon contact is a result of normal wetland biogeochemical processes [i.e., iron precipitates] and is not considered a stressor)	Oil sheen present but not contiguous over areas exceeding 200 square meters, likely a result of motorcraft use within or adjacent to the wetland	Oil sheen contiguous over moderate areas within the wetland exceeding 200 square meters but less than 0.1 hectares, likely a result of a spill or adjacent oil and gas extraction/exploration	Oil sheen contiguous over large areas within the wetland exceeding 0.1 hectares, likely a result of a spill or adjacent oil and gas extraction/exploration

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Fig 57. Indicators of oil and gas exploration impacts on wetlands: leaking pump jack 20 m from the AA with no evidence of oil spill within wetland– minor (top left), salt crust– moderate (top right), evidence of petroleum spill in wetland from discolored soil with odor– major (bottom left), small patch of petroleum on water surface– minor (bottom right).

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

Fig 58. Trash dumping in wetland: wetland used as a residential trash dump– minor (left) and old 55 gallon barrels– minor (right)

Step 2:

If no indicators of altered Nutrient Cycling AND no Chemical Contaminants are present, select the "No Indicators of Altered Nutrients and Contaminants Present" button (Fig. 59). This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if any indicators of alteration are present, ensure the "Excess Nutrients or Contaminants Present" button is selected and continue on to Step 3.

Step 3:

Fill in on the worksheet the percentage (0-100) of the AA impacted by each nutrient stressor indicator in the appropriate severity column (Fig. 59). Overlapping areas of nutrient indicators are only counted once for the highest severity indicator present. Complete the same steps above for contaminant indicators. Overlapping areas of chemical contaminants are only counted once for the highest severity indicator present. However, nutrient indicators may overlap chemical contaminant indicators. The metric score is autocalculated in the worksheet.

Data Processing Tips:

Overlapping areas of nutrient indicators are only counted once for the highest severity indicator present.

Overlapping areas of chemical contaminants are only counted once for the highest severity indicator present.

However, nutrients indicators may overlap chemical contaminant indicators. Because this would allow the metric score to be less than 0, scores less than 0 are automatically set to 0.

The metric is autocalculated in the worksheet but can be calculated with he following equation:

$$\text{Nutrient and Contaminant Score} = 1 - ((MiE * 0.25) + (MoE * 0.5) + (MaE * 0.75))$$

Where, MiE= extent of minor stressor indicators, MoE = extent of moderate stressor indicators, and MaE= extent of major stressor indicators.

Completing the description fields in the worksheet for indicators is helpful but not required.

Metric 2a. Excess Nutrients and Contaminants (Depressional and Riverine)

◉ Excess Nutrients or Contaminants Present	◯ No Indicators of Altered Nutrient and Contaminants Present			◯ AA is not a Wetland
Indicators of Altered Nutrient Cycling	**Minor**	**Moderate**	**Major**	**Indicator Description**
Livestock/animal waste				
Residential Runoff and Septic/sewage discharge			100	Input from wastewater treatment plant
Crop production				
Excessive algae or *Lemna* sp. (Do not count this metric if algae or *Lemna* blooms are a result of evapoconcentration of nutrients as wetland is drying.)				excessive lemna
TOTAL IMPACTED AREA			**100**	
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA			**75**	
Indicators of Chemical Contaminants	**Minor**	**Moderate**	**Major**	**Indicator Description**
Point source discharge (ditch or pipes from industries, etc.)				
Stormwater inputs (ditches, discharge pipes, culverts, adjacent impervious surface or railroad tracks)				
Increased salinity (e.g., salt crust)				
Industrial spills or dumping				
Oil sheen (does not include sheen from iron precipitates)				
TOTAL IMPACTED AREA				
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA				
METRIC SCORE 2a				**0.25**

Fig 59. Steps 2 and 3– Record nutrient and chemical contaminant indicators in the worksheet. The data provided are based on the example nutrient stressors presented in step 1.

Metric 2b. Sediment (Depressional)

Background: The sediment metric assesses the intensity and coverage of unnatural inputs of sediment to a wetland. Sediment can reduce water clarity or bury wetland plant seeds or invertebrate eggs altering biotic communities (Gleason et al. 2003). Sedimentation can also reduce basin volume and alter the hydrology of wetland ecosystems (Luo et al. 1997). The sediment loading metric only applies to depressional wetlands; sediment deposition in riverine wetlands, such as floodplains, is a natural, well-documented occurrence associated with overbank flooding (Jacobson and Coleman 1986; Noe and Hupp 2005; Pierce and King 2008). In fact, sediment deposition is necessary for streams to maintain a dynamic equilibrium between discharge, slope, sediment load, and sediment size (Lane 1995). Although sediment aggradation is a stressor that can impact riverine wetland functions, it can be difficult to identify sedimentation beyond what would normally be expected under unaltered conditions.

Assessment Methods: The sediment metric is scored by assessing the severity and areal extent of increased sedimentation that causes wetland function to shift away from reference conditions. Common indicators of altered sediment inputs include upland erosion such as rills or gullies, excessive turbidity in the water column, and silt covered vegetation.

Step 1:

In the field, outline on an aerial photo all areas within the AA where sediment loading has been altered (Fig. 60), matching the alteration to the indicator and severity from Table 5.

Data Processing Tips:

The areal extent of impact will not necessarily match the areal extent of the stressor. For example sparse rills may only occur at the highest elevation of the wetland occupying 3% of the wetland area, but the sediment inputs could effect the entire AA.

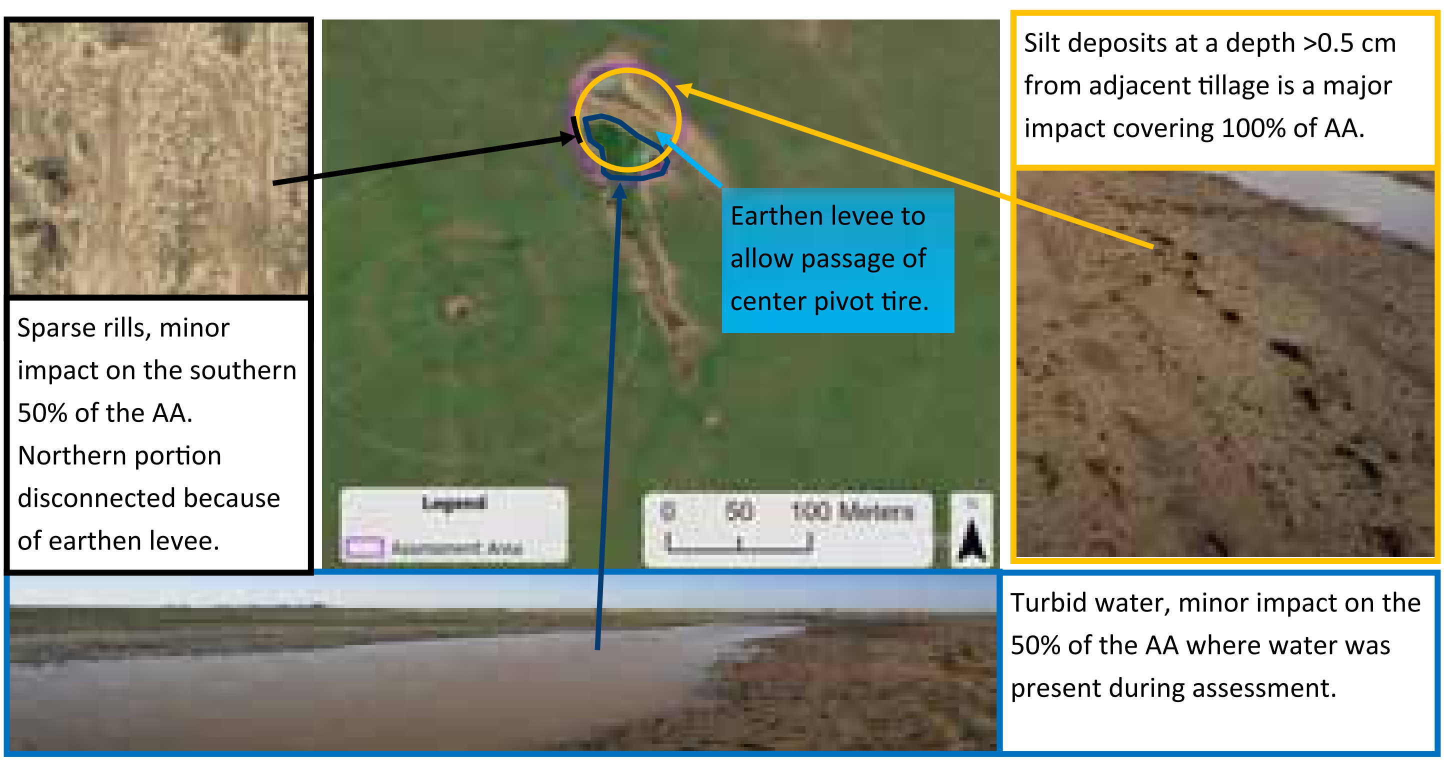


Fig 60. Step 1– Identify sedimentation stressors in the field.

Metric 2b. Sediment (Depressional)

Table 5. Indicators of altered sediment loading and severity descriptions

	Severity		
Indicators of Altered Sediment Loading	**Minor**	**Moderate**	**Major**
Sedimentation (e.g., presence of sediment plumes, fans or deposits)	Excessive turbidity (in excess of expectation for the system), silt laden vegetation	Sediment plumes or fans, silt deposits less than 0.5 centimeters in thickness	Silt deposits greater than 0.5 centimeters in thickness
Upland erosion (e.g., gullies, rills) within or adjacent to AA	Sparse rills connecting upland to wetland. Sediment washing down cattle/wildlife trails.	Dense rills connecting upland to wetland	Gullies connecting upland to wetland

Fig 61. Common indicators of altered sediment loading: turbidity in excess of expectation for depressional wetland– minor (left), silt deposits burying stems of woody vegetation – major (right).

Metric 2b. Sediment (Depressional)

Fig 62. Common indicators of erosion which lead to altered sediment loading in depressional wetlands: sparse, but actively eroding cattle trails adjacent to the AA– minor (top), deep and dense rills adjacent to the AA– moderate (bottom)

Metric 2b. Sediment (Depressional)

Step 2:

If no indicators of excess sediment are present, select the "No Indicators of Excess Sediment Present" button (Fig. 63). This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if any indicators of alteration are present, ensure the "Excess Sedimentation Present" button is selected and continue on to Step 3.

Step 3:

Fill in on the worksheet, the percentage (0-100) of the AA impacted by each stressor indicator in the appropriate severity column (Fig. 63). Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore, the total percent cover of indicators cannot exceed 100. The metric score is autocalculated in the worksheet.

Data Processing Tips:

Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore, the total percent cover of indicators cannot exceed 100.

The metric is autocalculated in the worksheet but can be calculated with he following equation:

$$\text{Sediment Score} = 1- ((MiE *0.25) + (MoE * 0.5) + (MaE * 0.75) + CL)$$

Where, MiE= extent of minor stressor indicators, MoE = extent of moderate stressor indicators, and MaE= extent of major stressor indicators.

◉ Excess Sedimentation Present ○ No Indicators of Excess Sedment Present ○ AA is not a Wetland

Indicators of Altered Sediment loading	Minor	Moderate	Major	Indicator Description
Sedimentation (e.g., presence of sediment plumes, fans or deposits, turbidity, silt laden vegetation)			100	Excessive sedimentation from adjacent tillage, turbid water
Upland erosion (e.g., gullies, rills) within or adjacent to AA				sparse rills
TOTAL IMPACTED AREA			**100**	
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA			**75**	
METRIC SCORE 2b		**0.25**		

Fig 63. Steps 2 and 3– Record sediment stressor indicators in the worksheet. The data provided are based on the example sediment stressors presented in step 1.

