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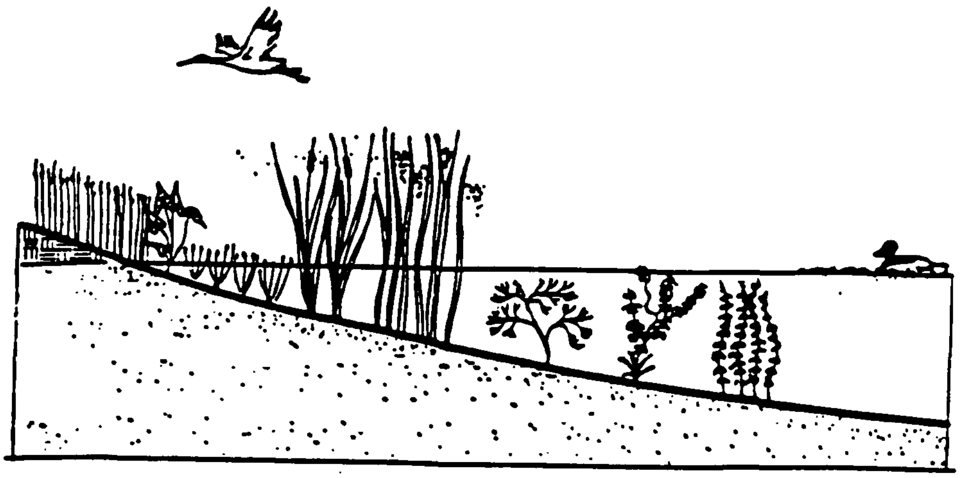
RESTORING AND CREATING WETLANDS: A HANDBOOK FOR THE ROCKY MOUNTAIN WEST



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Restoring and Creating Wetlands:

A Handbook for the Rocky Mountain West

by

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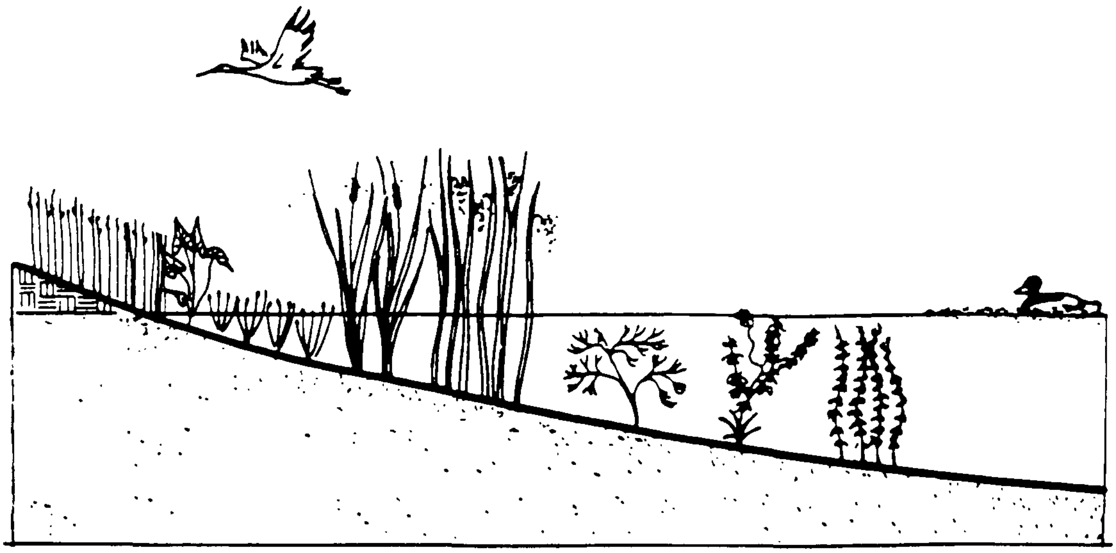
Contents



Introduction

In the semiarid basins and mountains of the West, water limits the productivity of most landscapes. Yet along floodplains, in marshes, and in other wet areas, productivity is very high. These wet ecosystems provide important habitat for many plants and animals, clean the water that flows through, can provide flood control value, and also create an abundance of forage for livestock and exceptional recreational opportunities. These areas are *wetlands*.

In many years, wetlands have saturated or flooded soils for a long period of time during the growing season. The saturated soils are called *hydric* because they develop *anaerobic* conditions (with no oxygen available to plants and animals in the soil) during this period of saturation. Plants called *hydrophytes* (water plants) dominate wetlands. Common hydrophytes include willows, alders, cottonwoods, cattails, bulrushes, and many sedges and rushes. The combination of abundant water, hydric soils, and hydrophytes occurs only in wetlands. Many different types of wetlands occur in the Rocky Mountain West, including marshes, wet meadows, peatlands, and riparian shrublands and forests. Each type has unique hydrological patterns and processes, plant species, and soils.

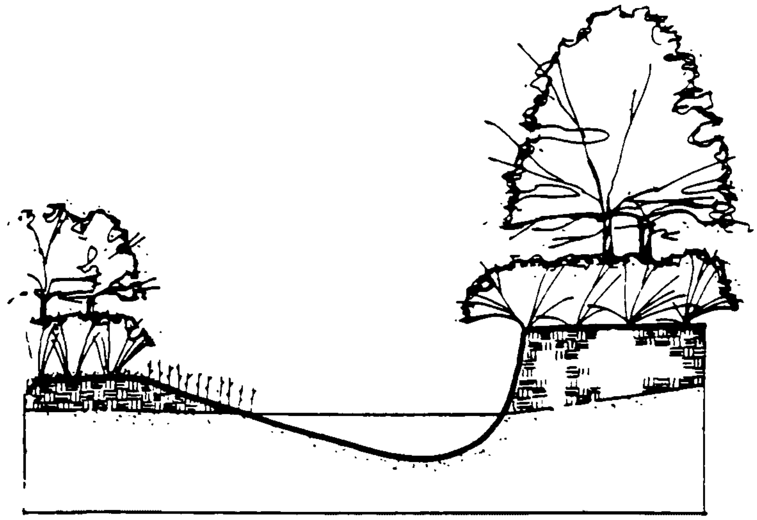
Human activities have often resulted in the draining, dewatering, and filling of Rocky Mountain wetlands. Although these activities have made urban and agricultural development possible, they have also greatly reduced the acreage of natural wetlands and eliminated the beneficial functions wetlands performed. Wetland restoration and creation is a way to restore these ecosystems that naturally function to provide clean water, healthy fish and wildlife populations, and important recreational opportunities.

Today, many dredge-and-fill activities in wetlands require a Section 404 permit under the federal Clean Water Act. Appropriate mitigation for unavoidable wetland losses is often a permit requirement. Mitigation usually involves the restoration of degraded wetlands or the creation of new wetlands as compensation. Many organizations and individuals are also interested in wetland restoration and creation – for waterfowl, shorebird or fish habitat, for environmental restoration, or for treatment of urban or agricultural runoff.

This handbook provides ideas and methods that will be useful in the design of wetland restoration and creation projects.

Rocky Mountain Wetland Types

Several different types of Rocky Mountain ecosystems are lumped together under the general term *wetlands*, including marshes, wet meadows, peatlands, and riparian shrublands and forests. Each wetland type has unique ecological characteristics. The methods for restoring and creating one wetland type may not be appropriate for another. For background, the four most common Rocky Mountain wetland types are described below. These names are used throughout this handbook.



Marshes are wetlands dominated by herbaceous plants, such as cattails and bulrushes. They have standing water for at least several weeks in most summers, and they occur at lower elevations in the mountains and on the plains and intermountain basins. Water and soil can be fresh or saline. Thus, salt and fresh water marshes occur.

Wet meadows have water tables near the soil surface but rarely have standing water more than 8 inches deep. They are dominated by herbaceous plants such as rushes and can occur at any elevation. Water and soil can be fresh or saline.

Peatlands occur where a constant flow of ground water reaches the surface, keeping soils saturated for most of the summer. Saturation maintains anaerobic conditions that retard the decomposition of roots and leaves, which accumulate to form peat. Peatlands are typically dominated by sedges, such as water sedge, and/or willows, such as planeleaf or wolf willow. The water supply can have low or high salt content, and it may be acidic, neutral, or basic.

Riparian wetlands occur on the banks and floodplains of streams. Flooding, sediment erosion, and deposition occur frequently. The soils are mineral sediments. Riparian wetlands are typically dominated by trees such as plains or narrowleaf cottonwoods, willows such as geyer or mountain willow, alders, and a wide variety of herbaceous plants such as canada reedgrass. Although *riparian* refers to the banks of streams, in the western U.S. this term is used broadly by some land management agencies to mean any wetland. In this handbook, the stricter definition is used.

These wetland types clearly have different hydrologic regimes, soils, and vegetation. Different methods must therefore be used for restoring and creating each wetland type. If project goals include creating a marsh for waterfowl habitat, then the hydrologic regime required by marsh plant species must be created, rather than a hydrologic regime suitable for wet meadow species.

Wetland Functions

Wetlands perform many different ecological functions, but it should be understood that no wetland provides all functions. Wetlands are well known as habitat for many species of wildlife, particularly migratory waterfowl and shorebirds, fishes, many mammals, amphibians, and songbirds. Many wetlands purify water by removing sediment and converting or using phosphorus and nitrogen compounds. In addition, wetlands may retain heavy metals and other pollutants. Stormwater runoff may be detained in certain wetlands, thereby providing flood control. Some wetlands serve as ground water discharge or recharge areas. These functions are all provided at no cost to the public.

The four wetland types described above each perform different functions. Marshes are the most important waterfowl habitat in the region, particularly where the water is shallow and the vegetation and invertebrate fauna are diverse. Shorebirds, fishing birds, many mammals, and most amphibians depend on marshes almost exclusively. Marshes also perform important water quality functions by assimilating large amounts of nutrients, sediment, and pollutants. In certain areas, marshes can retain stormwater and provide important education and recreation opportunities.

Wet meadows are important filters of water, removing sediments and pollutants. They provide very important forage for domestic livestock and wildlife. Many wet meadows retain large amounts of snowmelt water that is discharged to streams and other water bodies later in the summer.

Peatlands occur where abundant ground water is discharged. This water is filtered by the peat soils, and many heavy metals and pollutants are re-moved. The herbaceous plants in peatlands provide important forage for wild ungulates. Peatlands often contain rare plant species. These ecosystems are among the most beautiful in the Rocky Mountains.

Riparian wetlands provide important bank habitat for trout. Dead autumn leaves falling into streams can get lodged under rocks and provide food for the stream invertebrates upon which trout depend. Woody riparian vegetation is critical habitat for many songbirds. Riparian vegetation also anchors streambanks and prevents erosion. Some floodplains can retain water and reduce the risk of damaging floods downstream. This water is slowly discharged back to the stream, helping maintain base flows later in the summer.

When designing a wetland restoration or creation project, it is important to consider the functions that will be restored or created These functions should become a design focus for the project.

Definitions

The terms mitigation, restoration, creation, and enhancement are defined here as they are used in this text. These definitions are from Lewis (1989, in Kusler and Kentula 1989).

Mitigation: the actual restoration, creation, or enhancement of wetlands to compensate for permitted wetland losses. Mitigation must involve the lessening of unavoidable impacts created by a project.

Restoration: the processes of returning a site from a disturbed or totally altered condition to a previously existing natural or altered condition. This process requires some knowledge of the type of wetland that occurred prior to modification.

Creation: the process of converting a non wetland area to a wetland.

Enhancement: the increase in one or more values of all or a portion of an existing wetland by man's activities. Enhancement is not specifically discussed in this handbook, but many ideas for wetland enhancement could be derived from the material presented.

Impacts to Wetlands

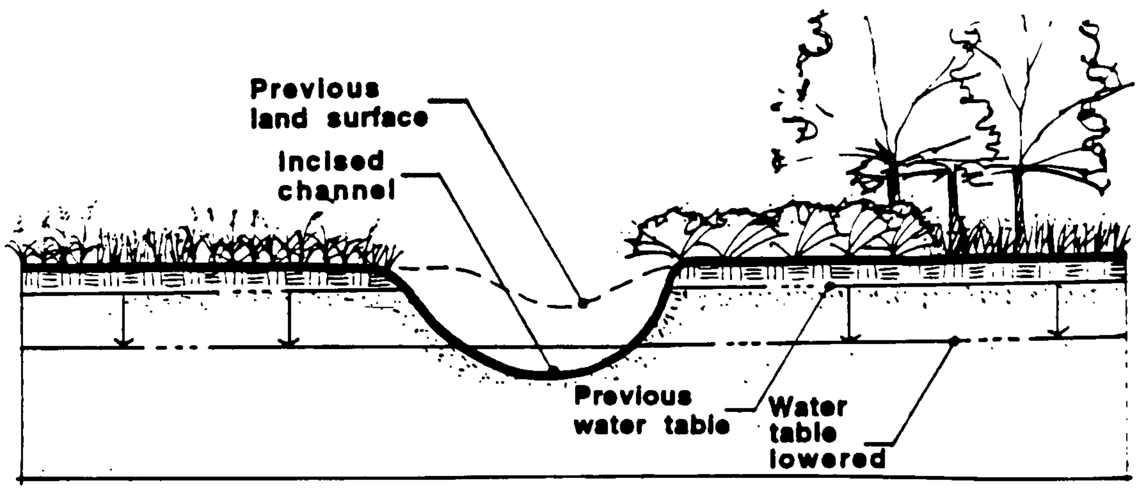
Many wetlands in the Rocky Mountain West have been impacted by man's activities. Hydrologic changes resulting from the construction of dams and diversion weirs are most common. These activities reduce spring and summer stream flows, diminish flooding, narrow stream channels, eliminate stream dynamics, and remove sediment from stream water. Some important plant species, such as cottonwood trees, reproduce primarily on the fresh bare sediment produced by flood waters. The reduction of flooding and spring flows has limited the natural reproduction of cottonwoods along many streams.

