Using Micro and Macrotopography in Wetland Restoration

USDA NRCS
Natural Resources Conservation Service

Wetland Restoration Supplement [Code 657]

Texas Zone 4 May 2004

This document is intended to be used as a tool to assist in the planning of wetland restorations where the natural topography of the site has been eliminated. The planner is encouraged to be creative when developing the restoration plan. The concepts within can also be used whenever the development of macrotopographic features are desired.

WHAT IS MACROTOPOGRAPHY?

Background Undisturbed wetland systems in east Texas typically consist of complexes that contain a diversity of topographic relief from extremely shallow areas with minor ridges (microtopography) to deeper wetland habitats that include some upland characteristics (macrotopography). When wetlands are drained or altered, they normally lose most of their micro and macro topographic relief through land leveling or other agricultural activities.

Macrotopographic features are wetland "ridge and swale" complexes whose basins are depressional in landscape position and occur on terraces and in floodplains. The basin areas are normally from 0.1 acre to 5 acres in size with depths running from 0-30 inches, depending on the landscape position. These types of wetlands can be found in a multitude of shapes ranging from simple circular basins, to complex amoeba-like outlines, to meandering scours. Ridges (linear) and mounds (circular or elliptical) make up the "upland" component of macrotopographic features that normally do not exceed 30" in height. Together, the ridge and swale features form ephemeral wetlands that hold water from only a few weeks to several months during the year.

Microtopographic features are normally thought of as those shallow depressions with less than 6 inches of depth between the swales and ridges. Examples of microtopography can be seen in flat fields where shallow "sheet" water stands for short durations after a rain. **Within the scope of this document, macrotopography will be assumed to include microtopographic features.**

WHY IS THE DEVELOPMENT OF MACROTOPOGRAPHY IMPORTANT?

The development of macrotopographic complexity creates a diversity of water regimes (hydroperiods) which can increase water quality, provide flood storage, and enhance the development of a more diverse vegetative community. This results in greater overall wildlife benefits through the development of a variety of habitats. The dispersal, germination, and establishment of plant species, and the life cycles of many amphibians, reptiles, and other wildlife species are dependent on variations in the timing, depth, and duration of flooding.

Food In the spring, shallow, ephemeral wetlands warm up before larger, deeper bodies of water, and provide important seasonal forage for shorebirds, waterfowl, nonmigratory bird species, and other wildlife. These types of wetlands produce significant amounts of protein-rich invertebrates including snails, worms, fairy shrimp, midge larvae, spiders, backswimmers, diving beetles, dragonflies, and damselflies. Organic (woody and herbaceous) debris, roots, leaves, and tubers from aquatic vegetation are additional food sources and provide substrates for macroinvertebrates.

Pickerel Frog

Habitat Wetland restoration plans that include undulating landscape features create a diversity of habitat types. Swales, oxbows, potholes and other macrotopographic basins provide varying hydroperiods from short-term ponding to seasonal and semi-permanent water conditions. A wetland, or wetland complex, with multiple hydroperiods can support a variety of habitat zones. Scrub-shrub, submergent, emergent, and floating-leaf communities (e.g., duckweed) are examples of herbaceous aquatic habitats. A diverse wetland plant community benefits numerous species of wildlife including many fur-bearing mammals, waterfowl, shorebirds, wading birds, amphibians and reptiles. Because native plants provide the best overall habitat, are essentially self-sustaining, and tend to be non-invasive, only native vegetation should be planted. Note: Wetland Wildlife Habitat Management (code 644) - Texas Zone 4 Supplement, has a list of native wetland plant species.

Low-level mounds or ridges (maximum 30 inches) are considered to be a component of macrotopography, and can greatly increase the biological diversity of restoration sites when combined with basins. Amphibians, for example, tend to have small home ranges. Thus, having a diversity of wetland types in close proximity to terrestrial habitats within the project area will support the greatest populations.

PLANNING

When developing macrotopographic features, the planner should determine the target species (i.e. species of concern) and review historical aerial photography to determine the appropriate features to include in the restoration project.