Metric 2c. Buffer Filter (Depressional and Riverine)

Background: Buffer filter is a measure of the capacity of the uplands surrounding a wetland to prevent nutrients, sediment and contaminants from reaching the wetland. Natural land-uses have the capacity to filter nutrients and capture sediment from adjacent agricultural or urban land (Castelle et al. 1994).

Assessment Methods: This metric is scored based on the length of intact buffer along 8 transects originating from the boundary of the AA. The length of the buffer required to perform filtration functions is based on the severity of the alteration of the adjacent land-use.

Step 1:

In the office, draw eight evenly spaced 250 m lines, or buffer transects, emanating perpendicularly from the AA perimeter starting at due North on an aerial photograph. For a standard AA, buffers will emerge from the AA in a starburst pattern (Fig. 64). Annotate any human impacted land-uses (Table 6) that intersect the buffer transects for further inspection in the field.

Data Processing Tips:

Create a polyline shapefile in ArcMap for drawing buffer lines.

When creating lines in ArcMap, use snapping to connect buffers to AA boundary. Right click to draw buffer lines based on direction/distance. A standard AA will have buffer lines extending in cardinal and ordinal directions.

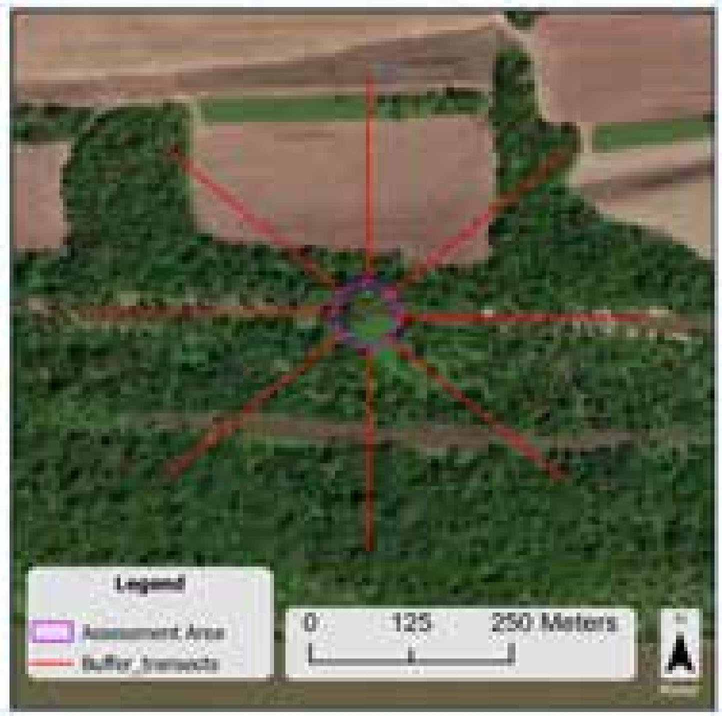


Fig 64. Step 1– Draw 8 evenly spaced 250 m buffer lines

Adjacent Open Water Adjustments:

If the AA is <u>directly adjacent</u> (i.e., sharing a boundary) to permanent open water (e.g., lake, large river, or slough), at least 30 meters wide, exclude that portion of the boundary from buffer calculations (Fig. 65). Determine the distance between buffer transects by evenly dividing the remaining perimeter length by 7.

Permanent open water not directly adjacent to the AA or less than 30 meters wide should be considered a buffer.

Data Processing Tips:

In ArcMap, use the measure tool to determine perimeter of boundary without adjacent open water and calculate buffer transect spacing.

Begin creating buffer transects from one end of the AA and proceed clockwise or counterclockwise.

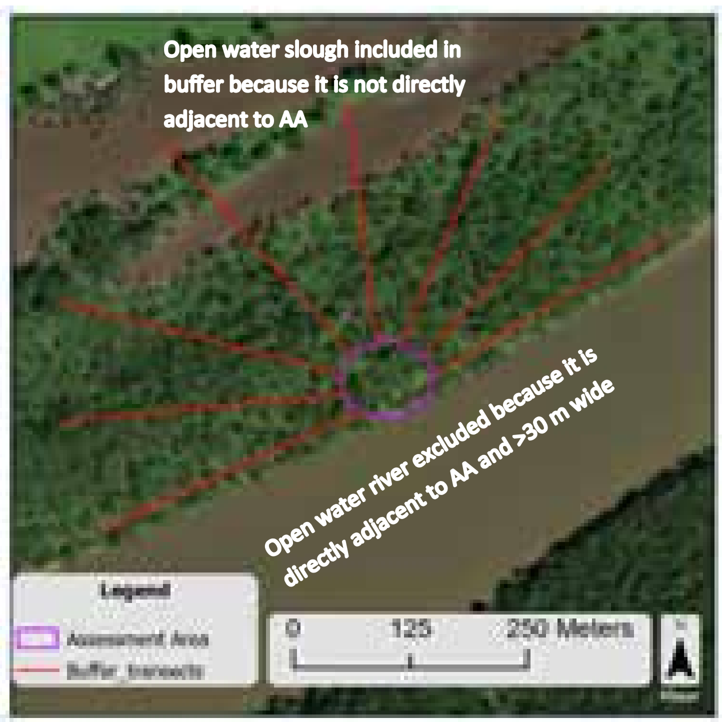


Fig 65. Avoid directly adjacent open water when drawing buffers

Metric 2c. Buffer Filter (Depressional and Riverine)

Step 2:

While in the field, annotate all human impacted land-use along each of the buffer transects on an aerial photo (Fig. 66). Record land-use as high impact, moderate impact or low impact according to Table 6.

Data Processing Tips:

If during the field visit certain areas of the buffer transect are inaccessible because of access restrictions or safety concerns, attempt to view other areas with similar aerial signatures in close proximity to the AA. Land-use type can be inferred from other portions of the buffer viewed during the site visit or from interpretation of the aerial photo. National Land Cover Dataset (NLCD) can aid in the determination of land-use for inaccessible areas.

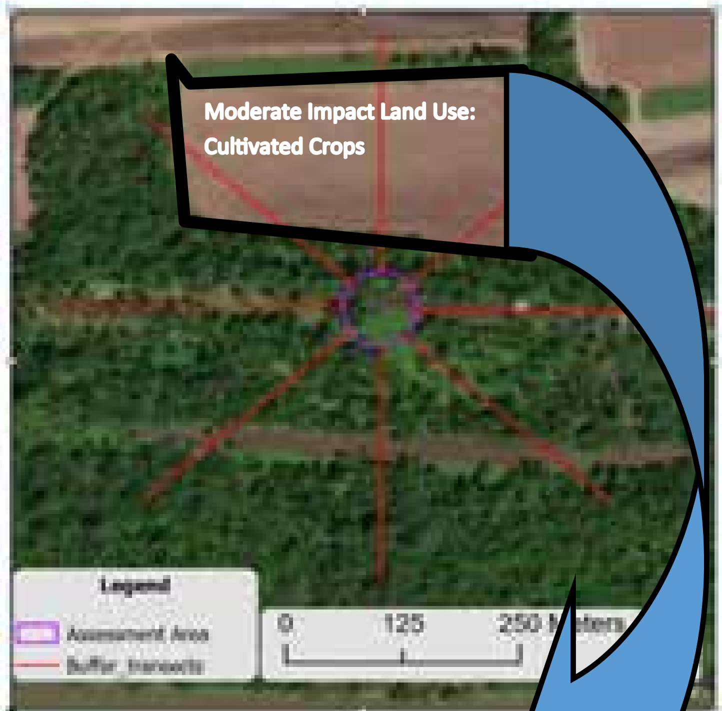


Fig 66. Step 2– Annotated land-use map and photo-documentation of moderate impact along buffer transect

Table 6. Land-use categories for Buffer Filter Metric and required buffer widths

Land use category	**Types of Land-use Beyond Buffer**	**Required Buffer width**
High Impact	Concentrated livestock husbandry (feedlot, dairy farm, pig farm) or urban area	250m
Moderate Impact	Conventional tilled agriculture, landscaped park, golf course, suburban area, active construction sites, areas of vegetation removal, earth moving operations	100m
Low Impact	No till agriculture, hay meadow, active paved road (at grade or elevated), gravel dirt/road, minimal use recreation area, silviculture, managed pasture (improved and native range), paved bike/foot trails, horse trails, railroad tracks, mowed lawn	30m
No Impact	Natural uplands and wetlands, rangeland with domestic livestock that mimics natural grazing (flash and low density grazing), water bodies not directly adjacent to AA, wildland parks	n/a

Metric 2c. Buffer Filter (Depressional and Riverine)

Additional Note on Grazing Lands:

Domestic livestock grazing, including both “improved pasture” and “native rangeland”, is one of the most common land-uses in Oklahoma. In most circumstances, grazing lands are considered “Low Impact” and to receive the maximum Buffer Filter metric score, the AA requires a 30 m buffer of “No Impact” (Table 6) from land used for livestock grazing. However, if native rangelands are managed to mimic natural grazing regimes, they are considered “No Impact” to the AA for the Buffer Filter metric. Indicators of natural grazing regime include fencing around the wetland to allow for rotational grazing, or low stocking rates on large contiguous tracts with sparse livestock feces.

Step 3:

In the buffer worksheet, record the distance until high impact land use is encountered along each transect (Fig. 67). If no high impact land-use is encountered within 250 meter, record 250.

Next, record the distance until moderate-impact land-use is encountered. If no moderate-impact land-use is found within 100 meters of the wetland, record 100.

Finally, record the distance until low-impact land-use is encountered. If no low-impact land-use is found within 30 meters of the wetland, record 30.

The metric score is autocalculated in the worksheet.

Data Processing Tips:

Using the annotated aerial image from the field, you can measure distances along the buffer until impacted land-use more accurately in ArcMap using the measure tool.

For each buffer transect, the percentage of the intact buffer before encountering low-impact, moderate-impact and high-impact land-use is autocalculated in the worksheet. This is done by dividing the low-impact distance by 30, the moderate-impact distance by 100, and the high-impact distance by 250. Then, the lowest value for each transect is automatically selected and recorded in the '% Intact' field. The metric score is then autocalculated by averaging all eight buffer values.

Buffer	Distance to High Impact	Distance to Moderate Impact	Distance to Low Impact	% Intact
1	250	39	30	0.39
2	250	48	30	0.48
3	250	100	30	1
4	250	100	30	1
5	250	100	30	1
6	250	100	30	1
7	250	100	30	1
8	250	85	30	0.85
Metric Score 2d	**0.84**			

Fig 67. Step 3– Record distance to each impact category (high, moderate and low) along each transect in the Buffer Filter Worksheet. The data provided are based on the example wetland buffer presented in Steps 1 and 2.

Metric 3a. Vegetation Condition (Depressional and Riverine)

Background: The vegetation condition metric is a measure of the degree of anthropogenic alteration to the vegetation present within a wetland.

Assessment Methods: The metric is scored as a percentage of area within a wetland that has been degraded through the spread of invasive species, the planting of crops or non-native grasses, excessive grazing, herbicide application, mechanical disturbance, and altered plant communities resulting from impaired hydrology.

Step 1:

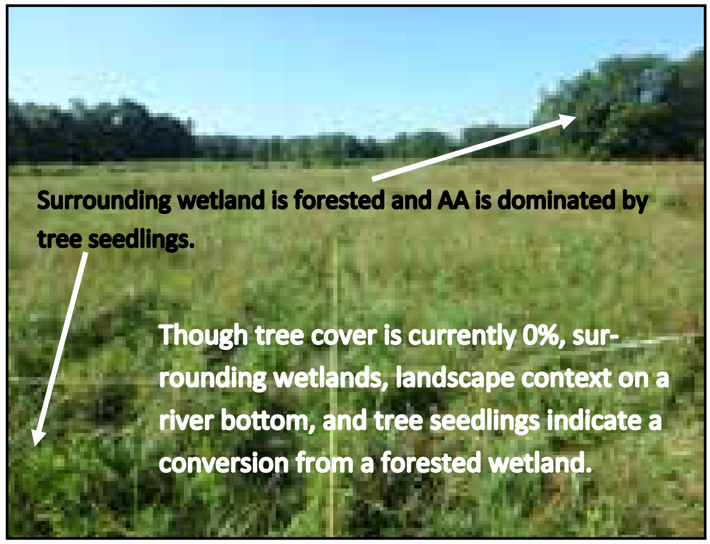
In the field, conduct a visual assessment of the current percent cover (0-100) of each vegetation layer, including only live vegetation. Record the value in the "Percent Cover of Layer" fields (Fig. 71).