Wetlands have been drained for agricultural and urban uses. In some areas woody plants, such as willows, have been removed from stream valleys to increase hay and grazing lands. Willows provide important wildlife habitat; in addition, their roots anchor and stabilize streambanks and provide important fish habitat. Streambank willow and alder leaves that drop into the water become the food that invertebrates consume. Thus, the aquatic food chain, including trout, depends upon streamside vegetation.

Removal of willows, channelization, and removal of sediment upstream can lead to channel erosion and downcutting. This channel degradation lowers local water tables, and can destroy streamside vegetation. The result is loss of fish and wildlife habitat and other wetland functions.

Urbanization has resulted in the leveling of large areas, and wetlands have been directly filled. Urban development also requires large amounts of gravel, much of which is mined from floodplains. The great extent of paved streets, parking lots, and roofs promotes rapid runoff of rain and snowmelt, making urban streams "flashy." Stormwater collection systems channel this runoff to urban streams, which can be badly degraded. Some urban streams have been "engineered" or otherwise channelized to carry this water and to reduce flood hazards. The natural functions and values of these systems are lost in the process.

Many of these impacted wetlands can be restored or new wetlands created to provide the functions and values that were lost.



INCISED CHANNEL

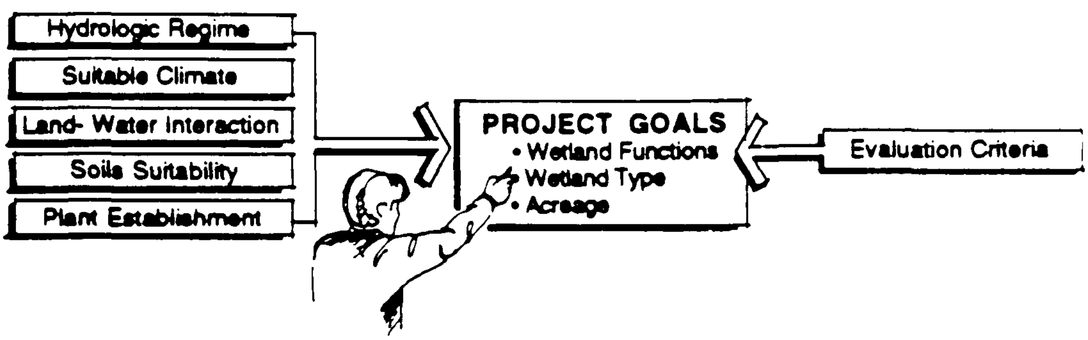
Channel incision can cause water tables on floodplains to drop, resulting in the degradation of riparian wetlands.

Planning the Project

Developing Project Goals

Restoring and creating wetlands requires making dry land wet via seasonal inundation or a high water table. Project goal should detail the type of wetland ecosystem and ecological functions to be developed. The existing and potential hydrologic regime of a project site must be carefully studied, and possible interactions between the land and water carefully planned. Also, to realize many of the wetlands functional benefits, appropriate plant species must be established.

If the project is compensatory mitigation for wetland impacts, will the project be performed *on-site* or *off-site* from where the wetland impacts are occurring? Is it necessary for the project to provide *in-kind* (the same type of wetland) mitigation, or is *out-of-kind* (a different type of wetland) mitigation acceptable? The type of wetland ecosystem that can be created on any site is often limited by the existing and potential site hydrologic regime, climate, and other factors. It may be most desirable to determine the mitigation goals, then find a suitable project site. Another important consideration is the size of the wetland that is planned.



A detailed description of project goals allows a careful plan to be designed, implemented, and later evaluated. When developing goals, consider the following:

1. Are the project goals compatible with the environment of the project site? Planning to create a cattail marsh in a high mountain environment would be unsuccessful because cattails are not sufficiently cold tolerant.

2. What will be the project water source? Determine whether the wetland will interact with surface water, ground water, or a combination of the two, and whether sufficient water is available for the project. Resolving the legal issue of water rights for all consumptive uses is also critical.

3. What is the quality of the water source? Water with excessive or insufficient salt, heavy metals, nutrients, and other substances can doom the project, yet water quality is usually unknown without chemical analysis.

4. What types of land-water interactions can be designed? Will the site have spring flooding or a high ground water table? Will it be filled by rainstorm runoff? Design the hydrologic functions that are desireable and appropriate for the site.

5. Does the site have suitable soils for the proposed plan? Impermeable soils can limit ground water connection; highly permeable soils can prevent water applied to the surface from saturating the soil.

6. How will the desired plant species be established? Establishing the desired plants on a site is an excellent indicator of project success, but many plant species are difficult to establish, and weeds often come to dominate disturbed soils on project sites.

7. Wetland restoration and creation is often done to replace lost wetland functions. Therefore, the project must be designed to perform these functions. One function may degrade another wetland function. For example, flood control results in sediment retention. Sediment accretion can reduce wetland longevity and cause vegetation changes as well. Thus, the effect of one wetland function on others must be considered in the planning phase.

8. Determine the evaluation criteria for project success or failure in the planning stages. Include aspects of the proposed hydrologic regime, vegetation, ecological functions, soils, and other characteristics to be developed at the site. Carefully planned projects should be successful. However, unexpected events and issues that can jeopardize project success always arise during and after construction. For example, an unusually dry or wet year can cause plantings to fail. A culvert inadvertently placed at the wrong elevation between two portions of a wetland can cause one area to be too dry or to have water that is too deep. Planning the evaluation methods in advance makes it easier to discover problems and develop solutions during and after construction.

Choosing the Wetland Type

Choosing the correct wetland type for a site is essential. First consider the regional climate and the types of wetlands that naturally occur in the project area. Choose several existing natural and created wetlands as *reference wetlands* to use for comparison while developing project goals. Study the hydrologic regime, water chemistry, and vegetation of the reference wetlands to clarify the regional potential. Data from reference wetlands are invaluable for planning the proposed project.

Next determine the potential for establishing the desired plant communities and wetland functions at the proposed wetland. Some of the easiest wetland types to create, such as cattail marshes, are not desirable or possible in most situations. Again, use the *reference wetlands* in the project area to develop ideas about the wetland community types that are possible and the plant species that are present in them.

Consider allowing the wetland functions to drive the planning process. Each wetland type provides different ecological functions. For example, if wildlife habitat is to be the primary wetland function, first determine the wildlife species of interest. Developing a wetland community dominated by woody plants, such as willows, is desirable for attracting warblers and vireos, but a bulrush-dominated marsh community is more appropriate for rails, marsh wrens, and white-faced ibis. The hydrologic requirements of these wetland community types are very different and must be planned.

Remember that the time required for establishing a functioning ecosystem is different for each wetland type. A bulrush marsh at a low elevation site can be developed in one or two growing seasons if the hydrologic regime is properly established and if the planting is successful the first year. By contrast, establishing a cottonwood forest or a sedge-dominated peatland may take decades, even if the hydrologic regime and plantings are successful. The most rapidly established wetland types (marshes) should not be chosen merely because short-term success can be shown. Restoring or creating a more difficult wetland type may be much more valuable in the long term. The evaluation of project success must recognize the time scales required for the wetland type being created.

Selecting the Site

Each potential project site should first be screened for "red flags," including hazardous waste buried in soils, complex or inappropriate land ownership, easements or covenants, accessibility for equipment, presence of federal- or state-designated rare and endangered species, and other site- or region-specific issues.

RED FLAGS !
- ☐ Hazardous Waste
- ☐ Inaccessible
- ☐ Land Covenants
- ☐ Rare Species

SITE REQUIREMENTS
- ☑ Water Availability
- ☑ Disturbed Land
- ☑ Non-important Habitat

SITE SELECTION

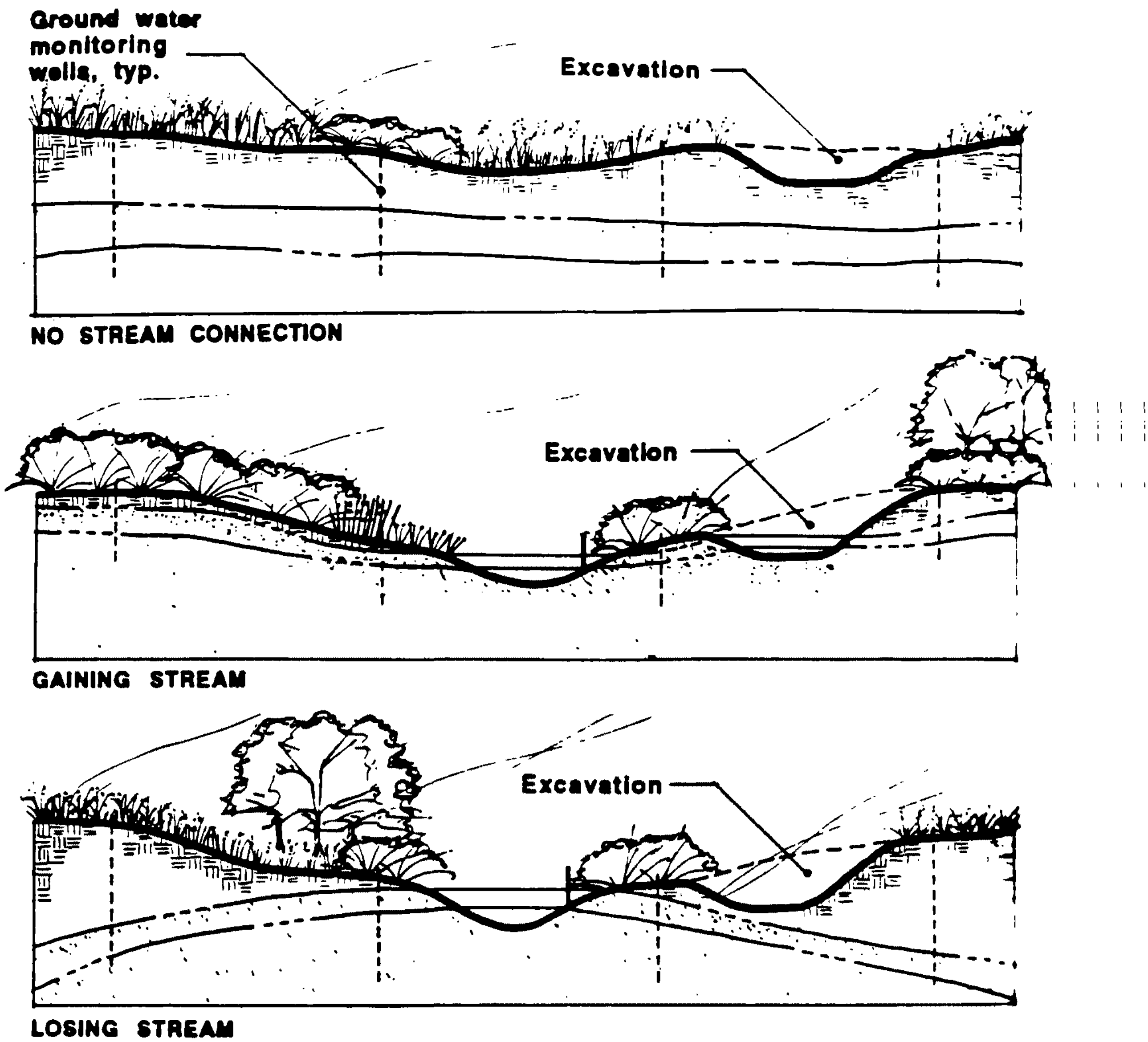
The availability of water for creating the appropriate interaction between the hydrologic regime and the land is paramount in site selection and must be considered next. A water table close to the soil surface, proximity to a surface water body, or access to other surface water is key. The project must, with a reasonable degree of effort, make the dry project site wet.

The land itself should be carefully considered. It should not currently be important habitat, and it is desirable if the land is already disturbed. Examples of sites that have good potential for wetland restoration and creation projects are ditched or drained wetlands, degraded streambanks, incised and/or channelized stream valleys, gravel and placer mines on floodplains, barren reservoir and lake margins, and areas with a water table close to the soil surface (within 3 to 4 feet). Although these lands are disturbed or degraded, all are close to surface and ground water.

It may also be possible to enlarge an existing wetland. If this is attempted, make sure that the existing wetland is protected from construction activities.

U.S. Fish and Wildlife Service National Wetland Inventory maps can be used to identify sites with channelized streams and wetlands fragmented by filling and draining. These sites could provide excellent project opportunities.