Eastern Tiger Salamander

Amphibians and Reptiles A primary focus of macrotopography development is the creation of habitat for frogs, toads, salamanders, newts, turtles, and snakes. These amphibians and reptiles are known as herpetofauna or commonly called “herps”. Amphibians are an especially diverse group and require wetlands with differing hydroperiods and habitat types. Because macrotopographic basins are often completely dry by summer or early fall, they are normally free of fish. Occasionally pools do retain water year round, but due to warm water conditions that create low oxygen levels, they still do not support fish populations. This is important because fish are primary predators of larval, tadpole, and adult amphibians. In general, sites flooded for longer periods will have more predators of amphibians.

The timing and duration of flooding are important factors that dictate which amphibians will use a particular wetland. Amphibian species are extremely variable in their habitat requirements. Most breeding occurs from May through August, with eggs hatching anywhere from 4 to 20 days later. Complete metamorphosis may take an additional 7 weeks to 3 months. Some species may need as much as a year to develop, with a few species even over-wintering as tadpoles, requiring permanent water.

Table 1 (modified from Knutson et. al.) is an example of the diversity in preferred breeding periods and guild associations, for a study in an Iowa and Wisconsin.

Table 1[1]

			Breeding[2]		Nonbreeding[3]			Hibernation[4]		
Common name	Scientific name	Breeding period	Perm. water	Temp. water	Water	Forest/ litter	Open	Water	Forest/ litter	Ground
Wood frog	Rana sylvatica	Mar.-Apr.	N	Y	N	Y	N	N	Y	N
Chorus frog	Pseudacris triseriata	Mar.-May	N	Y	N	Y	Y	N	Y	N
Spring peeper	Pseudacris crucifer	Mar.-Summer	N	Y	N	Y	N	N	Y	N
Leopard frog	Rana pipiens	Apr.-June	Y	Y	Y	N	Y	Y	N	N
Pickerel frog	Rana palustris	Apr.-mid June	Y	N	Y	Y	Y	Y	N	N
American toad	Bufo americanus	Apr.-June	Y	Y	N	Y	Y	N	Y	N
Eastern gray treefrog	Hyla versicolor	May-Aug.	Y	Y	N	Y	N	N	Y	N
Cope's gray treefrog	Hyla chrysoscelis	May-Aug.	Y	Y	N	Y	Y	N	Y	N
Cricket frog	Acris crepitans	May	Y	N	Y	N	N	N	Y	N
Green frog	Rana clamitans	Mid May-July	Y	N	Y	N	N	Y	N	N
Bullfrog	Rana catesbeiana	May-July	Y	N	Y	N	N	Y	N	N
Fowler's toad	Bufo woodhousii	Mar.-Aug.	N	Y	N	N	Y	N	N	Y

[1] Species that can successfully survive or reproduce in a habitat during the identified life-history phase are identified with a Y; those that do not with an N.
[2] Will breed in permanent water or temporary (ephemeral) ponds.
[3] Active, nonbreeding portion of the year is spent in the water or along the water edges, in trees or forest litter, or in open, nonforested habitats (grasslands).
[4] Hibernation or estivation period is spent in or near water, in forest litter, or underground.

In east Texas, the species that metamorphose their life cycle by early summer are the ones we need to target. Therefore, **macrotopographic basins should be designed to keep water available until at least mid-July.** Note that the process of a wetland drying out is beneficial. It eliminates insect and vertebrate predators, allows seeds to germinate, and exposes detritus to processes of oxidation thereby releasing nutrients.

When planning a site for amphibian and reptile habitat, macrotopographic features should make up approximately 30-50% of the area. The water (swale, meander, etc.) and the upland habitat (mound) acreage are combined to get the percent of macrotopographic features. It can be assumed that for every acre of water created, an additional acre of mound is created.

Placing large logs, rocks and debris piles within pools and in the shallows will provide basking and loafing habitat for turtles and snakes. Turtles will use flat, sandy, exposed, shoreline for egg laying. Macrotopography mounds are readily used by turtles, frogs, and snakes. Larger mounds will invite alligators. Alligators prey on turtles, frogs, and snakes.