Data Processing Tips:

Descriptions of each vegetation layer (i.e., Tree, Shrub, Herbaceous/Emergent, Submergent/Floating Leaved) are presented in Table 7. Cover is the area of ground surface covered by each layer . Percent cover for each vegetation layer should range from 0 to 100, and since layers can overlap each other, overall cover for all layers can range from 0 to 400 (100% cover in all four layers).

Step 2:

If the wetland has been converted from a forested wetland to a non-forested wetland (<30% canopy cover), select the 'Historic Forested Wetland has been Cleared" checkbox. This checkbox should be selected based on landscape context and local vegetation knowledge (Fig. 68). This box should not be selected for restoration sites on a trajectory towards reforestation.



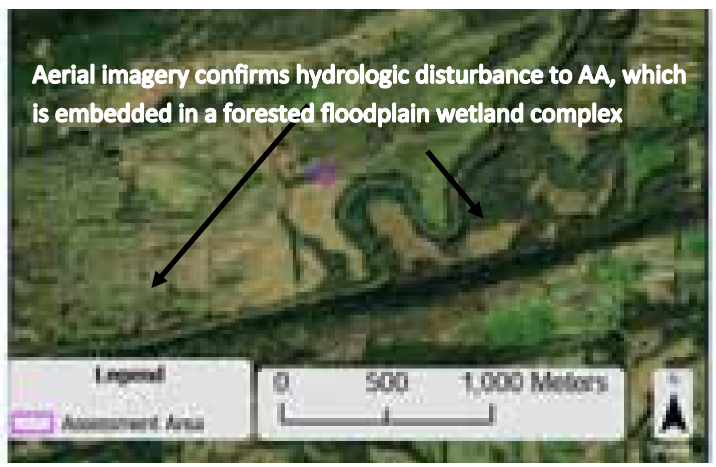


Fig 68. Step 2– Determine if wetland has been converted from forested to non-forested by observing surrounding wetlands and knowledge of landscape context.

Table 7. Descriptions of vegetation layer categories

Vegetation Layer	**Description**
Tree	Woody stems ≥ 8 cm diameter at breast height (DBH)
Shrub	Woody stems < 8 cm DBH
Herbaceous/ Emergent	All non-woody plants growing on dry land or with stems emerging above the water surface
Submergent	Non-woody plants growing below the water surface
Floating Leaved	Non-woody plants with leaves floating on the surface of the water- can be rooted to the substrate or free-floating

Metric 3a. Vegetation Condition (Depressional and Riverine)

Step 3:

Determine the percent cover (0-100) of all 'Indicators of Vegetation Removal" from anthropogenic activities (Table 8). <u>Record the percentage of the AA</u> where vegetation has been removed for all layers present and impacted. For removal of woody vegetation, it may be necessary to utilize existing stumps and brush to estimate canopy cover lost. The sum of "Percent Cover of Layer" and the "Indicators of Vegetation Removal" for any layer can never exceed 100.

Table 8. Indicators of vegetation removal

Indicator	Description
Tree or shrub cutting (estimate cover lost)	Estimate cover lost for shrub and tree layers based on physical indicators such as existing stumps or evidence of brush clearing. Clearing of invasive woody species (e.g., *Tamarix*) is not included as a stressor.
Ground disturbance exposing soil surface (e.g., excessive grazing, animal trampling, rooting, or mechanical disturbance)	Record the areal cover within the AA where the soil surface has been exposed as a result of stressors for all layers impacted, including feral hog rooting, cattle trails/trampling, excessive grazing, and mechanical disturbance for activities like pipeline construction or tillage for agricultural activities). Grazing for invasive species or monoculture control should not be included in this field.
Dead vegetation (e.g., herbicide application or altered hydroperiod)	Record the areal cover of dead vegetation as a result of stressors for all layers impacted, including herbicide application, or altered hydroperiod. Dead vegetation resulting from altered hydroperiod should only be documented when clear indicators of hydroalteration (e.g., berms, ditching) have caused changes to vegetation development. This stressor does not include normal seasonal plant senescence, or mortality resulting from normal hydrologic cycles or during periods of drought.
Mechanical disturbance from structures	Mechanical disturbance from structures includes rip-rap, right of ways, and roads that occur with the AA. When these structures are present, they generally preclude the growth of all vegetation layers. Record the areal extent of disturbance for all vegetation layers present within the AA.

Fig 69. Indicators of vegetation removal including feral hog rooting (left) and excessive cattle grazing/trampling

Metric 3a. Vegetation Condition (Depressional and Riverine)

Step 4:

Determine the percent cover (0-100) of all 'Indicators of Vegetation Disturbance" (Table 9). Record the percentage of the cover of each vegetation layer where indicators of disturbance are present. The sum of all "Indicators of Vegetation Disturbance" for any layer can never exceed 100.

Data Processing Tips:

Indicators of vegetation disturbance are recorded as the percentage of the vegetation layer and not as a percentage of the whole AA. Therefore, indicators of stress can range from 0 to 100 even when the overall cover for that layer is less than 100%. For example, if the AA includes 50% cover of herbaceous vegetation, and 25% of the herbaceous cover is invasive species, 25% invasive species cover should be recorded under herbaceous cover.

Table 9. Indicators of vegetation disturbance

Indicator	Description
Haying, mowing, brush hogging	Record the vegetation cover for layers impacted by active mechanical disturbance to reduce the height of vegetation for any purpose including baling hay or improving accessibility. Indicators of mechanical cutting of the herbaceous layer are most likely to occur within the same growing season as the assessment. Whereas, indicators of mechanical disturbance to woody layers may persist for multiple years following impact.
Ground surface disturbance but subsequently revegetated (e.g., animal trampling, rooting or mechanical disturbance)	Record the vegetation cover for all layers impacted, where the ground has been disturbed but subsequently revegetated. Indicators of revegetated ground disturbance include unnatural microtopographic relief resulting from excessive hoof action or rooting.
Invasive Species and crop/ pasture grasses	Record the cover of invasive species for all vegetation layers. Invasive species include all plant species listed on the Oklahoma Non-Native Invasive Plant Species List found in Appendix A or https://www.okinvasives.org/plants-database. Crop and pasture grasses such as Bermuda grass (*Cynodon dactylon*) or corn (*Zea mays*), while not invasive, are also included in this stressor because of the potential loss of biodiversity in a wetland resulting from cultivation.
Native monoculture (only emergent and submergent layers)	Native monocultures occur when more than 50% of an assessment area is dominated by one native perennial species (herbaceous and submergent/floating leaved layers only) including cattails (*Typha* sp.), river bulrush (*Schoenoplecuts fluviatis*), giant cutgrass (*Zizaniopsis miliacea*), shoreline sedge (*Carex hyalinolepis*) and reed canary grass (*Phalaris arundinacea*). Other species may persist and be interspersed within native monocultures, but the monoculture greatly reduces diversity and cover of other native species. Native monoculture cover is scored as the percent cover greater than 50%. For example, a wetland with 70% cover cattails (*Typha* sp.) would receive a score of 20% (70-50= 20)
Upland plant encroachment and/or stunted vegetation as a result of altered hydroperiod (increased or decreased)	Vegetation cover of upland plant encroachment and/or stunted vegetation as a result of altered hydroperiod should be documented for all vegetation layers impacted, when clear indicators of hydroalteration (e.g., berms, ditching) have caused changes to vegetation development and/or community composition. This stressor does not include normal shifts in the vegetation community to more upland dominated plant communities that may occur seasonally or during periods of drought.

Metric 3a. Vegetation Condition (Depressional and Riverine)

Fig 70. Indicators of vegetation disturbance including, native monoculture of cattails (*Typha* sp.) (top left), stunted vegetation as a result of altered hydroperiod– berm and artificial flooding (top right), crop planting (bottom left), and mowing (bottom right).

Metric 3a. Vegetation Condition (Depressional and Riverine)

Step 5:

The metric is autocalculated in the worksheet (Fig. 71).

Data Processing Tips:

The metric is calculated as follows:

Vegetation condition score = 1 - (VegDisturbed + VegRemoved) / (VegCover + VegRemoved)

Where, VegDisturbed = percentage of disturbed cover for all layers within the AA, VegCover = the total cover of live vegetation for all layers within the AA, and VegRemoved = the total cover of removed vegetation for all layers within the AA

If the "Historic Forested Wetland has been cleared (canopy cover now <30%)" is selected, the overall score is reduced by 0.5 and the metric is calculated as follows:

Vegetation condition score = 0.5 - (0.5* (VegDisturbed + VegRemoved) / (VegCover + VegRemoved))

☑ Historic Forested Wetland has been cleared (canopy cover <30%)- excludes projects on a trajectory towards restoration

	Vegetation Layers			
	Tree	**Shrub/ sapling**	**Herbaceous/ Emergent**	**Submergent/ Floating leaved**
Percent Cover of Layer (live vegetation)	0	20	90	
Indicators of Vegetation Removal from Anthropogenic Activities (Percentage of the AA impacted) ◊				
Tree and shrub cutting (estimate cover lost)				
Ground disturbance exposing soil surface (e.g., excessive grazing‡, animal trampling, rooting, or mechanical disturbance)				
Dead vegetation (e.g., herbicide application, or altered hydroperiod⁝)				
Mechanical disturbance from structures (e.g. rip-rap, or roads etc.)				
Total Removed Cover				
Sum of existing and removed cover		20	90	
Indicators of Vegetation Disturbance (Percentage of live vegetation cover impacted)				
Haying, mowing, brush hogging		100		
Ground surface disturbance but subsequently revegetated (e.g., animal trampling, rooting or mechanical disturbance)				
Invasive species and or crop/pasture *			30	
Native Monoculture†				
Upland plant encroachment and/or stunted vegetation as a result of altered hydroperiod (increased or decreased)⁝				
Percent disturbed cover per layer		20	27	
METRIC SCORE 4a	0.29			

Fig 71. Record vegetation cover and indicators in the vegetation community worksheet. The data provided are based on the example presented in step 1 and 2.

Metric 3b. Habitat Connectivity (Depressional and Riverine)

Background: The habitat connectivity metric is a measure of the degree of human alteration to the landscape around a wetland that could impact wildlife movement.

Assessment Methods: This metric is scored as the percentage of natural habitat within a 1 km buffer connected to the AA. Acceptable habitat includes native uplands, aquatic systems, other wetlands, and several man-made features with little impact to wildlife movement such as dirt roads.

Step 1:

In the office, delineate a 1 km buffer around the boundary of the AA on an aerial photograph before visiting the wetland (Fig. 72).

Data Processing Tips:

The Buffer tool (Analysis Toolset) in ArcMap can quickly generate a 1 km buffer around the AA.

Fig 72. Step 1– Delineate 1 km buffer around AA

Step 2:

In the office, assign all habitat within the 1000 m buffer into three categories, natural, marginal and dispersal barriers (Fig. 73) using Table 10.

Delineate a polygon around the AA that only includes connected natural habitat.

Delineate a second polygon around the AA that includes connected marginal and natural habitat.

Data Processing Tips:

Create a shapefile in ArcMap for digitizing connected habitat boundaries.

Including multiple aerial images, as well as National Land Cover Dataset (NLCD) and TIGER road layers in ArcMap can be extremely helpful for delineating habitat types.

Connected habitat includes areas within the 1 km buffer where an uninterrupted corridor of at least 25 m wide can be drawn to the AA boundaries. See Figure 74.

Including marginal habitat, you may connect additional natural habitat areas to the AA that were previously disconnected when considering natural habitat alone. See Figure 75.