Before creating designs other than preliminary concept plans, data on the physical and chemical characteristics of the site should be collected and analyzed. Several sites should be selected for study because many sites are not suitable for the size or type of wetland that the project may require or have the budget to support. For example, many streams in the West are *losing streams*, meaning that the stream water is being lost to the ground water system. In these valleys, the ground water is deeper below the soil surface with increasing distance from the stream. Excessive depth to water table will make many types of wetland projects impossible. Some streams are *gaining streams*, which receive ground water and have different opportunities. By investigating a number of sites, chances that one will suit the project purpose are increased.



Creating a wetland adjacent to an existing swale or channel is possible only under certain ground water conditions. The top figure shows a seasonally dry swale with a deep water table. The middle figure is a gaining stream with a permanently high water table. The bottom figure shows a losing stream with a seasonally high water table. The proposed excavation shown will create a successful wetland only along the gaining stream.

Collecting the Data

HYDROLOGY
- [x] Water Surface Elevation
- [ ] Seasonal Water Levels
- [ ] Flood Frequency
- [ ] Ground Water Configuration
- [ ] Long-term Hydrologic Patterns

SOILS
- [x] Soil Texture
- [ ] Salinity
- [ ] Nutrients

VEGETATION
- [x] Potential Species for each Wetland Type
- [ ] Appropriate Water Level
- [ ] Propagation Methods for Chosen Species

PROJECT PLANNING DATA

Field data on the hydrologic regime, soils, and water chemistry of the proposed site and a knowledge of the life history characteristics of the desired plants are essential for designing a successful project. Before any work begins, establish at least one permanent benchmark to use for comparing elevations and cross-checking all aspects of the project.

Hydrology

A thorough study of the existing surface and ground water *hydrologic regime* at the proposed site is the best way to develop a realistic understanding of the potential for restoring or creating a wetland there. The data and analyses will be valuable in goal setting and absolutely critical to the final design, grading plan, and project cost estimate.

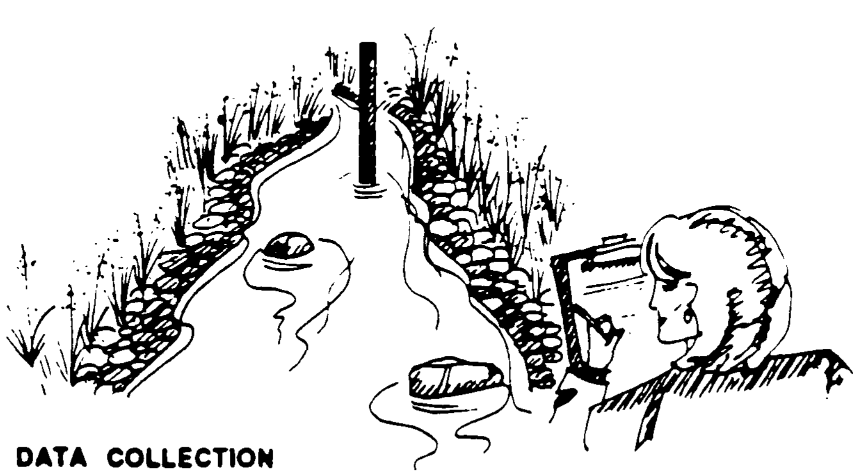
Surface water

If lakes or streams occur near the project site, water elevation, flow rate, and seasonal fluctuations are important to quantify. Water levels and flow volumes in some streams and lakes in the western U.S. are monitored by the U.S. Geological Survey, state governments, and other agencies, and data are available to the public. Where data are absent, collecting original data will be necessary.

Important surface water characteristics to understand are:

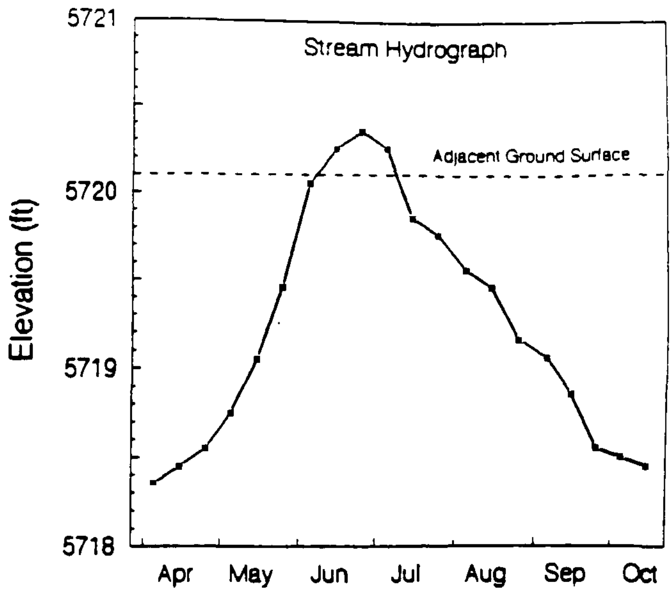
Water surface elevations in relation to the site. This can be determined by installing and monitoring staff gauges. These are essentially sturdy rulers anchored in a non-turbulent portion of the stream. The staff gauge should be surveyed for elevation, and water levels converted to water elevations. A hydrograph of water elevation by date for the period of record can be developed and used in the planning process. The data are used to determine the final site elevation for grading plans. For example, on a floodplain, grading the site to a certain elevation may allow it to flood, while grading it higher may prevent it from flooding.

State water laws. When planning a project that would result in the consumptive use of surface or ground water, state water laws must be considered. State law grants water rights to users, and in most areas all water is adjudicated to prior uses. It is unlawful to use water that belongs to someone else.



DATA COLLECTION

Seasonal water level differences. Knowing the difference in water elevation between the seasonal high and seasonal low is essential to the final grading plan. Use the hydrograph to determine the amount of seasonal change. Some sites have water tables that may fluctuate as little as one foot; others may fluctuate 5 to 10 feet.



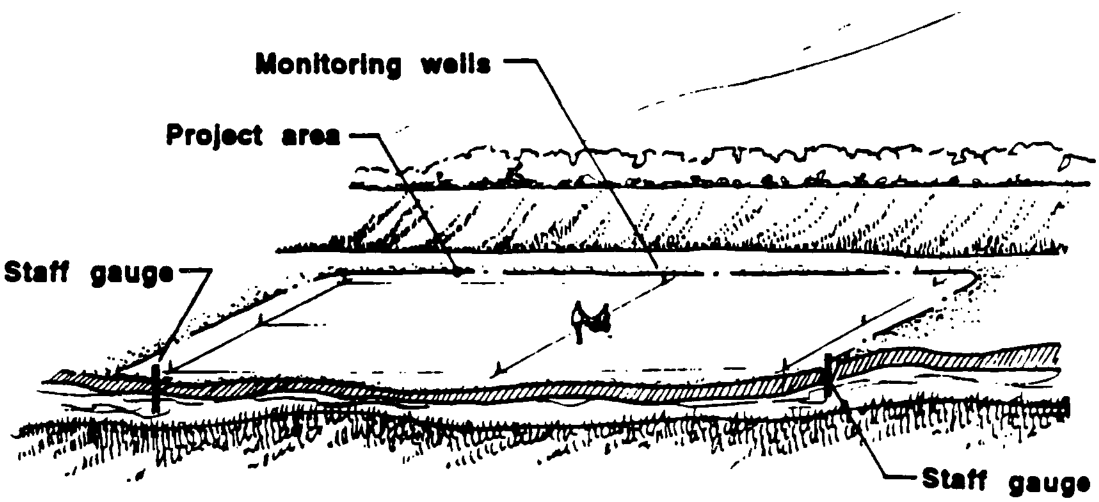
The frequency of flooding and the potential for damaging effects on the site. The magnitude of 2-year, 5-year, 10-year, and less frequent floods can be determined using stream gauge records.

Ground water

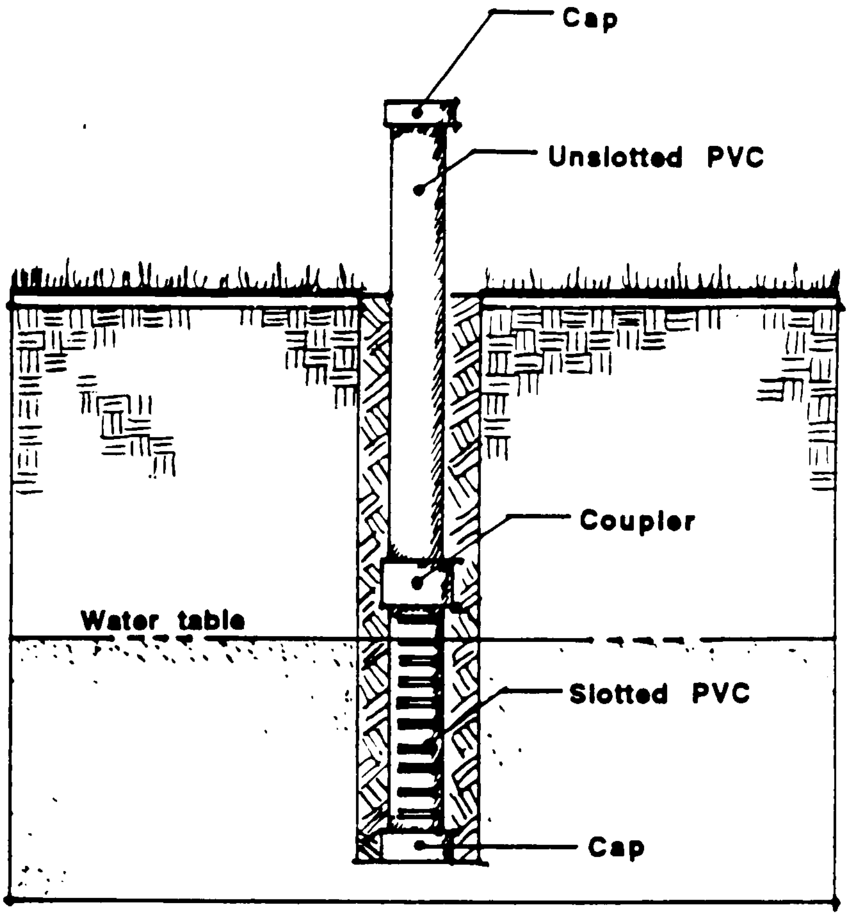
In most areas, ground water flows downgradient to, from, or parallel with a stream. But in some areas, it may not be connected to any identifiable surface waters. Ground water should be investigated using a grid of monitoring wells, as shown here.

Wells should be oriented across the site in lines perpendicular to the flow of water.

More than one line of wells may be necessary, depending upon the size and complexity of the site. Wells can be machine- or hand-augered. They can be shallow but must intersect the water table at all seasons, including the dry season.



GROUND WATER MONITORING



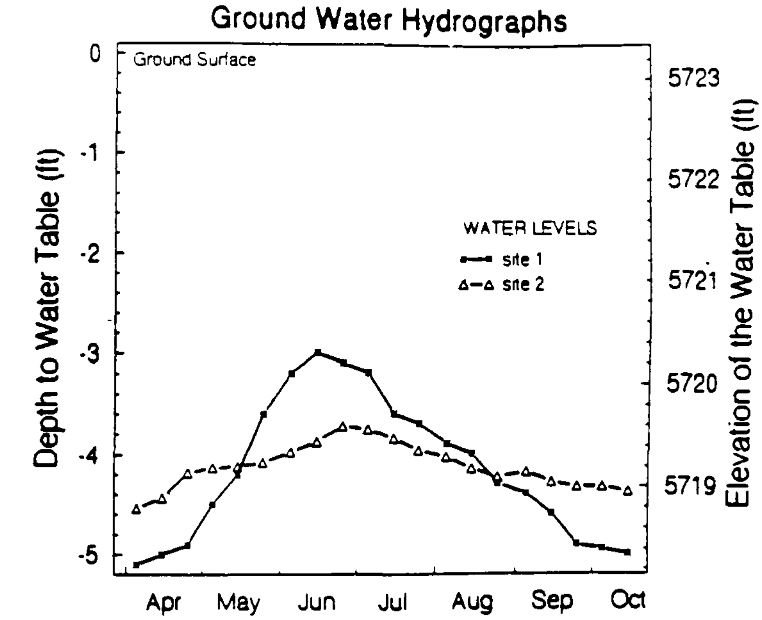
MONITORING WELL CONSTRUCTION

Wells are constructed of PVC pipe, with machine- or hand-slotted pipe below the water level and unslotted pipe above the water level. The pipe must be capped on both ends and firmly anchored in the ground by backfilling with sand or loosely packed native soil. The slotted PVC pipe must not fill with sediment.