Where restoration sites have a designed water level, such as those with levees and control structures, approximatey 30% of the area should have macrotopographic features. Consider concentrating macrotopographic features in and near the more shallow water reaches.

Where restoration sites do NOT have a designed water level, such as in floodplains where high stream flows would destroy levees and control structures, approximatey 50% of the area should have macrotopographic features. Note that in these landscapes, the macrotopographic basins may provide the only standing water on the restoration site. Consider concentrating the deeper macrotopographic features in the lower elevations of the site, and shallower features in the higher elevations.

Shorebirds Shallow, ephemeral wetlands provide an abundance of aquatic invertebrates that are a critical food source for shorebirds during migration. Most shorebird species will utilize wetland habitats with water depths from 0-3 inches, and will rarely forage in water depths greater than 6 inches. Maximizing areas which provide conditions from mudflats through 3 inches deep during spring and late summer will provide the greatest benefits for migratory shorebirds.

Waterfowl These same shallow basins provide important invertebrate forage for waterfowl, particularly during spring migration when nutrient needs prior to nesting are high. In addition, several species of dabbling ducks (e.g. mallards and blue-winged teal) will utilize temporary wetlands for pair bonding and mating. Although these temporary ponds may not have water long enough to provide brood habitat in most years, they serve an important function in distributing pairs across the landscape and allowing for courtship rituals. Visually isolating basins, or portions of basins, through irregular shaping will particularly benefit species such as mallards which are more territorial. When combined with semi-permanent basins in close proximity, macrotopographic basins contribute to excellent wetland complexes for waterfowl breeding.

Soils It is important for the planner to identify those portions of the restoration site which have hydric soils or soils that will most likely respond to macrotopographic development. Look for soils that have low permeability, a restrictive under-lying layer, or high water tables.

Sites which have soils that are hydric due only to flooding may not be appropriate if the soils are well drained and are not very frequently flooded. In these cases, it may not justify the expense of creating macrotopography and the planner should consider only vegetative restoration measures. If it is unclear whether or not there is sufficient hydrology to maintain the needed water levels within the basin areas, a water budget should be calculated.

Succession and Long-term Management Succession of wetlands is a natural process that can result in significant habitat changes over time. Primary changes include, for example, the development of aquatic macrophytes, invasion of wetlands by trees and shrubs, and canopy closure over wetlands embedded in forested landscapes. Such changes can alter the species composition of wetlands over time by selecting for species that favor or can tolerate later successional stages. Early successional species will consequently be lost, thereby lowering diversity, and can only be restored by periodically reversing succession. Plans to periodically (e.g. every 10-20 years) reverse the effects of succession in some portion of all wetlands (e.g. 5-10% of the total number per year) are important to consider. Natural processes that can reverse succession vary among regions and should mimic local regimes but may include flooding, drying, and burning. Human disturbance regimes such as mowing, timber harvest, draw-downs, or even herbicides may be considered, but only with extreme caution because of possible negative indirect effects.

MACROTOPOGRAHIC BASINS

The macrotopograhic basins are described in abbreviated format as: shape/size/depth.
Where:

1) the shape is described below
2) the size is in acres
3) the depth is in feet

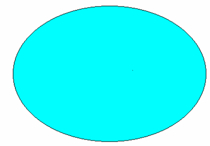
For example, a macrotopograhic basin described as Oxbow/1.5/0.5-1.0-2.0:

1) has shape #2 below,
2) is 1.5 acres in size, and
3) is composed of 3 depths (0.5’, 1.0’ and 2.0’)

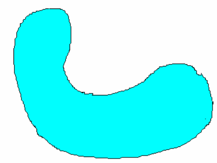
BASIN SHAPE DESCRIPTIONS

Basins should be irregular in shape. Irregular shapes increase edge and provide additional cover for waterfowl and other wildlife utilizing the site.