Fig 73. Step 2– Delineate connected habitat boundaries

Metric 3b. Habitat Connectivity (Depressional and Riverine)

Table 10: Natural habitat, marginal habitat and dispersal barriers for delineating habitat connected to the AA for the Habitat Connectivity Metric (Steps 2 and 3).

Natural Habitat (includes any linear disturbances that minimally impact wildlife movement)
open water
other wetlands
natural uplands
nature or wildland parks
railroad tracks
roads not hazardous to wildlife (e.g., unpaved roads, farm roads, low speed/low traffic paved roads)
swales and ditches
vegetated levees
open range land
Marginal Habitat
hay meadows
pine plantations
pedestrian/bike trails with near constant traffic
forests converted to rangeland
Dispersal Barriers (not included in connected habitat)
Natural or marginal habitat less than 25 meters wide
commercial developments
fences that interfere with animal movements (e.g., high fences for commercial hunting)
intensive agriculture (e.g., row crops, orchards, vineyards)
dryland farming
heavily managed pasture lands (e.g., improved Bermudagrass pastures)
most paved roads (excludes low speed/low traffic roads)
lawns
parking lots
intensive livestock production (e.g., horse paddocks, feedlots, chicken confinement buildings, etc.)
residential areas
sound walls
sports fields
traditional golf courses
urbanized parks with active recreation
energy development

Metric 3b. Habitat Connectivity (Depressional and Riverine)

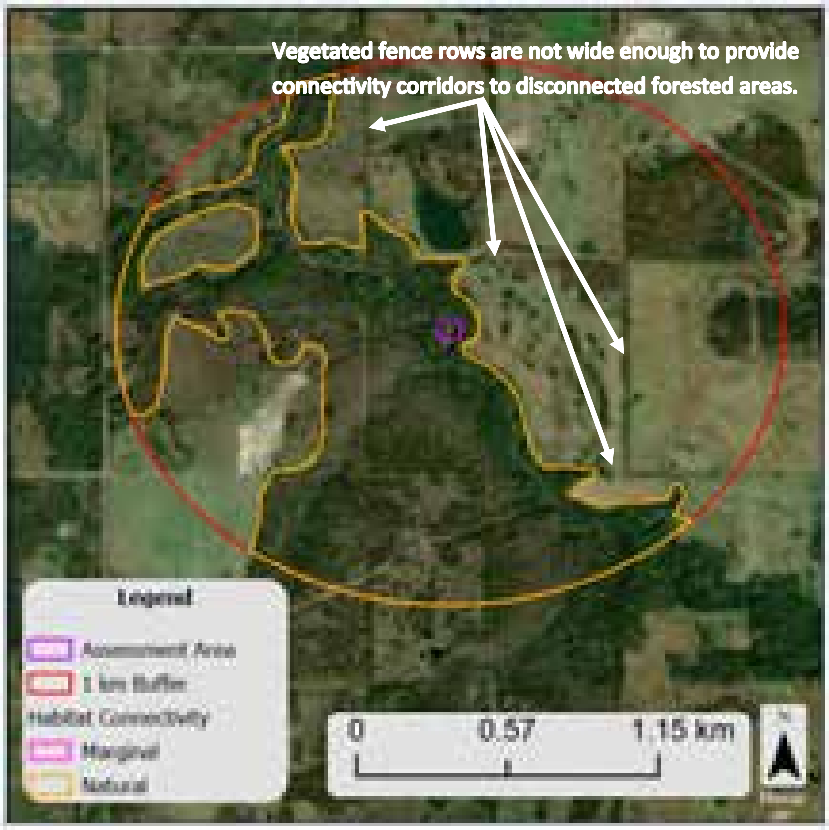


Fig 74. Sample assessment area demonstrating corridors that are not wide enough (minimum 25 m wide) to be included in connected habitat.

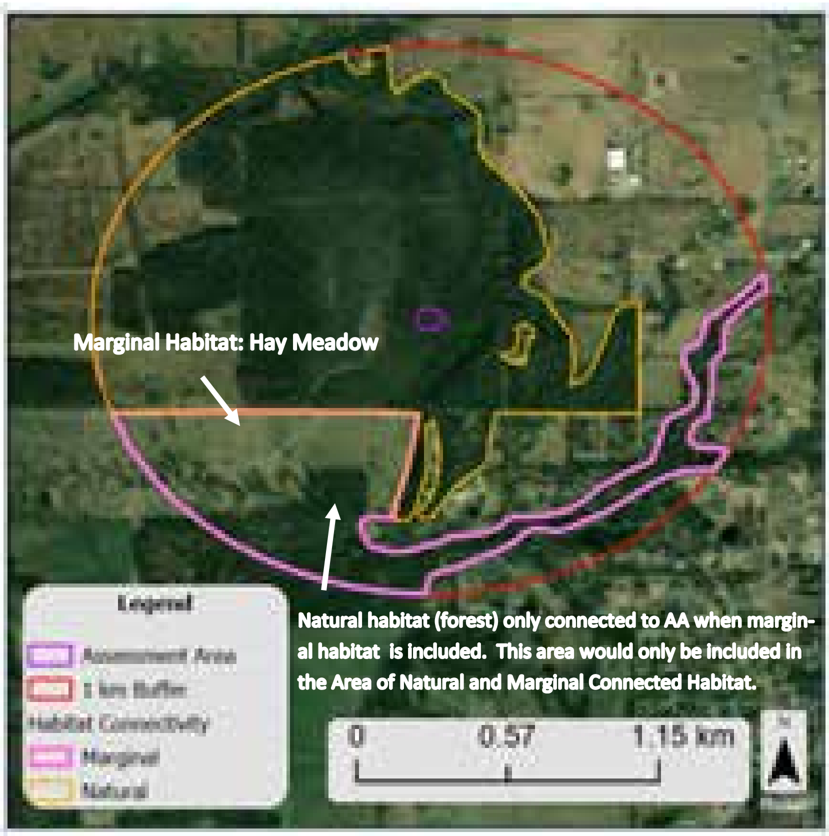


Fig 75. Sample assessment area where marginal habitat may connect large areas of natural habitat to the AA that were previously disconnected when considering natural habitat only.

Metric 3b. Habitat Connectivity (Depressional and Riverine)

Step 3:

Print aerial imagery with habitat types marked from Step 2. Confirm land-use within the 1 km buffer in the field for all areas that are feasibly accessible based on landowner permission, time required for access or other logistical constraints. (Fig. 76)

Data Processing Tips:

Mark areas for further inspection on the aerial image where land-use is not clear on the aerial imagery. In particular, it can be difficult to discern native rangelands, hay meadows and improved pasture.

Ideally, mark places that can be observed from the road or accessed from the AA. Apply aerial signature of field verified locations to inaccessible locations in the 1 km buffer.

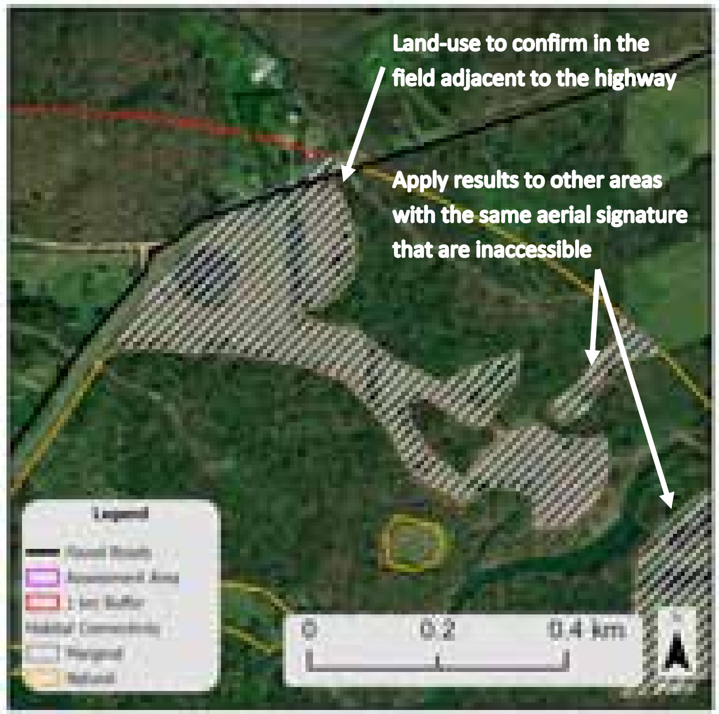


Fig 76. Step 3– Annotate and print aerial imagery for field.

Step 4:

Calculate the area within the 1 km buffer created in Step 1 (Fig. 77, Note: this area should be close to 340 ha but may vary slightly based on AA size or shape).

Calculate the area within the natural habitat polygon and the natural/marginal habitat polygons created in Step 2 and confirmed in Step 3.

Data Processing Tips:

Use the calculate geometry function in the shapefile's attribute table in ArcMap to determine the area of the buffer and connected habitats.

Step 5:

Fill in the buffer and connected habitat areas in the Habitat Connectivity Worksheet (Fig. 77). The metric is autocalculated in the worksheet.

Data Processing Tip:

The Habitat Connectivity metric can be calculated manually using the following equation:

Habitat connectivity score = (NMH/BA + NH/BA)/2

Where, NMH = the area of natural and marginal habitat connected to the AA, NH = the area of natural habitat connected to the AA and BA= the area within the 1 km buffer.

Area of Natural and Marginal Connected Habitat	206
Area of Natural Connected Habitat	188
Area within 1000 m buffer	340
METRIC SCORE 3b	0.58

Fig 77. Step 5. Record buffer and habitat boundaries in the Habitat Connectivity metric worksheet. The data provided are based on the example habitat connectivity buffer presented in Steps 1-3.

Final Scoring

Once the OKRAM assessment has been completed, metric scores are aggregated into a final score that ranges from 0 (generally a site that is no longer functioning as a wetland) to 1 (a wetlands with no indicators of disturbance). After the metric scores are entered into the worksheets, the final score is calculated automatically in the Condition Score worksheet. There is a separate Condition Score worksheet for Depressional and Riverine wetlands (Fig .78).

To calculate OKRAM scores manually, each attribute score (i.e., Hydrology, Water Quality and Biota) is first calculated by taking the average score of all metrics within that attribute. Then, all attribute scores are averaged to determine the final OKRAM score. Final OKRAM scores can be calculated manually with the following equations:

Depressional Overall Condition Score: = (((Hydroperiod + Water Source + Hydrologic Connectivity)/3) + ((Nutrients/Contaminants + Sediment + Buffer Filter)/3) + ((Vegetation + Habitat Connectivity)/2))/3

Riverine Overall Condition Score: = (((Hydroperiod + Water Source + Hydrologic Connectivity)/3) + ((Nutrients/Contaminants + Buffer Filter)/2) + ((Vegetation + Habitat Connectivity)/2))/3

If only one AA is needed, the output from the Condition Score worksheet is the final score for the site.

When multiple AAs are needed for site-specific assessments, average the OKRAM score from all AAs together to determine the final score for the site.