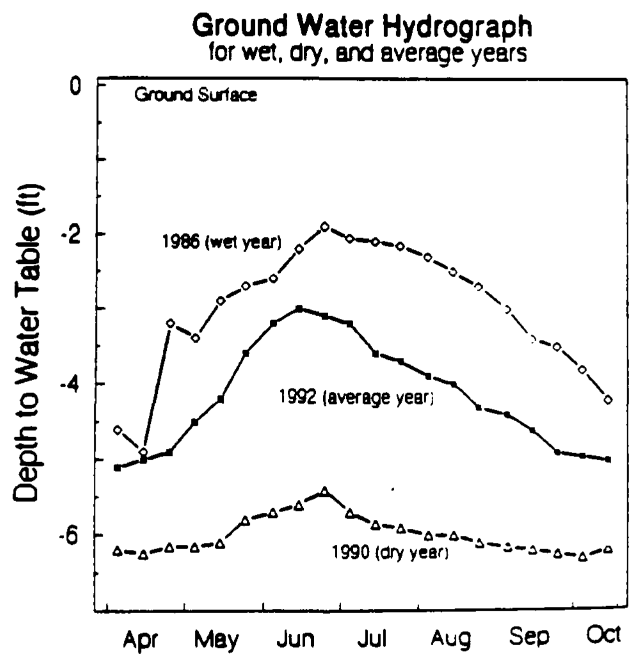
The depth to water table can be read with a measuring tape if within 2 or 3 feet of the ground surface, but if deeper a simple well reader constructed with an ohmmeter can be used. The well data should be converted to depth to water table from the ground surface. If possible, the top of the well casing should be surveyed to determine its exact elevation and location. Then water table depths can be converted to true elevation and compared from well to well.

The following aspects of ground water should be investigated.

The depth to ground water and its elevation should be investigated with ground water monitoring wells. The ground water data should be plotted as hydrographs, with both depth to water table and elevation plotted by date. It may not be feasible to rely on ground water as the primary project water source if the water table is more than 4 feet below the soil surface or if there is great seasonal fluctuation.

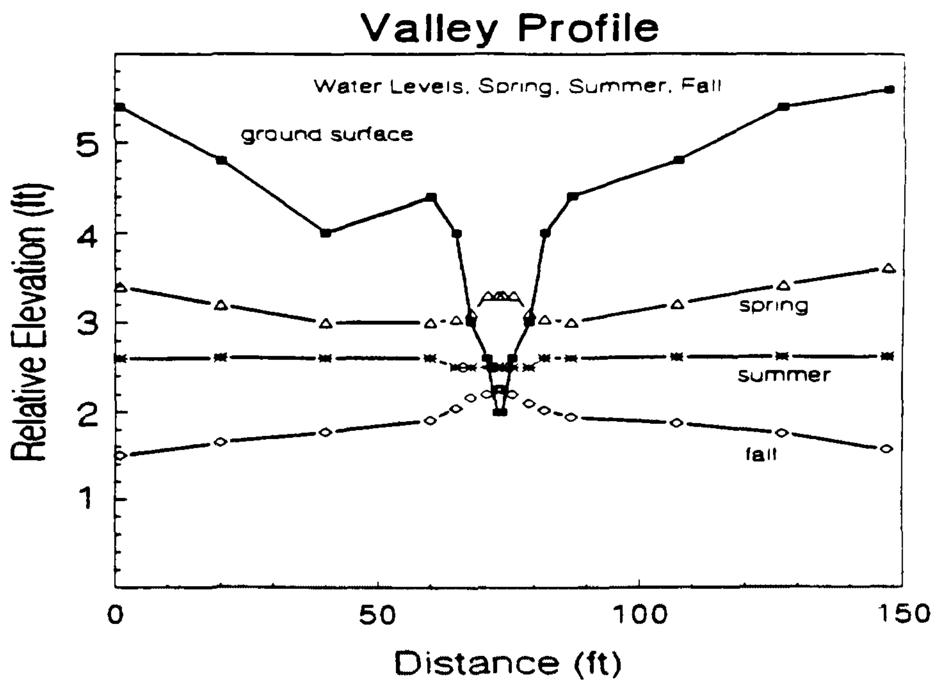


The seasonal fluctuation of the water table can be as little as a few inches or as much as several feet. Quantifying the amount of fluctuation is important because it helps determine the final land surface elevation. For example, site 1 in the above hydrograph has more than 2 feet of seasonal fluctuation; site 2 has less than 1 foot.



Estimating where the water table will be in other years. Although the project grading creates new ground surface elevations, the water table fluctuates from year to year. Because of this, it is important to be able to predict water table elevations for average, wet, and dry years. All hydrologic data must be considered in relation to the multi-year periodicity of dry and wet climatic cycles. A few months data on stream, lake, or ground water levels should be related to longer-term data from nearby streams or lakes by creating graphs showing water levels from one station for many different years, as shown on the hydrograph to the left. Precipitation records for the watershed can also help determine if data were collected during a wet or dry year.

The ground water slope and shape across the site should be evaluated by creating water table profiles across the valley. Profiles for several dates can be created to show how the water table shape changes seasonally.



Soil

Soil is unconsolidated material that serves as the rooting medium for plants. Although most sites in the western U.S. have soils, the substrate at other sites, such as cobbly placer mine spoil piles and salt pans, does not support plant growth and is considered non-soil.

Several soil characteristics are important in wetland restoration and creation planning. Some applicable data can be derived from published U.S. Soil Conservation Service surveys, but site-specific study is usually necessary.

Soil texture. By passing a soil sample through a series of sieves with different sized holes, the *soil texture*, or proportion by weight of each particle size class (clay, silt, sand), can be determined. Soil texture, along with measures of soil permeability, is important information for many projects. Coarse-textured soils are more permeable to water, and fine-textured soils are less permeable. Surface water diverted into a basin with fine-textured soils may remain perched on the surface because permeability is slow. This cannot be expected in coarse-textured soils. However, coarse-textured soils located on a floodplain may have a direct connection with the stream and its water through the ground water.

Soil salinity. Many soils in the western U.S. have high salt content. If water with an electrical conductance greater than 800 umhos/cm^2 is created due to soil salts, salinity may become a key site character. Soil salinity can be determined in an analytical laboratory or estimated by creating a saturated soil and distilled water paste, extracting the water with a vacuum pump, then measuring its electrical conductance. Soil extracts with conductivity greater than 4,000 umhos/cm^2 can be harmful to plants.

Soil salts can be leached if water passes through the site. However, if water evaporates from the site, the salt is retained and salinity increased.

Soil nutrients and organic matter. Soil nutrients, particularly nitrogen and phosphorus compounds, provide essential nutrients for plant growth. Total phosphorus in concentrations greater than approximately 10 ug/l can lead to the creation of eutrophic water bodies, with abundant algal growth, which may be undesirable. Phosphorus can be released from soil to the water column in the anaerobic environments created by soil saturation.

Soil permeability. Soil cores should be collected and tested in a laboratory for permeability rate. A crude method of determining soil permeability is to pound a steel pipe into the soil leaving the pipe extending a few inches above ground. Put a given volume of water into the pipe and determine the time it takes to percolate into the soil. This can be converted into a permeability rate of inches of water per square inch of land surface per day. Because permeability can vary over a site, the soil should be evaluated in at least three representative places.

Topographic Surveying

The site must be surveyed prior to final planning because all work must be based on true or relative elevations. Accurate elevations also allow accurate cost estimates. Elevation data is needed to interpret hydrologic data and to create a final grading plan.

It is recommended that one-foot contour intervals be mapped at a scale of 1 inch = 50 feet. Mapping to 6-inch contour intervals may be required where the final grading in relation to water level is critical.

If project budgets make it impossible to survey the entire site to produce detailed maps, at a minimum, survey the stream staff gauges, ground water monitoring wells, and areas where restoration work may be planned.

Protecting Existing Wetlands

No actions should disrupt the surface or ground water flow characteristics of sites with existing wetlands. Construction should occur at a season when wildlife use is low. Siltation of existing waterways must not occur, and no fill material should be stored on site. Any existing wetlands in the construction area should be fenced off, and fines leveed for vehicles that enter the protected area.

Developing a Planting Plan

The planting plan should be based on the wetland type to be created, the water table to be developed, and the types of vegetation desired. The planting plan must recognize that each plant species can live and reproduce only in a limited range of environmental conditions. When planning which plant species to use, the physical environment, especially air temperatures, proposed water depth and duration, and salinity of the water source should be considered. Using this knowledge a list of potential plant species for the site can be developed. Different species are selected for marsh, wet meadow, peatland, and riparian wetlands. Within each wetland, the species must fit the water table gradients to be created.

Diagrammatic wetland cross-sections on these pages illustrate species preferences for hydrologic conditions. A site planting plan should include similar diagrams to illustrate where along the hydrologic gradient each species should be planted.

After earthwork is completed, the water table elevations and flooding patterns rarely are exactly as planned. Water levels should be monitored immediately, and for several weeks if necessary, to determine the actual water levels created. This information must be used to modify the planting plan. Planting before monitoring the hydrologic regime as established can result in plants drowning or desiccating. Remember that plantings are susceptible to the stress of high or low water. Drowning can occur in a matter of days, especially for seedlings or stem cuttings. On pond edges wave erosion can destroy planting beds.

Numerous plant species could be used in restoration or creation projects. A few common Rocky Mountain wetland species are listed below along with the types of information required for planning. Additional information should be sought from local wetland experts, nurseries (see Appendix), and the scientific literature.

Fresh water marshes

Conductance < 800 umhos/cm^2; water up to 2.5 feet deep.

Scirpus lacustris; softstem bulrush

Habitat: Marshes on the plains and basins up to 9,000 feet elevation.

Hydrologic Regime: Prefers water from 6 to 24 inches deep, but will grow in drier areas and in sites with water periodically to 3.5 feet deep.

Water Chemistry: Usually in fresh water, but can grow in areas that are periodically brackish.

Propagation: Easily propagated from viable seeds. Seeds can be stored wet or dry, but dry seeds may take months to germinate in a wet environment.

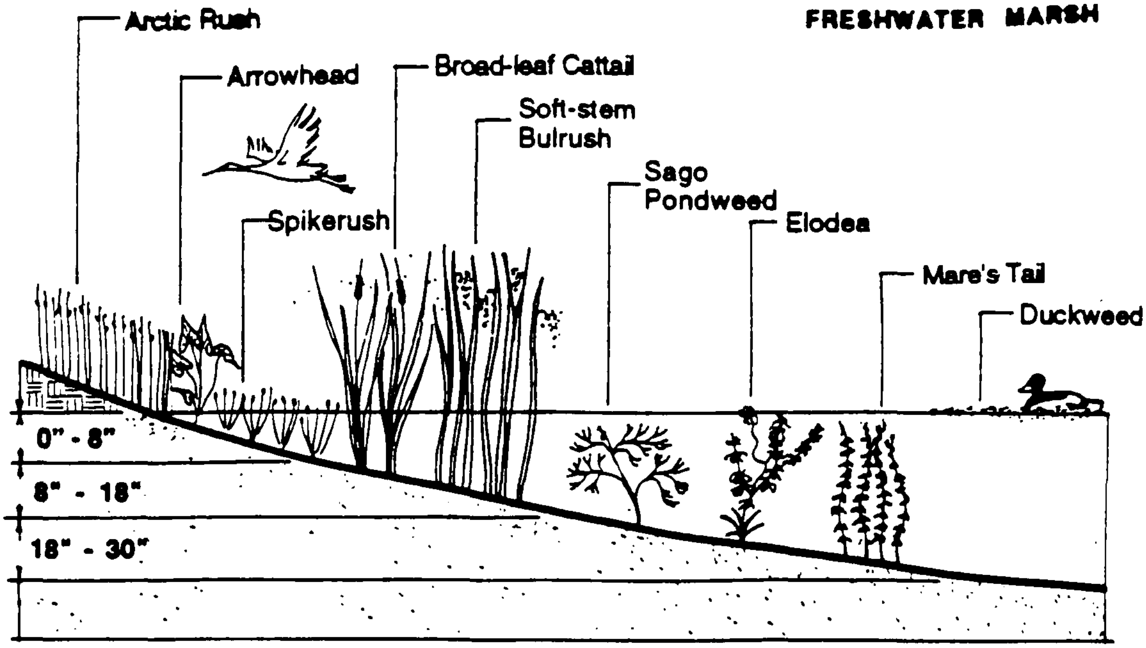
Typha latifolia; broadleaf cattail

Habitat: Marshes on the plains and basins up to 9,000 feet elevation.

Hydrologic Regime: Prefers water from 6 to 16 inches deep, but will grow in drier areas and in sites with water periodically to 2.5 feet deep.

Water Chemistry: Usually in fresh water, but can grow in areas that are periodically brackish (electrical conductance of water up to 1,000 umhos/cm^2).

Propagation: Easily propagated from tubers collected in the field. Also viable seeds are produced and germinate readily on damp soil or even under water. Seeds can be stored wet or dry.



Sagittaria spp.; arrowhead

Habitat: Marshes on the plains and basins up to 8,000 feet elevation.

Hydrologic Regime: Prefers water from 6 to 12 inches deep, but will grow in drier areas once established.

Water Chemistry: Usually in fresh water, but can grow in areas that are periodically brackish.

Propagation: Easily propagated from rhizomes. Viable seeds are produced. Seeds can be stored wet or dry, but dry seeds may take months to germinate.

Sparganium eurycarpum; giant burreed

Habitat: Marshes on the plains and basins up to 6,500 feet elevation.

Hydrologic Regime: Prefers water from 6 to 18 inches deep, but will grow in drier or wetter areas once established.

Water Chemistry: Fresh water.

Propagation: Easily propagated from rhizomes. Viable seeds are produced. Seeds can be stored wet or dry, but dry seeds may take months to germinate.