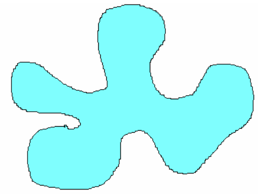
1) Shape: **Oval**
Description: Generally circular



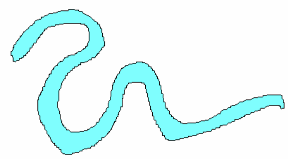
2) Shape: **Oxbow**
Description: Kidney shaped with 2 lobes



3) Shape: **Amoeba**
Description: Multiple lobes with random shape, high perimeter to surface area ratio



4) Shape: **Meander**
Description: Mimics an abandoned stream channel meander

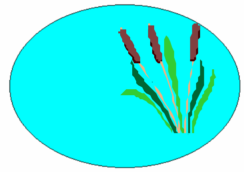


DEPTH DESCRIPTIONS

AERIAL VIEW | **CROSS SECTION**

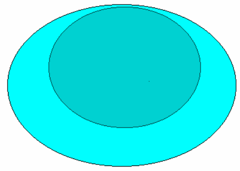
When <u>1 depth is indicated</u>:

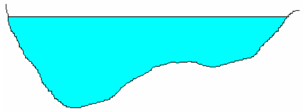
? the basin is primarily 1 depth



When <u>2 depths are indicated</u>:

? each depth composes approximately 50% of the area

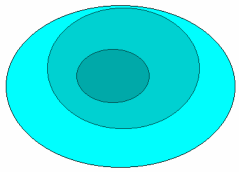


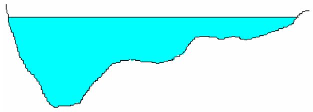


When <u>3 depths are indicated:</u>

the depths compose approximately:

? deepest depth = 20% of the area
? middle depth = 30% of the area
? shallowest depth = 50% of the area





HABITAT MOUNDS

Fill excavated from the macro-topograhic basins can be used to create multiple upland habitat conditions based on the height, shape, and location of habitat mounds. Variations in habitat mound design can provide escape areas, denning sites, nesting opportunities, and plant diversity, as well as providing visual breaks within the wetland complex. All side slopes for mounds should have a minimum slope of 6:1, but should be as flat as is feasible.

Where restoration sites have a designed water level, habitat mounds should vary in elevation from above to below the expected normal waterline. Approxmately 1/3 of the mounds should be 6 inches to 1.0 foot **below** the normal water elevation, 1/3 should be 6 inches to 1.0 foot **above**, and 1/3 should be **at** the normal water elevation.

Where restoration sites *do not* have a designed water level, habitat mounds primarily provide upland habitat and tend to direct water flow during flood conditions. Approximately 50% of the mounds should be 6 inches to 1.0 foot above average ground level, and 50% should be 1.0 to 2.0 foot above the normal ground elevation. Mounds should mimic the natural landscape as much as possible. For example, if the site is located on the interior of a river oxbow, ridge and swale design may be appropriate (see figures 2 and 3). When possible, place mounds in such a way as to increase meander distance by directing water flow in a path that meanders across the unit.

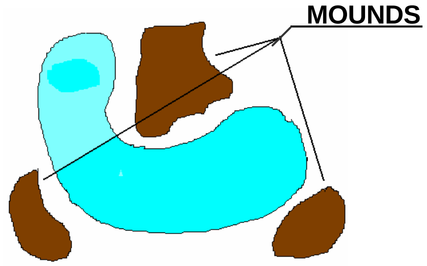


Figure 1

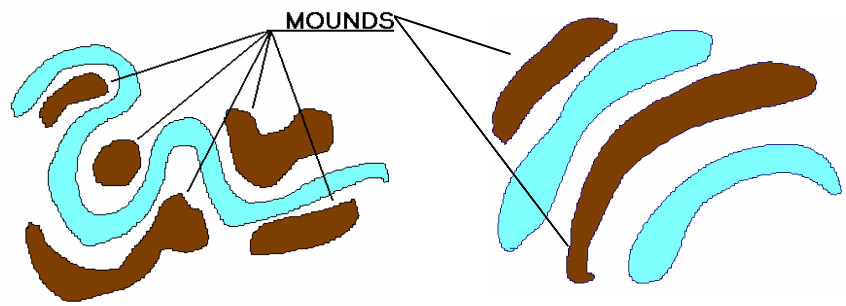


Figure 2

Figure 3

ADDITIONAL MODIFICATIONS

Ditches of varying depths and widths can connect basins to diversify a site. They provide additional cover for waterfowl as well as escape routes away from predators. Connection ditches may have 3:1 (or flatter) side slopes. In some cases, they can also be used for boat access to the site for hunting and recreational viewing, or to limit vehicular traffic of the site. See Figure 4.