4. OKRAM Overall Condition Score - Depressional

	Metric	Score
1	***Hydrology***	
1a.	Hydroperiod	0.25
1b.	Water source	0.78
1c.	Hydrologic Connectivity	1
	Hydrology Attribute	**0.68**
	(metric 1a +metric 1b + metric 1c)/3	
2	***Water Quality***	
2a.	Nutrients/Contaminants	0.75
2b.	Sediment	0.5
2c.	Buffer Filter	0.54
	Water Quality Attribute	**0.60**
	(metric 2a +metric 2b + metric 2c)/3	
3	***Biota***	
3a.	Vegetation	0.72
3b.	Habitat Connectivity	0.8
	Biota Attribute	**0.76**
	(metric 3a + metric 3b)/2	
	Overall Condition Score	**0.68**

4. OKRAM Overall Condition Score- Riverine

	Metric	Score
1	***Hydrology***	
1a.	Hydroperiod	1
1b.	Water source	0.9
1c.	Hydrologic Connectivity	0.2
	Hydrology Attribute	**0.70**
	(metric 1a +metric 1b + metric 1c)/3	
2	***Water Quality***	
2a.	Nutrients/Contaminants	1
2b.	Buffer Filter	0.75
	Water Quality Attribute	**0.88**
	(metric 2a +metric 2b)/2	
3	***Biota***	
3a.	Vegetation	1
3b.	Habitat Connectivity	0.42
	Biota Attribute	**0.71**
	(metric 3a + metric 3b)/2	
	Overall Condition Score	**0.76**

Fig 78 Example scoring worksheets for a Depressional wetland (top) and Riverine wetland (bottom)

Final Scoring

The following guidelines can be used to assign condition categories to assessment sites based on OKRAM score (Dvorett et al. 2014, Gallaway et al. 2016):

Good: 1– 0.85

Fair: 0.84 – 0.5

Poor: 0.49 - 0

Good wetlands generally have minimal active impact from humans, maintain natural hydrologic regimes, sustain native vegetation communities, and exist within relatively undisturbed landscapes.

Fair wetlands generally have some combination of local anthropogenic disturbance, landscape alteration, and impacted vegetation communities.

Poor wetlands are generally significantly impacted by both local and landscape stressors.

Fig 79. Pictures of Riverine wetlands in good (top left) and poor (top right) condition, and Depressional wetlands in good (bottom left) and poor conditions (bottom right).

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Appendix A: Invasive species for use with the vegetation condition metric

Species	Common name	Systems Affected
Aegilops cylindrica	jointed goatgrass	cropland/pastureland, rangeland
Agrostemma githago	corncockle, purple cockle	cropland/pastureland
Ailanthus altissima	tree-of-heaven, copal tree	urban/garden, rangeland
Albizia julibrissin	mimosa, silktree, powderpuff	forest/woodland, rangeland, riparian/aquatic
Alliaria petiolata	garlic mustard	forest/woodland
Alternanthera philoxeroides	alligator weed, pig weed	riparian/aquatic
Anthemis cotula	stinking chamomile, dogfennel,	cropland/pastureland
Arctium minus	lesser burdock, small burdock,	cropland/pastureland, rangeland
Arundo donax	giant reed	riparian/aquatic, urban/garden
Avena fatua	wild oats, flaxgrass, wheat oats	cropland/pastureland, disturbed/waste areas
Barbarea vulgaris	yellow rocket, winter cress	cropland/pastureland, disturbed/waste areas, urban/garden, rangeland
Bothriochloa bladhii	plains bluestem, Caucasian	cropland/pastureland, disturbed/waste areas
Bothriochloa ischaemum	yellow bluestem	cropland/pasture, disturbed/waste areas, rangeland
Bromus arvensis	field brome	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland
Bromus catharticus	rescue grass	disturbed/waste areas, urban/garden, cropland/pastureland
Bromus inermis	smooth brome, awnless brome	cropland/pastureland, riparian/aquatic, range-land
Bromus japonicus	Japanese brome	disturbed/waste areas, cropland/pastureland
Bromus racemosus	meadow brome, bald brome	rangeland, forest/woodland
Bromus secalinus	rye brome, chess, cheat	rangeland, disturbed/waste areas, cropland/ pastureland
Bromus sterilis	poverty brome, barren brome-	disturbed/waste areas, cropland/pastureland
Bromus tectorum	cheatgrass	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland
Broussonetia papyrifera	paper mulberry	disturbed/waste areas, forest/woodland, ri-parian/aquatic, urban/garden
Cardiospermum halicacabum	balloon vine, love in a puff	disturbed/waste areas, cropland/pastureland, forest/woodland, rangeland, riparian/aquatic
Carduus nutans	musk thistle	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland

Species	**Common name**	**Systems Affected**
Centaurea solstitialis	yellow star thistle	forest/woodland, rangeland
Centaurea stoebe	spotted knapweed	riparian/aquatic, rangeland, cropland/ pastureland, disturbed/waste areas
Cichorium intybus	chicory, French endive, coffee-	disturbed/waste areas, cropland/pastureland
Cirsium arvense	Canada thistle, Californian this-	cropland/pastureland, rangeland
Cirsium vulgare	bull thistle, spear thistle	cropland/pastureland, rangeland, riparian/ aquatic, disturbed/waste areas, forest/ woodland
Clematis terniflora	sweet autumn clematis, leather-leaf clematis, yam-leaved clematis, sweet autumn virginsbower	disturbed/waste areas, urban/garden, riparian/aquatic, forest/woodland
Conium maculatum	poison hemlock, deadly hemlock, poison parsley	rangeland, riparian/aquatic, disturbed/waste areas, cropland/pastureland, forest/woodland
Convolvulus arvensis	field bindweed, creeping jenny,	cropland
Cyperus rotundus	nutgrass, cocograss, purple nutsedge	cropland/pastureland, disturbed/waste areas, riparian/aquatic, rangeland, forest/woodland, urban/garden
Dactylis glomerata	orchard grass, cocksfoot	cropland/pastureland, forest/woodland, rangeland, disturbed/waste areas
Daucus carota	Queen Anne's lace, bird's nest, wild carrot	rangeland, disturbed/waste areas, cropland/ pastureland
Dianthus armeria	Deptford pink	disturbed/waste areas, cropland/pastureland, rangeland
Dioscorea oppositifolia	Chinese yam	forest/woodland
Dipsacus fullonum	common teasel, venuscup teasle, teasel	riparian/aquatic, rangeland, forest/woodland, disturbed/waste areas
Duchesnea indica	mock strawberry, India mock-	urban/garden, forest/woodland
Dysphania ambrosioides	Mexican tea	disturbed/waste areas, forest/woodland, cropland/pastureland
Echinochloa crus-galli	barnyard grass, cockspur, Japanese millet, watergrass	cropland/pastureland, disturbed/waste areas, rangeland, riparian/aquatic
Egeria densa	Brazillian egeria, Brazilian	riparian/aquatic
Eichhornia crassipes	common water hyacinth, water	riparian/aquatic
Elaeagnus angustifolia	Russian olive, Russian oleaster	riparian/aquatic
Elaeagnus pungens	thorny olive, thorny elaeagnus	disturbed/waste areas, forest/woodland
Elaeagnus umbellata	autumn olive, Autumn oleaster	disturbed/waste areas, cropland/pastureland, forest/woodland, rangeland

Species	Common name	Systems Affected
Eragrostis cilianensis	candy grass, lovegrass, stink	disturbed/waste areas, urban/garden
Erodium cicutarium	redstem stork's bill, redstem filaree	rangeland, forest/woodland, disturbed/waste areas, urban/garden
Euonymus fortunei	wintercreeper, climbing euony-	forest/woodland, rangeland, urban/garden
Fatoua villosa	hairy crabweed	urban/garden, cropland/pastureland
Glaucium corniculatum	blackspot hornpoppy	cropland/pastureland, rangeland
Glechoma hederacea	ground ivy, creeping charlie	forest/woodland, distubred/waste areas
Hedera helix	English ivy	urban/garden, forest/woodland
Hydrilla verticillata	hydrill	riparian/aquatic
Hypericum perforatum	common St. Johnswort, St.	rangeland, disturbed/waste areas
Ipomoea purpurea	tall morningglory, common morningglory	cropland/pastureland, disturbed/waste areas, forest/woodland, urban/garden
Iris pseudacorus	yellow iris, yellow flag iris,	riparian/aquatic
Juniperus virginiana	eastern red cedar	ALL
Kochia scoparia (=Bassia sco-	common kochia, fireweed, Mex-	disturbed/waste areas, cropland/pastureland
Koelreuteria paniculata	golden rain tree	disturbed/waste areas
Lactuca serriola	prickly lettuce, China lettuce,	disturbed/waste areas, cropland/pastureland
Lantana camara	lantana	disturbed/waste areas
Lepidium draba (=Cardaria draba)	heartpod hoarycress, whitetop, hoary cress	cropland/pastureland, rangeland, riparian/aquatic
Lespedeza cuneata	sericea lespedeza, lespedeza	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland
Ligustrum quihoui	waxyleaf privet	forest/woodland, disturbed/waste areas
Ligustrum sinense	Chinese privet	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland
Linaria dalmatica	dalmatian toadflax	cropland/pastureland, disturbed/waste areas, rangeland
Lolium perenne	perennial rye grass, Italian	rangeland, riparian/aquatic
Lonicera japonica	Japanese honeysuckle	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland

Species	Common name	Systems Affected
Lonicera maackii	Amur honeysuckle	forest/woodland, disturbed/waste areas, urban/garden
Ludwigia grandiflora	large-flower primrose-willow	riparian/aquatic
Lygodium japonicum	Japanese climbing fern	forest/woodland, riparia/aquatic
Lythrum salicaria	purple loosestrife, purple lyth-	riparian/aquatic
Medicago lupulina	black hop medic, black medic, hop clover, yellow trefoil	distubed/waste areas, forest/woodland, riparian/aquatic
Melia azedarach	Chinaberry tree, Indian lilac	cropland/pastureland, disturbed/waste areas, urban/garden, forest/woodland, rangeland, riparian/aquatic
Melilotus albus	white sweetclover, honey-clover	cropland/pastureland, disturbed/waste areas
Melilotus officinalis	yellow sweetclover	rangeland, disturbed/waste areas, cropland/pastureland, forest/woodland
Microstegium vimineum	Nepalese browntop, Japanese stiltgrass	disturbed/waste areas, forest/woodland, riparian/aquatic
Morus alba	white mulberry	forest/woodland, rangeland, disturbed/waste areas
Murdannia keisak	marsh dayflower, Asian spiderwort, watermoving herb	riparian/aquatic
Myriophyllum aquaticum	parrotfeather, Brazilian watermilfoil	riparian/aquatic
Myriophyllum spicatum	Eurasian watermilfoil, shortspike	riparian/aquatic
Nandina domestica	heavenly bamboo, nanten, sacred bamboo	forest/woodland, riparian/aquatic
Nasturtium officinale	watercress	riparian/aquatic
Nymphoides peltata	yellow floatingheart	riparian/aquatic
Onopordum acanthium	Scotch thistle, Scotch cottonthistle	disturbed/waste areas, cropland/pastureland, rangeland, urban/garden
Paspalum dilatatum	dallisgrass, water grass, Dallas grass	disturbed/waste areas, rangeland, forest/woodland, riparian/aquatic, cropland/
Paulownia tomentosa	princess tree, royal paulownia	forest/woodland, disturbed/waste areas, riparian/aquatic

Species	Common name	Systems Affected
Perilla frutescens	beefsteak plant, purple mint	disturbed/waste areas, riparian/aquatic, cropland/pastureland, forest/woodland
Persicaria maculosa (=Polygonum persicaria)	spotted ladysthumb	disturbed/waste areas, riparian/aquatic, cropland/pastureland, urban/garden
Phalaris arundinacea	reed canary grass	riparian/aquatic, disturbed/waste areas, cropland/pastureland
Phragmites australis	common reed	forest/woodland, cropland/pastureland, dis-turbed/waste areas, rangeland, riparian/aquatic
Phyllostachys aurea	bamboo, golden bamboo	disturbed/waste areas, urban/garden, forest/woodland, riparian/aquatic
Pistacia chinensis	Chinese pistache	urban/garden, riparian/aquatic, cropland/pastureland
Pistia stratiotes	water lettuce, tropical duck-	riparian/aquatic
Polygonum aviculare	prostrate knotweed, yard knot-	cropland/pastureland, disturbed/waste areas
Potamogeton crispus	curly pondweed	riparian/aquatic
Potentilla recta	sulfur cinquefoil, erect cinque-	disturbed/waste areas
Pueraria montana	kudzu	cropland/pastureland, forest/woodland, rangeland, disturbed/waste areas, urban/garden, riparian/aquatic
Pyrus calleryana	callery pear	disturbed/waste areas, forest/woodland, ur-ban/garden
Ranunculus sardous	hairy buttercup	cropland/pastureland, riparian/aquatic, urban/garden
Rhaponticum repens (=Acroptilon repens)	Russian knapweed, hardheads	rangeland, riparian/aquatic, forest/woodland, cropland/pastureland, disturbed/waste areas
Rosa multiflora	multiflora rose	disturbed/waste areas, rangeland, forest/woodland, cropland/pastureland
Rumex acetosella	common sheep sorrel, field sor-rel, red sorrel	disturbed/waste places, riparian/aquatic, rangeland, forest/woodland
Rumex crispus	curly dock, narrowleaf, sour dock, yellow dock	cropland/pastureland, rangeland, disturbed/waste places
Rumex obtusifolius	bitter dock, bluntleaf dock	rangeland, cropland/pastureland
Salsola collina	slender Russian thistle, tumble-	cropland/pastureland, rangeland