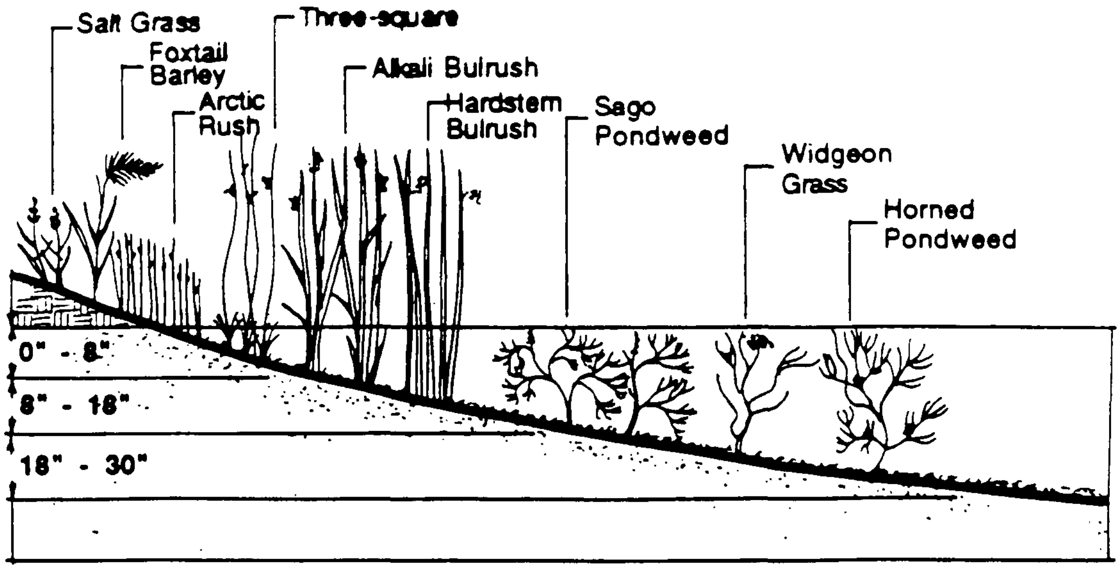
Potamogeton pectinatus; sago pondweed

Habitat: This is a true aquatic plant that is common in ponds and wetlands throughout the lower elevations.

Hydrologic Regime: Requires standing water, and will grow in water to more than 6 feet deep.

Water Chemistry: Fresh to slightly brackish.

Propagation: Produces abundant tubers and seeds, which are easily collected in low water.



Saline marshes

Saline water (conductance >800 umhos/cm^2); up to 2.5 feet deep

Scirpus acutus; hardstem bulrush

Habitat: Marshes on the plains and basins up to 9,000 feet elevation.

Hydrologic Regime: Prefers water from 6 to 18 inches deep, but will grow in drier or wetter areas once established.

Water Chemistry: Fresh or brackish.

Propagation: Easily propagated from rhizomes. Viable seeds are produced. Seeds can be stored wet or dry. Dry seeds may take months to germinate.

Scirpus americanus; three-square

Habitat: Marshes on the plains and basins up to 9,000 feet elevation.

Hydrologic Regime: Prefers water from 6 to 18 inches deep, but will grow in drier or wetter areas once established.

Water Chemistry: Fresh or brackish.

Propagation: Easily propagated from rhizomes. Viable seeds are produced. Seeds can be stored wet or dry. Dry seeds may take months to germinate.

Scirpus maritimus; alkali bulrush

Habitat: Marshes on the plains and basins up to 6,500 feet elevation.

Hydrologic Regime: Prefers water from 6 to 18 inches deep, but will grow in drier or wetter areas once established.

Water Chemistry: Brackish or saline.

Propagation: Easily propagated from rhizomes. Large viable seeds are produced. Seeds can be stored wet or dry. Dry seeds may take months to germinate.

Wet meadows

Carex lanuginosa; hairy sedge

Habitat: Meadows with a water table at the soil surface or occasionally with shallow standing water. Found up to 8,500 feet elevation.

Hydrologic regime: Prefers wet sites with periodic shallow standing water or a water table at the soil surface.

Water Chemistry: Fresh water only.

Propagation: Propagated from rhizomes, but probably germinable seeds are also produced.

Juncus arcticus; arctic rush

Habitat: Abundant in wet meadows throughout the west up to 10,500 feet elevation.

Hydrologic regime: Water table near the surface is ideal. Some standing water is tolerated, but this species will drown in water over 8 inches deep.

Water chemistry: Fresh or slightly brackish.

Propagation: Easily propagated from rootstocks. Seeds tiny and germination not well known.

Deschampsia cespitosa; hairgrass

Habitat: Mainly mid- to high-elevation wet meadows.

Hydrologic regime: Perfers wet sites without standing water, but will grow in a variety of water regimes.

Water chemistry: Fresh water.

Propagation: Easily propagated from seeds.

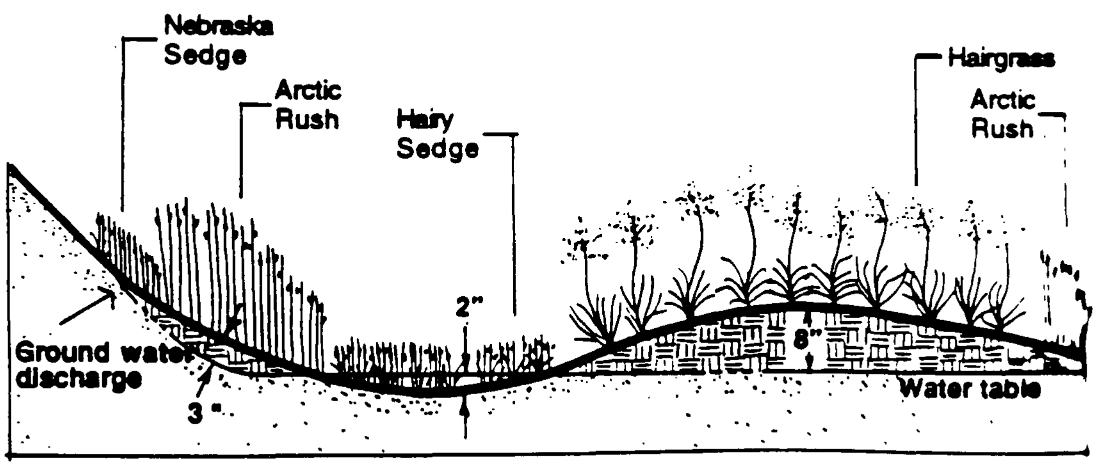
Carex nebraskensis; nebraska sedge

Habitat: Abundant at springs and in the wetter portions of wet meadows at elevations below 8,500 feet.

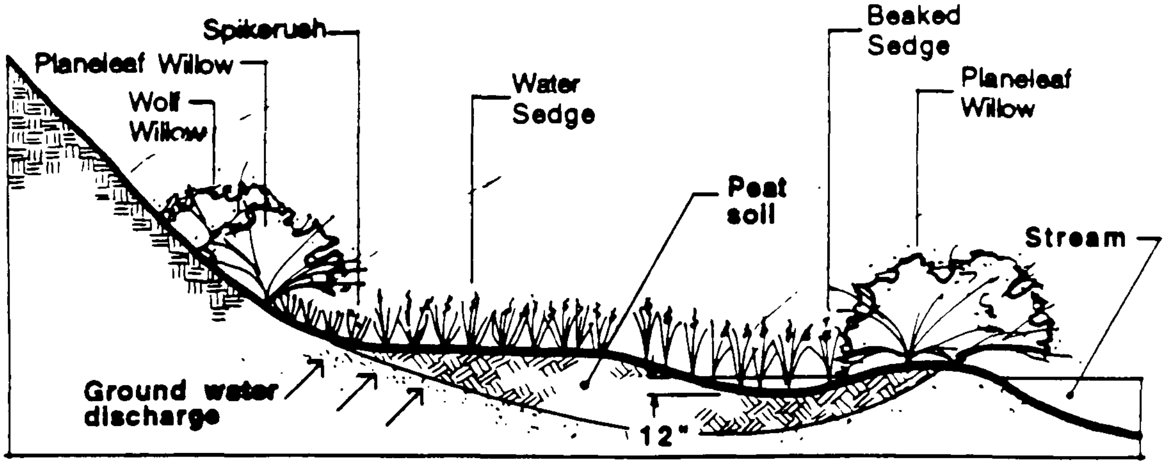
Hydrologic Regime: Prefers constantly wet sites where the water is not deep. It does especially well where water is moving.

Water chemistry: Fresh or slightly brackish.

Propagation: Easily propagated from rootstocks. Germination of seeds unknown.



WET MEADOW



Peatlands

Carex aquatilis; water sedge

Habitat: Abundant at higher elevations from alpine tundra down to 6,000 feet elevation.

Hydrologic regime: Prefers the wettest sites that are not deeply flooded.

Water Chemistry: Fresh or slightly brackish water. Will tolerate saline or acid water and will tolerate significant heavy metal contamination in soil and water.

Propagation: Easily propagated from rootstocks. Seeds germinate but have low viability. Germination best after pretreatment by flushing with water for several days.

Carex utriculata; beaked sedge

Habitat: Abundant at higher elevations from subalpine down to 7,000 feet elevation.

Hydrologic regime: Prefers sites that have spring and early summer flooding up to 16 inches deep, but that can dry out later in the summer.

Water Chemistry: Fresh or slightly brackish. Will tolerate saline or acid waters and will tolerate significant heavy metal contamination in soil and water.

Propagation: Easily propagated from rootstocks. Seed germination occurs, but methods are not well known.

Eleocharis quinqueflora; spikerush

Habitat: Low alpine down to at least 7,000 feet elevation.

Hydrologic Regime: Most common where there is abundant flowing water, as at springs.

Water Chemistry: Fresh or slightly brackish.

Propagation: Easily propagated from rootstocks. Produces viable seeds, but germinability unknown.

Salix planifolia; planeleaf willow

Habitat: Low alpine down to at least 7,000 feet elevation.

Hydrologic Regime: Peatland margins where nutrients are abundant and water table is near the soil surface most of the summer. Also, can be abundant in somewhat drier circumstances.

Water Chemistry: Fresh or saline.

Propagation: Propagated from stem cuttings, but little data on success.

Riparian woodlands

Populus deltoides; plains cottonwood

Habitat: Floodplains of small to large streams at elevations below 8,000 feet.

Hydrologic Regime: Spring flooding required to create bare wet soils as the germination surface. Adult plants root to the water table.

Water Chemistry: Fresh water.

Propagation: Easily propagated from seed, stem cuttings, or poles.

Populus angustifolia; narrowleaf cottonwood

Habitat: Similar to plains cottonwood, but at higher elevations; requirements are similar.

Salix exigua; sandbar or coyote willow

Habitat: The most common willow on low elevation floodplains.

Hydrologic regime: On sites that flood periodically. Can also occur where the water table is more than 2 feet below the soil surface.

Water chemistry: Fresh water.

Propagation: Easily propagated from stem cuttings.

Salix geyeriana; geyer willow

Habitat: This and many other tall willows are abundant on mountain floodplains.

Hydrologic regime: Prefers areas that have water tables near the soil surface, but can tolerate shallow flooding and deeper water tables as well.

Water chemistry: Fresh water. Some species can tolerate heavy metal pollution.

Propagation: Easily propagated from stem cuttings, but could also be grown from seed.

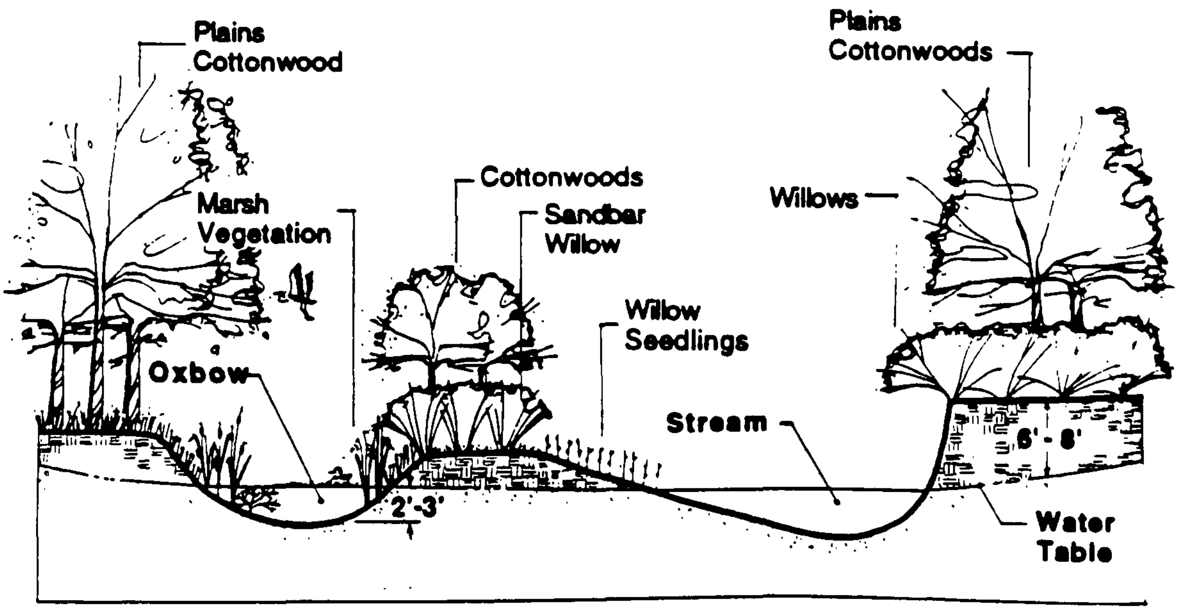
Cornus stolonifera; red-osier dogwood

Habitat: Streambanks throughout the mountains below 10,000 feet elevation. Usually understory to cottonwood, blue spruce, or alder.