Note: In situations where amphibians are the primary species of concern, connecting ditches should be limited because they provide access routes for predatory fish, particularly if connected to deeper, more permanent pools.

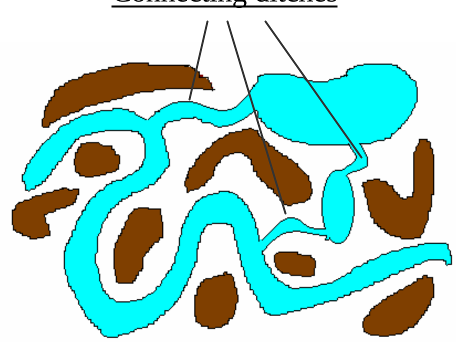


Figure 4

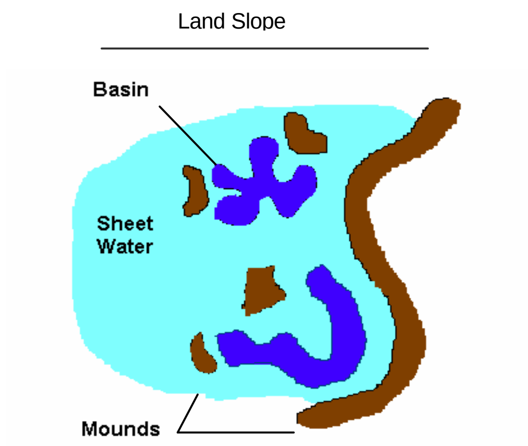


Figure 5

On gently sloping sites, an efficient means of providing shallow, "sheet" water habitat is through the creation of linear habitat mounds. The excavated material from a macrotopographic basin is used to form a low, meandering ridge on the down slope side of the basin(s). Typical heights for the mound range from 1 to 2 feet. By using the spoil in a creative manner, the total shallow water on a project site can be substancially increased. The impounded sheet water provides seasonal or ephemeral water for shallow feeders such as shorebirds, while the excavated basins provide longer hydroperiod wetland habitats. This method can also be utilized where wetland meadow conditions are desired.

CONSTRUCTION

Creative Borrowing Borrow areas for dikes or embankments can be incorporated into the development of macrotopographic features. Potholes, swales, meanders, and other shallow water habitats can serve as borrow areas for needed fill. All side slopes for basins should have a minimum slope of 6:1. Note that, when feasible, slopes should be as flat as possible. Slopes exceeding 20:1 are not considered excessive for habitat purposes. Examples of this include situations where equipment operators randomly fill their scrapers leaving shallow, single-trip borrow sites. Note that the borrow areas will result in the basins being the deepest portions of the wetland complex. In seasonal or ephemeral wetlands these areas provide a diversity of hydroperiods by holding water later into the year than the remainder of the wetland.

Rough-finish Grading Desired macrotopographic features will have rough surfaces on all side slopes and top, an undulating bottom, and a ragged shoreline.

Woody Debris

- Provides sunning and resting areas for turtles and snakes
- Provides loafing sites for waterfowl
- Is a source for organic soil material
- Provides additional vertical and horizontal habitat
- Is an excellent substrate for invertebrates

Depending on water velocities the debris may or may not have to be partially buried. Use as needed.

ASSOCIATED TECHNICAL STANDARDS

This technical note can also be used in association with the following technical standards:

- Wetland Creation [code 658]
- Wetland Enhancement [code 659]
- Wetland Wildlife Habitat Management [code 644]

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