Species	Common name	Systems Affected
Salsola tragus	Russian thistle, tumbleweed	disturbed/waste areas, rangeland, urban/ garden, cropland/pastureland
Salvinia molesta	giant salvinia, African payal, wa-	riparian/aquatic
Scabiosa atropurpurea	mourningbride, pincushion flow-	Disturbed/Waste Areas, Cropland/Pasture
Schedonorus pratensis	meadow mountain fescue,	cropland/pastureland, disturbed/waste areas
Securigera varia	crown vetch, purple crownvetch	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic,
Senecio vulgaris	old man in the spring, common groundsel	cropland/pastureland, disturbed/waste areas, urban/garden
Setaria viridis	green brittlegrass, bottle grass, pigeongrass, wild millet, green	cropland/pastureland, disturbed/waste areas, urban/garden
Sisymbrium altissimum	tall tumble mustard, tall hedge-mustard, Jim Hill mustard, tall	cropland/pastureland, forest/woodland, dis-turbed/waste areas
Sonchus asper	spiny sowthistle, prickly sowthis-tle, perennial sowthistle	forest/woodland, disturbed/waste areas, rangeland, urban/garden, riparian/aquatic, cropland/pastureland
Sonchus oleraceus	common sowthistle, annual sowthistle	cropland/pastureland, disturbed/waste areas, riparian/aquatic
Sorghum halepense	Johnsongrass	forest/woodland, disturbed/waste areas,
Stellaria media	common chickweed, nodding chickweed	cropland/pastureland, urban/garden, dis-turbed/waste areas, forest/woodland
Tamarix spp.	saltcedar	riparian/aquatic
Thlaspi arvense	field pennycress, Frenchweed, stinkweed, fanweed	cropland/pastureland, disturbed/waste areas, urban/garden
Triadica sebifera	tallowtree, Chinese tallow	rangeland, forest/woodland, urban/garden, riparian/aquatic
Trifolium incarnatum	crimson clover	disturbed/waste areas, cropland/pastureland
Tripidium ravennae ssp. ra-	ravennagrass	riparian/aquatic
Ulmus parvifolia	lacebark elm, Chinese elm	rangeland, urban/garden
Ulmus pumila	Siberian elm	forest/woodland, disturbed/waste areas,
Verbascum thapsus	common mullein, big taper,	rangeland, forest/woodland, urban/garden,

Data presented in this appendix originate from:

Oklahoma Invasive Plant Council. 2023. Oklahoma Invasive Plant Database (https://www.okinvasives.org/plants-database; date accessed: 27 Jan 2023). Norman, OK.

About the Invasive Plant Database

This database contains the Dirty Dozen and the Watch List which were created by the Oklahoma Invasive Plant Council. The Dirty Dozen is a list of the 13 worst invasive plants in Oklahoma. The Watch List is made up of invasive plants that are known to be one or more of the following:

1. Present in Oklahoma and/or a bordering state.
2. Negatively affecting the economy, environment, or human health in Oklahoma and/or a bordering state.

Listed as a noxious weed or an aquatic nuisance plant species in Oklahoma and/or a bordering state.

This database is to be used to facilitate education and management of invasive plant species in Oklahoma. The Invasive Plant Database is not a static list, but is subject to change as new data become available.

Appendix B: OKRAM Worksheets

Dichotomous Key for HGM Wetland Classification in Oklahoma

1. Wetland is within the 5 year floodplain of a river but not fringing an impounded water body.	*Riverine(5)*
1. Wetland is associated with a topographic depression, flat or slope	2
2. Wetland is located on a topographic slope (slight to steep) and has groundwater as the primary water source. Wetland does not occur in a basin with closed contours.	*Slope* (15)
2. Wetland is located in a natural or artificial (dammed/excavated) topographic depression or flat.	3
3. Wetland is located on a flat without major influence from groundwater.	*Flat* (**Hardwood Flat**)
3. Wetland is located in a natural or artificial (dammed/excavated) topographic depression.	4
4. Topographic depression has permanent water greater than 2 meters deep and wetlands are restricted to the margin of the depression.	*Lacustrine Fringe (10)*
4. Topographic depression does not contain permanent water greater than 2 meters.	*Depression (11)*

Dichotomous Key for Riverine Wetland Subclassification in Oklahoma

5. The wetland is a remnant river channel that is periodically hydrologically connected to a river or stream every 5 years or more frequently.	**Connected Oxbow**
5. The wetland is not an abandoned river channel.	**6**
6. The hydrology of the wetland is impacted by beaver activity.	**Beaver Complex**
6. The hydrology of the wetland is not impacted by beaver activity.	**7**
7. The wetland occurs within the bankfull channel (includes vegetated ephemeral channels, bars and islands).	**In-channel**
7. The wetland is directly adjacent to the river channel or occurs on a topographic floodplain (may include back-channels, swales or other topographic relief).	**8**
8. Stream is intermittent or ephemeral	**Floodplain (Non-perennial)**
8. Stream is perennial	**9**
9. Stream is a 1st or 2nd order	**Floodplain (Upper Perennial)**
9. Stream is a 3rd order or higher	**Floodplain (Lower Perennial)**

Dichotomous Key for Lacustrine Wetland Subclassification in Oklahoma

10. Wetland is associated with a remnant river channel that is hydrologically disconnected from the stream or river of origin.	**Disconnected Oxbow**
10. Wetland is associated with a reservoir or pond created by impoundment or excavation.	**Man-made Lacustrine Fringe**

Dichotomous Key for Depressional Wetland Subclassification in Oklahoma

11. Wetland was created by human activity.	12
11. Wetland was not created by human activity.	13
12. Wetland does not have discernible water outlets.	**Closed Impounded Depression**
12. Wetland has discernible water outlet(s).	**Open Impounded Depression**
13. Wetland primary water source is groundwater.	**Groundwater Depression**
13. Wetland primary water source is surface water.	14
14. Wetland does not have any discernible water outlets.	**Closed Surface Water Depression**
14. Wetland has discernible water outlet(s).	**Open Surface Water Depression**

Dichotomous Key for Slope Wetland Subclassification in Oklahoma

15. Wetland is hydrologically connected to a low order (Strahler <=4), high gradient, or ephemeral stream.	**Headwater Slope**
15. Wetland is hydrologically connected to a high order (Strahler >=5), low gradient river. Slope may be imperceptible or extremely gradual (includes wet meadows).	**Low Gradient Slope**

Site Description

Site Name	
Date of Assessment	
Assessor Name(s)	
Assessor Affiliation(s)	

Location Information

Site Latitude	
Site Longitude	
Coordinate System	
Level III Omernik Ecoregion	
Directions/Access Notes	

Assessment Area Information

Size of Wetland					
# of Assessment Areas					
Assessment Area ID		**AA Type**		**AA size**	
Reason for Assessment					

HGM Classification (circle one class and any relevant subclasses)

HGM Class	**Depression**	**Flat**	**Slope**	**Lacustrine**	**Riverine**
Regional Subclass	*Closed Impounded*	*Hardwood*	*Headwater*	*Disconnected Oxbow*	*Connected Oxbow*
	Open Impounded		*Low-gradient*	*Man-made Lacustrine*	*Beaver Complex*
	Groundwater				*In-Channel*
	Open Surface Water				*Floodplain (non-perennial)*
	Closed Surface Water				*Floodplain (upper perennial)*
					Floodplain (lower perennial)

Additional Site Characteristics (circle dominant condition)

Hydrologic Condition at time of assessment	Ponded/inundated		Saturated Soil (no surface water)			Dry
Hydroperiod	Temporary *(inundated for <1 month)*		Seasonal *(inundated for extended periods of growing season)*	Semi-permanent/ Permanent *(inundated except during drought years)*		
Dominant Vegetation	Forested	Scrub/Shrub	Emergent	Submergent/ Floating Leaved		Unvegetated
Management	Unmanaged		Agriculture	Stormwater	Water treatment	Water supply	Wildlife

Site Notes

Additional AA Description

Site Name								
Date of Assessment								
Location Information								
Site Latitude								
Site Longitude								
Additional Assessment Area Information								
Assessment Area ID		**AA Type**			**AA size**			
HGM Classification (circle one class and any relevant subclasses)								
HGM Class	**Depression**		**Flat**	**Slope**	**Lacustrine**			**Riverine**
Regional Subclass	*Closed Impounded*		*Hardwood*	*Headwater*	*Disconnected Oxbow*			*Connected Oxbow*
	Open Impounded			*Low-gradient*	*Man-made Lacustrine*			*Beaver Complex*
	Groundwater							*In-Channel*
	Open Surface Water							*Floodplain (non-perennial)*
	Closed Surface Water							*Floodplain (upper perennial)*
								Floodplain (lower perennial)
Additional Site Characteristics (circle dominant condition)								
Hydrologic Condition at time of assessment	Ponded/inundated		Saturated Soil (no surface water)					Dry
Hydroperiod	Temporary *(inundated for <1 month)*		Seasonal *(inundated for extended periods of growing season)*		Semi-permanent/ Permanent *(inundated except during drought years)*			
Dominant Vegetation	Forested	Scrub/Shrub	Emergent	Submergent/ Floating Leaved				Unvegetated
Management	Unmanaged		Agriculture	Stormwater	Water treatment	Water supply		Wildlife
Additional Assessment Area Notes								

1. Hydrologic condition

a. Hydroperiod

Instructions:

1. In the office, mark potential hydroperiod stressors that occur within 500 meters of the AA on aerial imagery for further inspection in the field.
2. In the field, confirm hydroperiod stressors identified in the office, as well as any other hydroperiod stressors observed. Match the alteration observed in the field to the indicator and the severity from the table on the following worksheet (1a.Hydroperiod Indicators). Annotate an aerial image with the aerial extent of impact from all identified indicators.
3. If no hydroperiod stressors are identified, select the “No Indicators of Altered Hydroperiod Present" button. This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if indicators of alteration are present, ensure the "Hydroperiod is impacted" button is selected and continue on to Step 4.
4. Record the percentage (0-100) of the AA impacted by each indicator in the appropriate severity column. Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore the total percent cover of indicators cannot exceed 100. The metric is autocalculated in the worksheet.