Hydrologic regime: Common in areas that occasionally flood.

Water Chemistry: Fresh water.

Propagation: Stems root easily.



LOW ELEVATION RIPARIAN SYSTEM

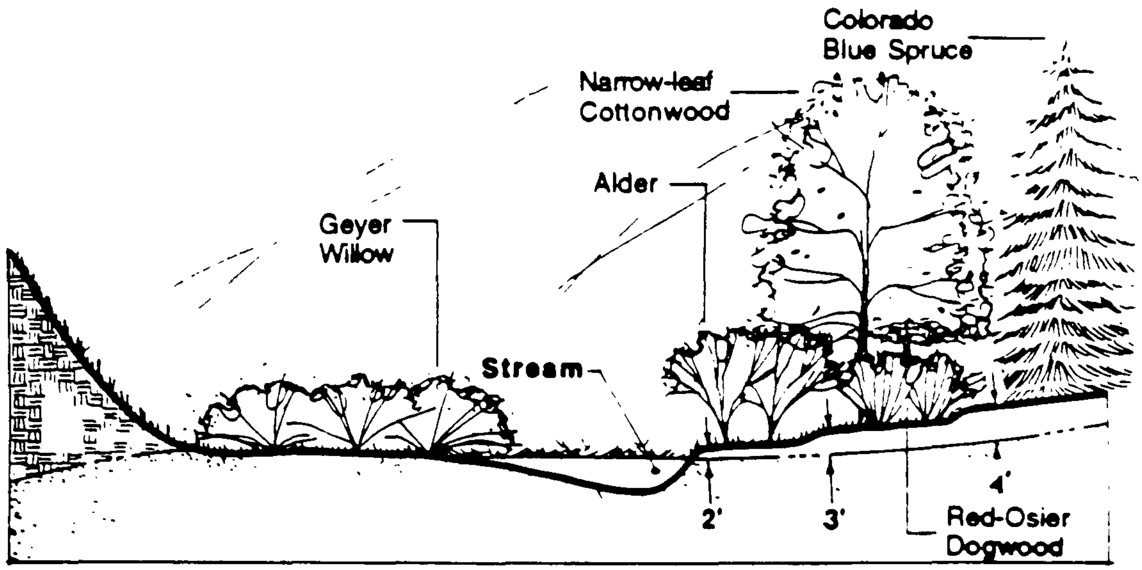
Alnus tenuifolia: thinleaved alder

Habitat: Streambanks at low elevation in the mountains.

Hydrologic Regime: Prefers floodplains with periodic but not long-term flooding.

Water Chemistry: Fresh water.

Propagation: Easily grown from seed collected in later summer. Chill seeds and germinate on moist soil in spring. Inoculate potting soil with soil collected from under alders in the field.



BEAVER COMPLEX ON FLOODPLAIN

Outside Consulting Expertise

It may be necessary to hire an expert wetland consultant to assist with portions of the goal setting, site selection, pre-planning data collection, data analysis and project design. Consultation with stream hydrologists, ground water hydrologists, topographic surveyors, landscape architects, nurserymen and other professionals may also be necessary. It may be desirable to discuss the plans with a contractor to determine what problems in implementation could occur with the proposed designs.

Preparing a Budget

The project budget can be developed by any competent engineer or landscape architect. Earthwork should be calculated carefully, as this is usually the largest budget item. The cost of plantings should be determined after the planting plan is completed. Remember that the company providing plants should guarantee their survival. This will help assure good stock and a careful match of plants to the hydrologic regime created. The guarantee will cost more, but it will relieve any budget problems should the plantings fail.

Estimates for erosion control, weed control, topographic surveying, monitoring, project evaluation, and other items should be included in the project budget.

When the estimate is complete, ten percent should be added to the estimated project cost for modifications to the project during its second year. This is essential because it is not possible to design projects perfectly, and because unexpected events, such as a flood, may make remedial actions necessary.

Considering the Results

Projects aren't always carried out perfectly. An important part of planning is to anticipate difficulties, potential changes in design as new information occurs, and other occasions that may call for flexibility. If project goals are kept in sight, any necessary adjustments can be made compatible with the expected results.

Factors that could limit project success

A number of easily overlooked factors can create unforeseen and many times uncorrectable problems. It is suggested that one person be in charge of the final decisions and all contractors report to that person.

Grading to the wrong elevation can necessitate redesign of the entire project. It most commonly occurs due to insufficient or incorrect hydrological data, analyses, and assumptions. Errors in grading can also occur because of poor topographic control from errors in the original surveying, or from poor project supervision. Contractor error is rare, but contractors may ignore project plans because they have ideas to make the job easier for them.

Poor data on soil or water chemistry can create a saline or eutrophic wetland.

A flood or other unplanned natural disaster should be anticipated when working near watercourses. Floods can wet the site and deposit fresh sediment that could provide an excellent seedbed if planned into the project. However, an unexpected flood could undo much of the project. For this reason, streambank work is suggested for early summer, after snowmelt runoff. Summer plantings have time to root and stabilize the site before the next spring flood. Be prepared to obtain sand bags or other stabilizing materials if needed.

Inappropriate matching of plantings with the hydrologic regime created can cause the planting to fail. Always plan to match plant species with the environment to be created. Then determine before planting exactly how the hydrologic regime of the completed project compares to the planned hydrologic regime. Mismatches will result in plant death, or at least in poor performance that cannot be blamed on the plant stock.

Grazing by geese, beaver, cattle, deer, muskrat, and other animals can destroy plantings. It may be necessary to protect plantings with fences for a period of time, or to repeat plantings in some areas. Beavers can be attracted to the new habitat and dam water delivery systems or culverts. Muskrats burrowing into islands and dikes can render them porous.

Anticipate weed invasions into the bare soil areas. Species such as purple loosestrife or canada thistle are best dealt with before their populations become large. In many areas weeds can become the dominant plants!

Planning to evaluate success

An important part of project preparation is determining in advance when and how the success of the final project will be evaluated. Don't hastily judge project success or failure. What looks disastrous the first year may end up successful, and what appears a success may prove to be a short-lived phenomenon. Certain agencies may require that a mitigation bond be held until project success is demonstrated. In these cases, demonstrating success is critical.

Timing of the evaluation depends on the type of wetland and the wetland functions being restored or created. Herbaceous wetlands, e.g., cattail marshes, can be established more quickly than riparian forests. The schedule for evaluation must take this into consideration. Similarly, some wetland functions may not be restored for years, but other functions may become effective within a relatively short time.

Established wetlands may be evaluated through the use of permanent plots or other methods. Both the hydrologic regime and the success of plantings must be considered. Techniques are discussed in *Monitoring to Evaluate Project Success*, page 38.

Implementing the Project

The most important aspect of implementing the plan is to work with a contractor who understands the project goals. Employ a project coordinator to be on site regularly and available by telephone daily during all critical construction phases. The coordinator will aid contractors in making field decisions and the inevitable changes to project plans. The project coordinator must also be responsible for ensuring that project plans are followed and grades are correct. This person must have surveying skills to check elevations from benchmarks, must know how to read the project plans and to identify plants called for in the grading plan, and must make observations and measurements of the hydrologic regime. This person must also have the authority to work with the contractor.

Working with Contractors

Few earthwork contractors have worked in wetlands. Contractors may try to grade sites like parking lots or make spot decisions without the benefit of the site analyses or data. For example, a contractor might be excavating a site to reach a ground water table and find that the water table is a foot lower in November than the grading plan calls for excavating. Understanding that project success means wetness, a contractor might make a field decision to excavate deeper, without realizing that they are already working at the annual water table low point. If this unplanned additional grading were to occur, spring high-water levels could be higher than desired, and project goals might have to be drastically changed. Substantial additional costs might be incurred trying to salvage the project.

Contractors can often make valuable field observations which contribute to project success. Encourage this type of communication.

Make sure the contractor knows where benchmarks are located and who to consult about changes or new ideas. Insist that grades be accurate and that absolutely no changes occur without approval of the project coordinator. The coordinator should never allow changes without considering their impacts on every other aspect of the project.

Erosion control during construction is important, especially when working adjacent to an existing water body. Clearly fence off-limits areas to notify contractors where construction is and is not allowed. Establish fines for rules violations.

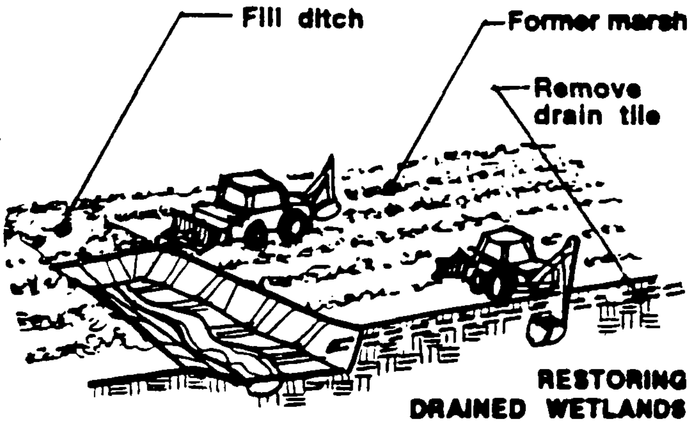
Making Changes during Construction

Slight changes to the design may often become necessary during construction, but do not make any changes without considering the ramifications to all other aspects of the project. For example, in many areas of the West, ground water tables are not level but slope toward or away from a water body, such as a stream. Pre-project ground water investigations may have detected this, but the planners were not sure exactly how to grade the site. An experienced heavy equipment operator can follow a water table or the top of the *gleyed* (grey) soil horizon that marks the seasonal high water level. However, if the water table is several feet lower on one end of the project site than another, sideslope grading problems may develop.

Restoring the Hydrologic Regime

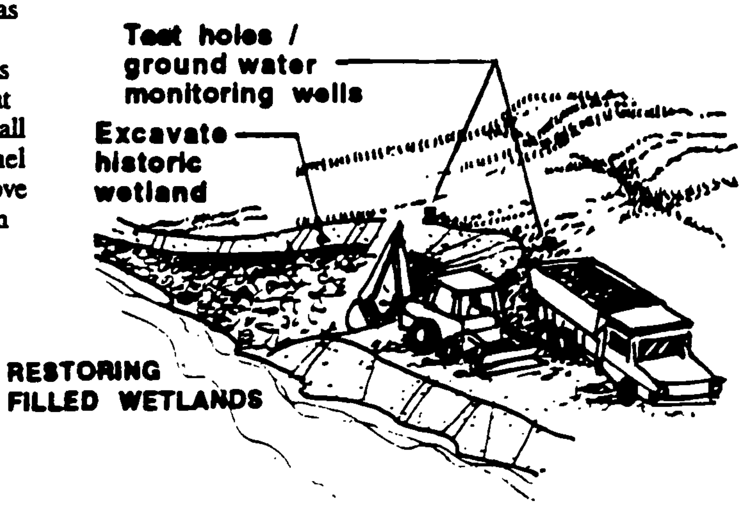
Restoring ditched or drained wetlands

A ditched or drained marsh or wet meadow provides one of the most straightforward restoration opportunities. Restoration should be planned after determining where the ditches and drain tiles occur and how the impacted area differs from unimpacted portions of the same site or a similar site. This information will focus the restoration project and provide criteria for success.



Underground tile drain systems are common in agricultural areas. All drains must be located, excavated, and at least a few tiles in each drain crushed. It may be difficult to determine the exact location of all drain systems, but usually an outlet to a ditch can be located.

Ditches are often apparent on aerial photographs even when they are not apparent on the ground. Even small ditches divert surface water or intercept ground water flow. The key is to stop the flow of water. Completely filling each ditch with the sidecast diggings is the simplest method of restoration, but it is rarely possible as erosion usually has removed the material. Importing fill is expensive and labor intensive, but it works. It may be possible to fill the ditch in a few key places and successfully stop the flow of water. However, water has a way of making its way around plugs and flowing back to the ditch. In Rocky Mountain National Park, large metal sheets are placed across ditches to act as dikes. This has been effective where the sheets are not undercut and where a small hand-dug channel is created to move water away from the ditch.



Restoring filled wetlands

Many wetlands that have been filled by agricultural practices, mine waste, highway construction, and other activities can be excavated and restored. Try to locate the filled project site on old aerial photographs to determine the shape and size of the original wetland. It will also be useful to drill through the fill to determine the character of the fill material, its thickness, and the depth to the old wetland surface (which can be identified by gleyed soil horizons). Ground water monitoring wells installed in each drill hole can help determine if the hydrologic regime is intact.

If hazardous material (mine tailings, municipal or industrial waste) is present, the cost of disposal may make the project expensive. If suspicious fill material is found, it should be tested in a laboratory to determine whether problems exist. If the wetland surface is fairly close to the soil surface, the excavation can be done relatively quickly with a large backhoe. Heavy equipment should be kept on the fill surface and not allowed onto the newly exposed wetland surface. A planting plan can then be developed.

Restoring streambanks and riparian wetlands

Many stream channels and associated riparian wetlands have been severely impacted by channelization, vegetation removal, channel incision, mining, and other activities. Channel incision can lower the local water table, limit the interaction of stream and floodplain, and dry up adjacent wetlands. The removal of streamside vegetation can allow excessive erosion, causing the stream channel to become wider and shallower, which is not desirable.

Streams are a function of their watershed and immediate environment. Stream channel characteristics are controlled by the relationships between and among flow volume, total sediment load and sediment particle size, channel bank vegetation, and valley gradient. Most streams are dynamic, and the channel characteristics, including position within the valley, change over time. These dynamics are essential. Efforts to confine or "stabilize" the channel with riprap, large boulders, logs, or structures result in stream and floodplain changes. These changes cannot be considered restoration because the natural processes are eliminated. A stream must be considered in the watershed context and in the site-specific context for restoration to be successful.

Channelized streams and streams in valleys disturbed by mining or other activities can be rehabilitated with the aid of a competent stream hydrologist. Methods for stream design are beyond the scope of this handbook, but every stream should be matched to its landscape. Floodplain interaction and well-developed riparian vegetation must be an integral part of the stream design.

Three factors affect restoration opportunities for streams and riparian wetlands.

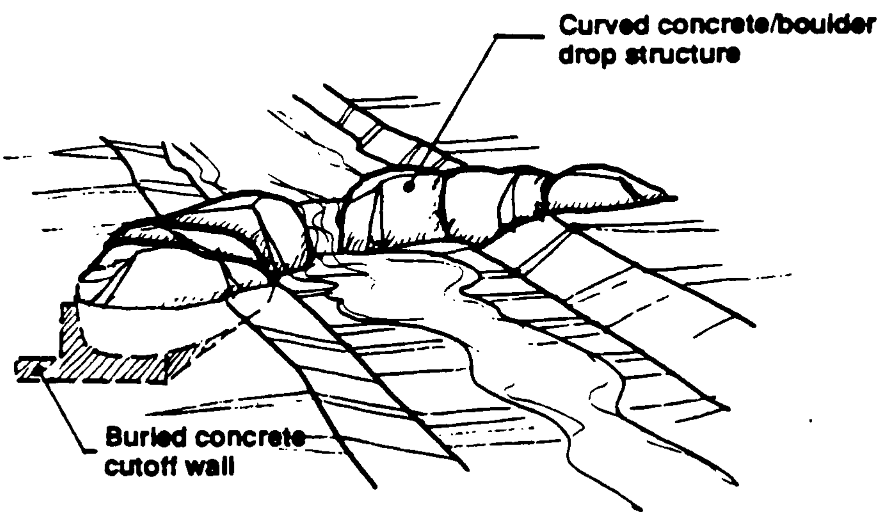
1. **Watershed Condition.** Watersheds in poor condition due to overgrazing, dam construction, urbanization, or other reasons may have very high or very low sediment loads or be flashy. Site-specific restoration cannot repair problems caused by upstream impacts, and many riparian restoration projects fail because of undetected off-site problems. Streams affected by upstream impoundments lack sediment and have "hungry water" that can erode channel and banks. Streams receiving abundant sediment from erosion in the watershed can deposit this sediment in the channel or floodplain, burying the vegetation.

2. **Stream Channel Integrity.** If a riparian restoration is planned adjacent to an incised stream channel, the channel may have to be rehabilitated first. The interaction of the stream and floodplain is essential for riparian restoration to be possible. Also, rehabilitating stream channels can raise local water tables and help support riparian vegetation.

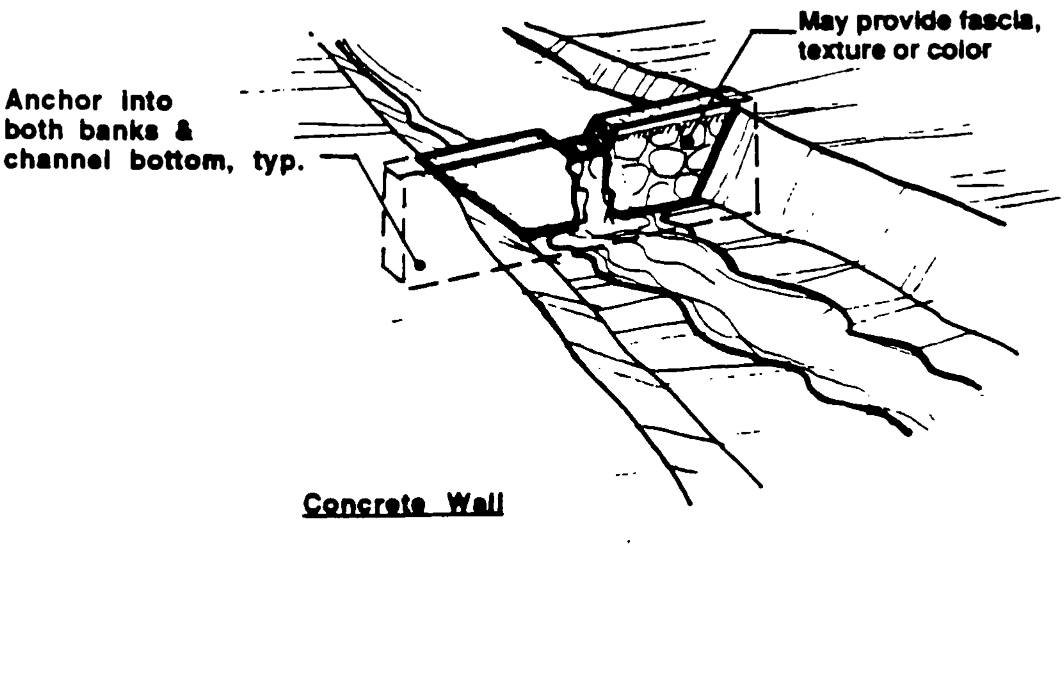
3. **Site Condition.** Unvegetated or badly overgrazed sites may have on-site erosion problems or support weed populations. These problems must be remedied before successful restoration can occur.

Restoring incised stream channels

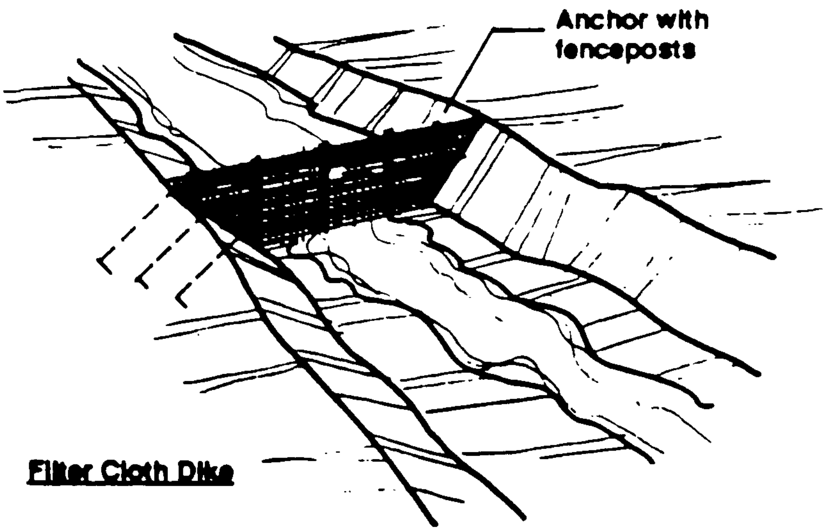
Engineering solutions for incised channels include the construction of concrete drop structures, rock-filled gabians, and small earth dikes. These structures must be carefully designed. They create small impoundments that store sediment and build up the channel. Some severely impacted watersheds have been successfully treated with dozens of small structures. Local water tables may rise in the area behind the structure, riparian vegetation is replenished, and streams have actually been converted from ephemeral to perennial flows by these techniques.



Boulder Drop Structure

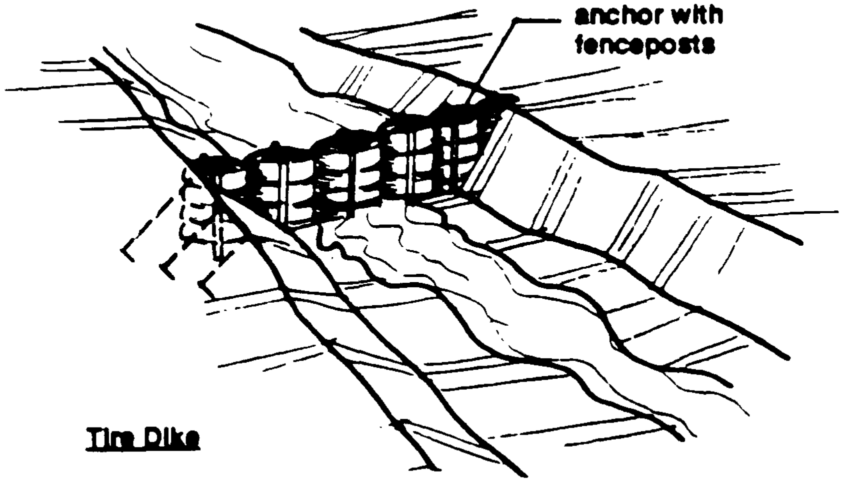


Concrete Wall



Filter Cloth Dike

Wire fence dikes are an inexpensive solution for use on small streams. They are built using steel fenceposts pounded into the stream channel in one or two rows. Wire is strung to the posts and filter cloth attached on the upstream side. Automobile tires have been used instead of filter cloth in some areas. The dike must be tied into the streambanks and the streambed. The structures can last for many years. They build up sediment in the channel and raise water tables as well.



Tire Dike

Establishing vegetation on eroded streamsides has been used successfully to change channel characteristics. Willows, alders, sedges, and rushes can stabilize banks, accumulate sediment, and over time create a narrower and deeper channel.

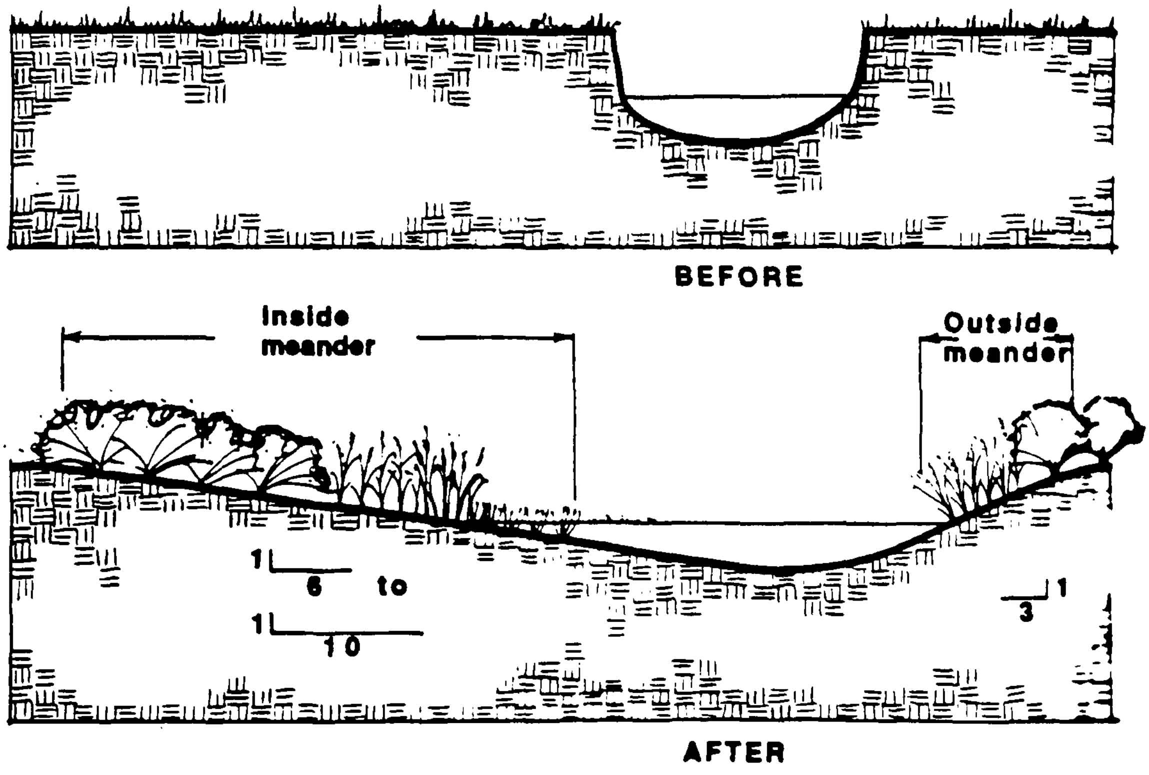
Restoring streambanks

Streambanks can often be improved simply by removing livestock to allow existing streambank vegetation to recover or expand. Grazing in riparian areas can be eliminated or reduced using fencing or by developing additional water sources away from the stream to disperse animals throughout the range.