○ Hydroperiod is impacted ○ No Indicators of Altered Hydroperiod Present ○ AA is not a Wetland

Indicators of Altered Hydroperiod	Minor	Moderate	Major	Complete Loss	Indicator Description
Fill/sedimentation					
Water being pumped into or out of the wetland					
Water control structures					
Culverts, discharges, ditches or tile drains into our out of the wetland					
Beaver dam removal					
Excavation/Dredging/Mining/ Impoundment					
TOTAL IMPACTED AREA					
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	**1**	
SEVERITY WEIGHTED AREA					
METRIC SCORE 1A					

1. Hydrologic condition

a. Hydroperiod	**Severity**			
Indicators of altered hydroperiod	**Minor**	**Moderate**	**Major**	**Complete Loss**
1. Fill/sedimentation	Silt covered vegetation, extremely turbid water, AND/OR rills on adjacent uplands	Sediment splays, completely buried vegetation, AND/OR silt deposits around trees	Silt deposits or fill that have greatly reduced wetland volume	Complete loss of basin
2. Water pumping into our out of the wetland	Water level is properly manipulated for wetland management activities including slow, cool-season drawdowns. Desirable annual moist soil plants present.	Water is pumped out of the wetland for agricultural or other human uses OR water level is poorly manipulated for wetland management activities including rapid, warm-season drawdowns. Undesirable weedy plants present (e.g. cocklebur).	n/a	n/a
3. Water control structures	Water level is properly manipulated for wetland management activities including slow, cool-season drawdowns (desirable annual moist soil plants present) OR water is passively managed to mimic natural wetland filling and drawdown.	Water level is poorly manipulated for wetland management activities including rapid, warm-season drawdowns. Undesirable weedy plants present (e.g. cocklebur).	Water control structures are derelict or no longer maintained, resulting in substantial lengthening or shortening of hydroperiod.	Water control structures are derelict or no longer maintained, resulting in complete wetland drainage or permanent deep water.
4. Culverts, discharges, ditches or tile drains in to or out of the wetland	Old drainages present that appear to have minor influences on current wetland hydrology (e.g. old ditches that have sedimented in or tile drains that have been damaged)	Water drained from wetland only during high water events AND/OR water enters wetland from culverts, diversions or ditches only during large storm events AND/OR water is consistently discharged into wetland from irrigation (e.g., agricultural or residential).	Water is drained from wetland at all times of the year but still retains wetland hydrology AND/OR water from culvert, diversion, irrigation or ditch is the dominant water source for the wetland.	Wetland completely dried OR Wetland completed converted to permanent deepwater
5. Beaver dam removal (excludes maintenance of restoration/ mitigation sites and activity in control structures/ infrastructure)	Beaver activity not a major driver of wetland hydrology and removal caused minimal changes in area, depth and duration of ponding.	n/a	Beaver activity was the primary source of wetland hydrology and removal caused major changes in area, depth and duration of ponding.	Wetland completely dried as a result of dam removal.
6. Excavation/ Dredging/ Mining/ Impoundment (excludes sediment removal to restore hydrology resulting from human-induced sedimentation)	Small areas of excavation within the AA to deepen water for habitat improvement that has minimal impact on the hydrology of the wetland.	n/a	Wetland excavated or impounded but still retains wetland hydrology. Hydroperiod substantially lengthened.	Wetland converted to permanent deepwater OR center of the wetland excavated to permanently dry remainder or wetland.

1. Hydrologic condition

b. Water Source (Depression)

Instructions:

1. In the office, delineate the catchment for the entire wetland that contains the AA.

2. In the office, identify indicators of altered water source with the catchment.

3. Where possible, confirm indicators of altered water source in the field.

4. In the worksheet below, record the percent cover (0-100) of each indicator of altered water source identified within the catchment. If the catchment's water source is completely unaltered, select the box labeled, "No Indicators of Altered Water Source Present". The metric score is autocalculated in the worksheet.

No Indicators of Altered Water Source Present: ☐

Catchment Indicators of altered water source	**% Cover**	**Severity Multiplier**	**Description**
Impervious surface (paved roads and ditches, parking lots, structures and roof tops, and compacted gravel and dirt roads)		1.5	
Irrigated agricultural land (center pivot, ditch, flood etc.)		1.5	
Dryland agricultural land that is tilled		0.5	
Woody encroachment (e.g., eastern red cedar (*Juniperus virginiana*) and salt cedar (*Tamarix* sp.))		0.5	
Impounded water		2	
Topographic alteration (leveling, excavation, mining)		1	
Total Altered Cover			
METRIC SCORE 1b			

1. Hydrologic condition

b. Water Source (Riverine)

Instructions:

1.In the office, identify the stream or the river that serves as the primary water source for the study wetland and follow it upstream. Record the distance (in meters) to the first upstream impoundment encountered in the 'Distance' field next to 'Upstream Impoundment'. If no impoundment is reached within 100 km (of stream distance) or before reaching the headwaters of the stream, leave this field blank.

2. In the office, follow the source river downstream. Record the distance (in meters) to the first downstream impoundment encountered in the 'Distance' field next to 'Downstream Impoundment'. If no impoundment is reached within 100 km (of stream distance) or before reaching the downstream confluence (i.e., stream changes name), leave this field blank.

3. In the office, delineate the catchment for the entire wetland that contains the AA.

4. In the office, identify indicators of altered water source within the catchment that are listed in the worksheet.

5. Where possible, confirm indicators of altered water source in the field.

6. In the worksheet, record the percent cover (0-100) of each indicator of altered water source identified within the catchment. If the catchment's water source is completely unaltered and there are no upstream or downstream impoundments, select the box labeled, "No Indicators of Altered Water Source Present". The metric score is autocalculated in the worksheet.

No Indicators of Altered Water Source Present: ☐

HUC 8 Indicators of altered water source	**Distance (m)**	**Score Reduction**
Upstream Impoundment		0
Downstream Impoundment		0

Catchment Indicators of altered water source	**% Cover**	**Severity Multiplier**	**Description**
Impervious surface (paved roads and ditches, parking lots, structures and roof tops, and compacted gravel and dirt roads)		1.5	
Irrigated agricultural land (center pivot, ditch, flood etc.)		1.5	
Dryland agricultural land that is tilled		0.5	
Woody encroachment (e.g. eastern red cedar (*Juniperus virginiana*) and salt cedar (*Tamarix* sp.))		0.5	
Impounded water		2	
Topographic alteration (leveling, excavation, mining)		1	
Total Altered Cover			
METRIC SCORE 1b Alternate			

1. Hydrologic condition

c. Hydrologic Connectivity

Instructions:

1. When in the field, outline on an aerial image all areas around the boundary of the entire wetland that encompasses the AA where hydrologic connectivity has been altered. In larger wetlands, the assessment of the connectivity metric should be restricted to the portion of the wetland within 500 meters of the AA boundary.
2. If no connectivity stressors are identified, select the "No Indicators of Altered Connectivity Present" button. This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if indicators of alteration are present, ensure the "Connectivity is impacted" button is selected and continue on to Step 3.
3. Record on the worksheet the percentage (0-100) of the perimeter where hydrologic connectivity is impaired. The metric score is autocalculated in the worksheet.

○ Connectivity is Impacted ○ No Indicators of Altered Connectivity Present ○ AA is not a Wetland

Indicators of altered connectivity	Perimeter Percentage	Description
Levees, Berms, Dams, Weirs, or other artificially steep grades		
Road Grades		
METRIC SCORE 1C		

2. Water Quality Condition

a. Excess Nutrients and Contaminants

1. When in the field, outline on an aerial image all areas within the AA where nutrient cycling has been altered, matching the alteration to the indicator and the severity on the worksheet titled '2a. Nutrient Indicators'. Complete the same assessment, marking areas where chemical contaminants have been observed, matching the alteration to the indicator and the severity on the worksheet titled '2a. Contaminant Indicators'

2. If no indicators of altered Nutrient Cycling AND no Chemical Contaminants are present, select the "No Indicators of Altered Nutrients and Contaminants Present" button. This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if any indicators of alteration are present, ensure the "Excess Nutrients or Contaminants Present" button is selected and continue on to Step 3.

3. Fill in on the worksheet the percentage (0-100) of the AA impacted by each nutrient stressor indicator in the appropriate severity column. Overlapping areas of nutrient indicators are only counted once for the highest severity indicator present. Complete the same steps above for contaminant indicators. Overlapping areas of chemical contaminants are only counted once for the highest severity indicator present. However, nutrient indicators may overlap chemical contaminant indicators. The metric score is autocalculated in the worksheet.

○ Excess Nutrients or Contaminants Present ○ No Indicators of Altered Nutrient and Contaminants Present ○ AA is not a Wetland

Indicators of Altered Nutrient Cycling	**Minor**	**Moderate**	**Major**	**Indicator Description**
Livestock/animal waste				
Residential Runoff and Septic/sewage discharge				
Crop production				
Excessive algae or *Lemna* sp. (Do not count this metric if algae or *Lemna* blooms are a result of evapoconcentration of nutrients as wetland is drying.)				
TOTAL IMPACTED AREA				
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA				
Indicators of Chemical Contaminants	**Minor**	**Moderate**	**Major**	**Indicator Description**
Point source discharge (ditch or pipes from industrial sources, etc.)				
Stormwater inputs (ditches, discharge pipes, culverts, adjacent impervious surface or railroad tracks)				
Increased salinity (e.g., salt crust)				
Industrial spills or dumping				
Oil sheen (does not include sheen from iron precipitates)				
TOTAL IMPACTED AREA				
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA				
METRIC SCORE 2a				

2.Water Quality

a. Nutrients	**Severity**		
Indicators of Altered Nutrient Cycling	**Minor**	**Moderate**	**Major**
Livestock/animal waste	Sparse domestic animal feces (e.g., cow pies), evidence of sparse feral pig activity (rooting, wallows, feces)	High concentration of domestic animal feces (e.g., cow pies), evidence of large scale feral pig activity (rooting, wallows, feces)	Runoff from wastewater lagoons into wetland, evidence of manure piles, poultry litter piles draining to wetland
Residential Runoff and Septic/sewage discharge	Residential dwellings within 200 meters of wetland	Residential dwellings within 50 meters of wetland	Discharge from wastewater/sewage treatment plant
Crop Production	n/a	n/a	Land within the AA has been converted to agricultural production, including both dryland and irrigated crops.
Excessive algae or Lemna sp. (Do not count this metric if algae or *Lemna* blooms are a result of evapoconcentration of nutrients as wetland is drying.)	Sparse mats or blooms of filamentous algae, *Lemna* , or cyanobacteria. Small contiguous patches are less than 200 square meters	Mats or blooms of filamentous algae, *Lemna* , or cyanobacteria may cover large areas but will not be contiguous for more than 0.1 hectares and will contain intermittent gaps where no mats or blooms or present.	Mats or blooms of filamentous algae, *Lemna* , or cyanobacteria that are contiguous for areas larger than 0.1 hectares.

2.Water Quality

a. Contaminants	Severity		
Indicators of Chemical Contaminants	**Minor**	**Moderate**	**Major**
Point source discharge other than wastewater treatment (ditch or pipes from industrial sources, etc.)	n/a	Discharge from industrial point source to adjacent water body that is intermittently connected to wetland	Direct discharge from industrial point source to the wetland
Stormwater inputs (ditches, discharge pipes, culverts, adjacent impervious surface or railroad tracks)	Adjacent impervious surfaces such as paved roads or railroads (within 10 meters of wetland)	Stormwater inputs from culverts or discharge pipes	n/a
Increased salinity (e.g., salt crust, excessively high conductivity)	Oil and gas exploration/extraction within 30 meters of AA (e.g., pumpjacks, tank batteries)	Salt crust present on soil surface (excludes saline wetlands such as those in the Great Salt Plains of Alfalfa County)	n/a
Industrial spills or dumping	Few small containers (5 gallons or less) scattered in the wetland with no signs of chemical contamination AND/OR evidence of limited dumping of trash	55 gallon drums or large industrial containers present, and signs of limited chemical contamination (e.g., sterile ground, dead vegetation) AND/OR construction/ demolition debris, appliance/ automotive parts AND/OR Evidence of drilling mud application.	Knowledge or evidence of industrial spill within or directly adjacent to the wetland AND/OR Mine tailings draining to wetland.
Oil sheen (sheen that breaks apart or fractures into platelets upon contact is a result of normal wetland biogeochemical processes [i.e., iron precipitates] and is not considered a stressor)	Oil sheen present but not contiguous over areas exceeding 200 square meters, likely a result of motorcraft use within or adjacent to the wetland	Oil sheen contiguous over moderate areas within the wetland exceeding 200 square meters but less than 0.1 hectares, likely a result of a spill or adjacent oil and gas extraction/exploration	Oil sheen contiguous over large areas within the wetland exceeding 0.1 hectares, likely a result of a spill or adjacent oil and gas extraction/exploration

2. Water Quality Condition

b. Sediment (Depressional)

1. When in the field, outline on an aerial image all areas within the AA where sediment loading has been altered, matching the alteration to the indicator and severity from the worksheet titled '2b. Sediment Indicators'.

2. If no indicators of excess sediment are present, select the "No Indicators of Excess Sediment Present" button. This will autogenerate a score of 1. If the site is not a wetland, select the "AA is not a wetland" button. This will autogenerate a score of 0. Otherwise, if any indicators of alteration are present, ensure the "Excess Sedimentation Present" button is selected and continue on to Step 3.

3. Fill in on the worksheet, the percentage (0-100) of the AA impacted by each stressor indicator in the appropriate severity column. Overlapping areas of indicators are only counted once for the highest severity indicator present. Therefore, the total percent cover of indicators cannot exceed 100. The metric score is autocalculated in the worksheet.

○ Excess Sedimentation Present ○ No Indicators of Excess Sedment Present ○ AA is not a Wetland

Indicators of Altered Sediment loading	Minor	Moderate	Major	Indicator Description
Sedimentation (e.g., presence of sediment plumes, fans or deposits, turbidity, silt laden vegetation)				
Upland erosion (e.g., gullies, rills) within or adjacent to AA				
TOTAL IMPACTED AREA				
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA				
METRIC SCORE 2b				

2.Water Quality

b. Sediment	**Severity**		
Indicators of Altered Sediment Loading	**Minor**	**Moderate**	**Major**
Sedimentation (e.g., presence of sediment plumes, fans or deposits)	Excessive turbidity (in excess of expectation for the system) AND/OR silt laden vegetation	Sediment plumes or fans, silt deposits less than 0.5 centimeters in thickness	Silt deposits greater than 0.5 centimeters in thickness
Upland erosion (e.g., gullies, rills) within or adjacent to AA	Evidence of sheet erosion from adjacent unvegetated or tilled areas. Few or sparse rills connecting upland to wetland. Sediment washing down cattle/wildlife trails.	Dense or numerous rills connecting upland to wetland.	Large rills or gullies connecting upland to wetland.

2. Water Quality Condition

c. Buffer filter

Instructions:

1. In the office, draw eight evenly spaced 250 m lines or buffer transects emanating perpendicularly from the AA perimeter starting at due north on an aerial image of the wetland. For a standard AA, buffers will emerge from the AA in a starburst pattern. If the AA is directly adjacent (i.e., sharing a boundary) to permanent open water (e.g., lake, large river, or slough) at least 30 meters wide, exclude that portion of the boundary from buffer calculations. Permanent open water not directly adjacent to the AA or less than 30 meters wide should be considered buffer.

2. In the field, annotate all human impacted land-use along each of the buffer transects on an aerial photo. Record land-use as high impact, moderate impact or low impact according to the table below

3. In the buffer worksheet, record the distance when high impact land use is encountered along each transect. If no high impact land-use is encountered within 250 meters, record 250. Next, record the distance when moderate-impact land-use is encountered. If no moderate-impact land-use is found within 100 meters of the wetland, record 100. Finally, record the distance when low-impact land-use is encountered. If no low-impact land-use is found within 30 meters of the AA, record 30. The metric score is autocalculated in the worksheet.

Land use category	Types of Land-use Beyond Buffer	Required Buffer width
High Impact	Intensive livestock (feedlot, dairy farm, pig farm) or urban area	250m
Moderate Impact	Conventional tilled agriculture, landscaped park, golf course, suburban area, active construction sites, areas of vegetation removal, earth moving operations	100m
Low Impact	No till agriculture, hay meadow, active paved road (at grade or elevated), gravel dirt/road, minimal use recreation area, silviculture, managed pasture (improved and native range), paved bike/foot trails, horse trails, railroad tracks, mowed lawn	30m
No Impact	Natural uplands and wetlands, rangeland with domestic livestock that mimics natural grazing (flash and low density grazing), water bodies not directly adjacent to AA, wildland parks	n/a

Buffer	Distance to High Impact	Distance to Moderate Impact	Distance to Low Impact	% Intact
1				
2				
3				
4				
5				
6				
7				
8				
Metric Score 2d				

3. Biotic Condition

a. Vegetation condition

Instructions:

1. In the field, conduct a visual assessment of the current percent cover (0-100) of each vegetation layer, including only live vegetation. Record the value in the "Percent Cover of Layer" fields.
2. If the wetland has been converted from a forested wetland to a non-forested wetland (<30% canopy cover), select the 'Historic Forested Wetland has been Cleared" checkbox. This checkbox should be selected based on evidence of removal (e.g., stumps), landscape context and local vegetation knowledge. This box should not be checked for restoration sites on a trajectory towards reforestation.
3. Determine the percent cover (0-100) of all 'Indicators of Vegetation Removal" from anthropogenic activities. Record the **percentage of the AA** where vegetation has been removed for all layers present and impacted. For removal of woody vegetation, it may be necessary to utilize existing stumps and brush to estimate canopy cover lost. The sum of "Percent Cover of Layer" and the "Indicators of Vegetation Removal" for any layer can never exceed 100.

4. Determine the percent cover (0-100) of all 'Indicators of Vegetation Disturbance". Record the **percentage of the cover of each vegetation layer** where indicators of disturbance are present. The sum of all "Indicators of Vegetation Disturbance" for any layer can never exceed 100.
5. The metric score is autocalculated in the worksheet.

☐ Historic Forested Wetland has been cleared (canopy cover now <30%)- excludes restoration projects on a trajectory towards reforestation

	Vegetation Layers			
	Tree	**Shrub/ sapling**	**Herbaceous / Emergent**	**Submergent/ Floating leaved**
Percent Cover of Layer (live vegetation)				
Indicators of Vegetation Removal from Anthropogenic Activities (Percentage of the AA impacted) ◊				
Tree and shrub cutting (estimate cover lost)				
Ground disturbance exposing soil surface (e.g., excessive grazingⱡ, animal trampling, rooting, or mechanical disturbance)				
Dead vegetation (e.g., herbicide application, or altered hydroperiod⁝)				
Mechanical disturbance from structures (e.g. rip-rap, or roads etc.)				
Total Removed Cover				
Sum of existing and removed cover				
Indicators of Vegetation Disturbance (Percentage of live vegetation cover impacted)				
Haying, mowing, brush hogging				
Ground surface disturbance but subsequently revegetated (e.g., animal trampling, rooting or mechanical disturbance)				
Invasive species and or crop/pasture *				
Native Monoculture†				
Upland plant encroachment and/or stunted vegetation as a result of altered hydroperiod (increased or decreased) ⁝				
Percent disturbed cover per layer				
METRIC SCORE 4a				

Notes:

◊Vegetation removal can be an effective management strategy for improving the quality of wetland vegetation by removing invasive species or native monocultures. Vegetation removal for invasive species or monoculture control should not be included in this field. Vegetation removal resulting from normal flood events is not considered a stressor and should not be listed.

ⱡ Excessive grazing represents areas where vegetation is eaten to the ground. Grazing can be an effective management strategy for improving the quality of wetland vegetation by removing invasive species or native monocultures. Grazing for invasive species or monoculture control should not be included in this field.

⁝ Only includes changes to vegetation development and/or community composition as a result of hydrologic alteration and does not include normal shifts to more upland dominated plants that may occur seasonally or during periods of drought.

* Invasive species include all plant species listed on the Oklahoma Non-Native Invasive Plant Species List developed by OK Native Plant Society, OK Biological Survey and OSU Natural Resource Ecology and Management Department. A species is considered invasive if it is listed as a problem in border states as well. https://www.okinvasives.org/plants-database

† Native monocultures occur when more than 50% of a an assessment area is dominated by one native perennial species including cattails (*Typha* sp.), river bulrush *(Schoenoplecuts fluviatis)* , giant cutgrass (*Zizaniopsis miliacea)* , and reed canary grass (*Phalaris arundinacea).* Native monoculture cover is scored as the percent cover greater than 50%. For example, a wetland with 70% cover reed canary grass would receive a score of 20% (70-50= 20).

3. Biotic Condition

b. Habitat connectivity

Instructions:

1.In the office before visiting the wetland, delineate a 1 km buffer around the boundary of the AA on aerial imagery.

2.In the office, assign all habitat within the 1 km buffer into three categories (natural, marginal and dispersal barriers) using the table below. Delineate a polygon around the AA that only includes connected natural habitat. Delineate a second polygon around the AA that includes connected marginal and natural habitat. Marginal and natural habitat must be at least 25 meters wide to be considered connected to the AA.

3. Print aerial imagery with habitat types marked from Step 2. Confirm land-use within the 1 km buffer in the field for all areas that are feasibly accessed, considering access permission, amount of time required or other logistical constraints
4. Calculate the area within the 1 km buffer created in Step 1. Calculate the area within the natural habitat polygon and the natural/marginal habitat polygons created in Step 2 and confirmed in Step 3.
5. Fill in the buffer and connected habitat areas in the Habitat Connectivity Worksheet. The metric score is autocalculated in the worksheet.

Natural Habitat (includes any linear disturbances that minimally impact wildlife movement)
open water
other wetlands
natural uplands
nature or wildland parks
railroad tracks
roads not hazardous to wildlife (e.g., unpaved roads, farm roads, low speed/low traffic paved roads)
swales and ditches
vegetated levees
open range land
Marginal Habitat
hay meadows
pine plantations
pedestrian/bike trails with near constant traffic
forests converted to rangeland
Dispersal Barriers (not included in connected habitat)
Natural or Marginal habitat less than 25 meters wide
Commercial Developments
Fences that interfere with animal movements (e.g., high fences for commercial hunting)
intensive agriculture (e.g. row crops, orchards, vineyards)
dryland farming
heavily managed pasture lands (e.g., improved bermuda grass pastures)
most paved roads (excludes low speed/low traffic roads)
lawns
parking lots
intensive livestock production (e.g. horse paddocks, feedlots, chicken ranches etc.)
residential areas
sound walls
sports fields
traditional golf courses
urbanized parks with active recreation
energy development

Area of Natural and Marginal Connected Habitat	
Area of Natural Connected Habitat	
Area within 1 km buffer	
METRIC SCORE 3b	

4. OKRAM Overall Condition Score - Depressional

	Metric	Score
1	***Hydrology***	
1a.	Hydroperiod	
1b.	Water source	
1c.	Hydrologic Connectivity	
	Hydrology Attribute	
	(metric 1a +metric 1b + metric 1c)/3	
2	***Water Quality***	
2a.	Nutrients/Contaminants	
2b.	Sediment	
2c.	Buffer Filter	
	Water Quality Attribute	
	(metric 2a +metric 2b + metric 2c)/3	
3	***Biota***	
3a.	Vegetation	
3b.	Habitat Connectivity	
	Biota Attribute	
	(metric 3a + metric 3b)/2	
	Overall Condition Score	

4. OKRAM Overall Condition Score- Riverine

	Metric	Score
1	***Hydrology***	
1a.	Hydroperiod	
1b.	Water source	
1c.	Hydrologic Connectivity	
	Hydrology Attribute	
	(metric 1a +metric 1b + metric 1c)/3	
2	***Water Quality***	
2a.	Nutrients/Contaminants	
2b.	Buffer Filter	
	Water Quality Attribute	
	(metric 2a +metric 2b)/2	
3	***Biota***	
3a.	Vegetation	
3b.	Habitat Connectivity	
	Biota Attribute	
	(metric 3a + metric 3b)/2	
	Overall Condition Score	

5. Additional notes and suggestions to improve this assessment

Metric	Score	Was the metric scored too high or too low? Why?	How can the metric be improved in the future?	Are there additional indicators that need to be considered?
1a. Hydroperiod				
1b. Water Source				
1c. Hydrologic Connectivity				
2a. Nutrients and Contaminants				
2b. Sediment				
2c. Buffer Filter				
3a. Vegetation				
3b. Habitat Connectivity				
Additional Notes				