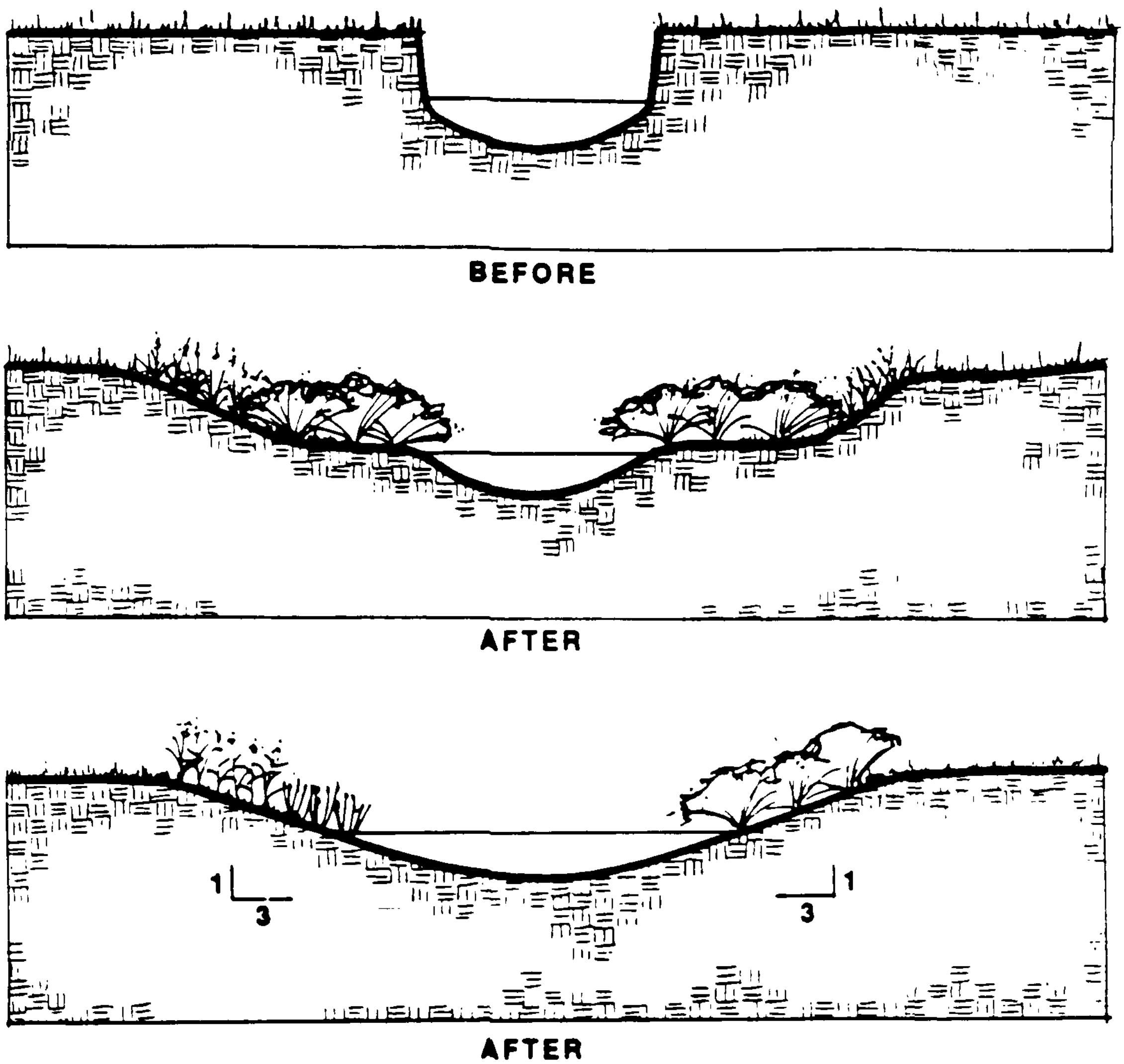
Earthwork to reduce the angle of banks allows plantings closer to the stream and to the water table elevation. Several configurations are possible depending upon whether the site is an outside bank, inside bank, meander, or straight run. Small terraces adjacent to the channel can be used to expand the floodplain. The optimum profile also depends on the size of stream and type of ecosystem (willow or grass-sedge) to be created.

Slopes of 3:1 or flatter aid plant establishment. On the insides of meander bends, a more gentle slope allows flood waters to interact with the newly created floodplain, and natural recruitment of willows and herbaceous plants can occur. Plant roots must grow to the elevation of the stream channel to be effective in streambank protection. If the stream undercuts the root mass, erosion occurs and restoration cannot succeed.

Temporary stabilizing material, such as netting, brush, or logs, may be useful for holding cut banks until new plantings have developed root systems. Wire fences may also be built parallel with the eroding bank. Dead plant material stuffed behind and through the wire captures sediment and helps stabilize the bank.



ALTERNATIVE TREATMENTS FOR INCISED CHANNELS



ALTERNATIVE TREATMENTS FOR INCISED CHANNELS

Creating a Wetland Hydrologic Regime

Ground water

Creating a wetland that interacts with a ground water system is generally done by excavating soil to create a new land surface at a lower elevation. The final elevation of the new surface is the most important design element and must be determined precisely. Baseline data on ground water levels should be collected during the growing season for at least one year. That data can be compared to precipitation, stream flow records, and ground water data from the same year and several other years to determine how typical the year of record was.

The site should be graded to "average" water year hydrologic conditions with a good idea of the difference between average and high and low water years. If the water table is fairly stable, fluctuating less than 1 foot during the year, this is not difficult. However, on sites that experience large seasonal ground water changes (greater than 3 feet), grading will be more challenging. Systems with large seasonal changes in the water table are likely to experience large differences between dry, average, and wet years.

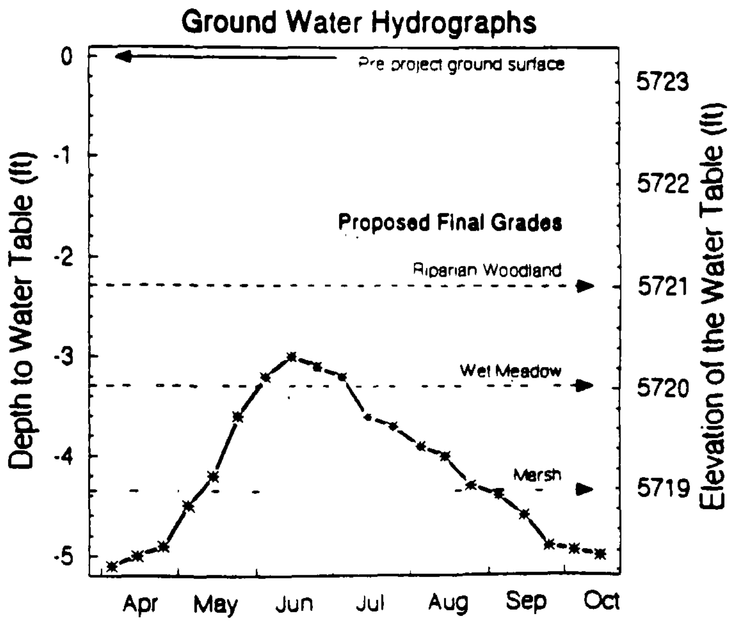
Using the ground water hydrograph shown here, the final elevation for excavation should be determined for the type of wetland desired.

For a bulrush marsh, inundation up to 18 inches deep should occur for several months each summer. The suggested elevation for the new land surface, using this example, would be near 5,719 feet.

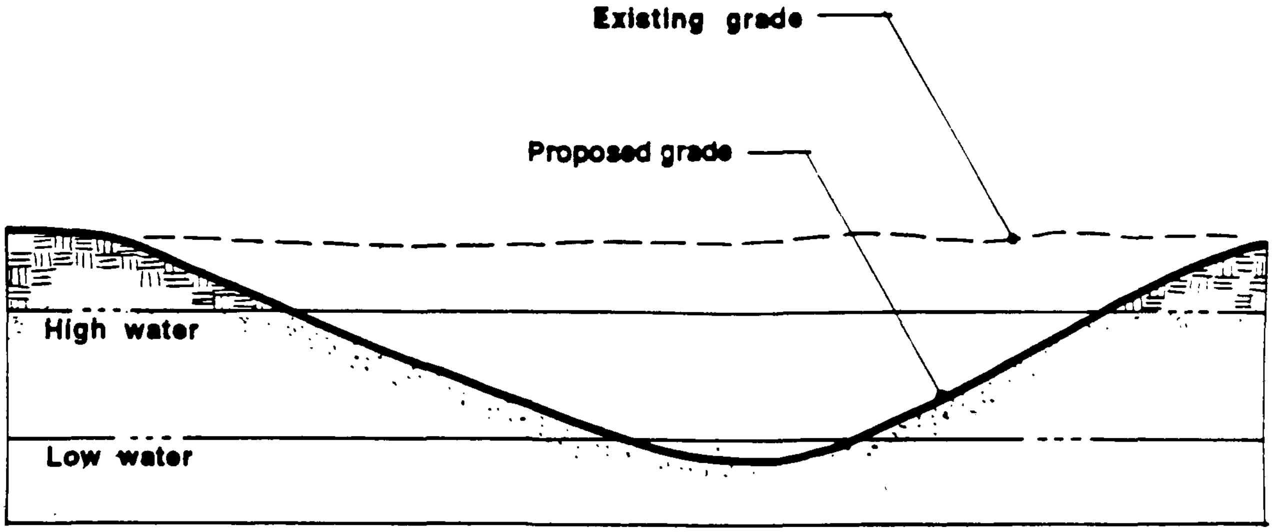
For a wet meadow, a water table near the soil surface for much of the growing season is recommended, but inundation with water deeper than 8 inches should not occur. A site elevation near 5,720 feet is suggested.

A riparian woodland adjacent to a stream channel would have a water table a foot or more below the soil surface on many years, with flooding on high water years. A final grade near 5,721 is suggested.

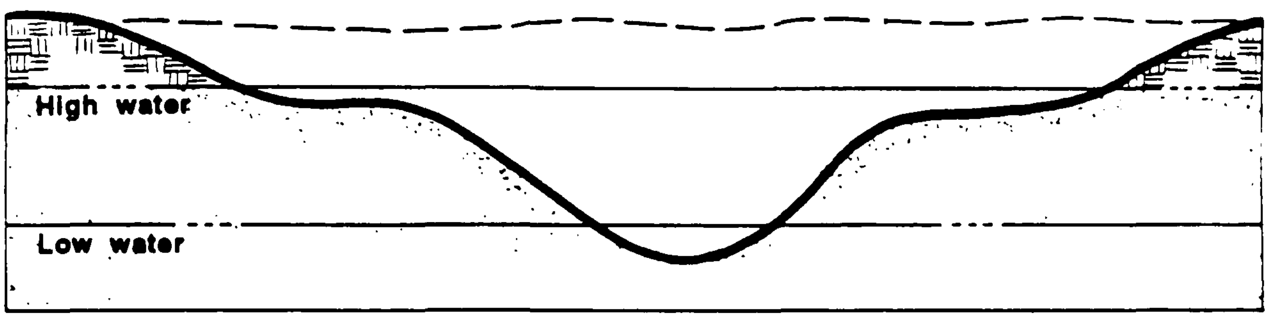
A peatland should not be attempted at this site because the hydrologic peak is of short duration.



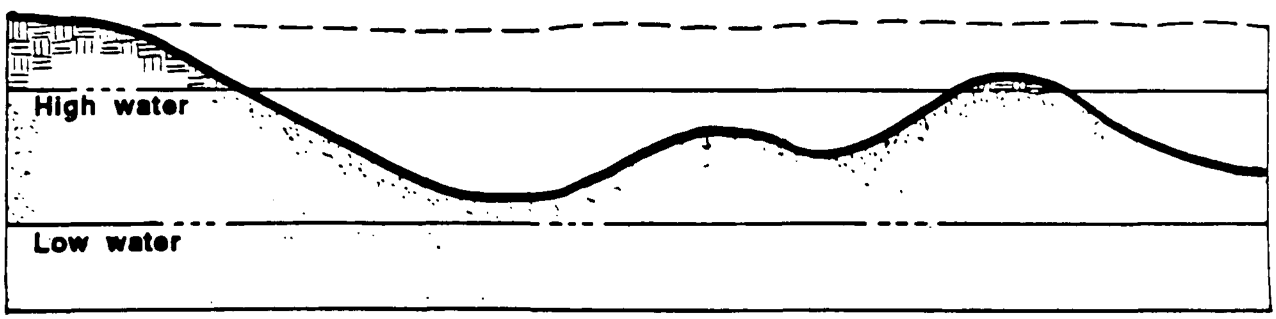
The final grade can be level or gently sloping at sites with small seasonal water elevation variability. Where larger seasonal water table variability occurs, incorporating at least 2 to 3 vertical feet of relief into the grading plan is advised. This can be accomplished by creating (1) a sloping surface, (2) a pond with adjacent terraces, or (3) a series of small ponds, mounds, and ridges.



SIMPLE WETLAND



TERRACED WETLAND

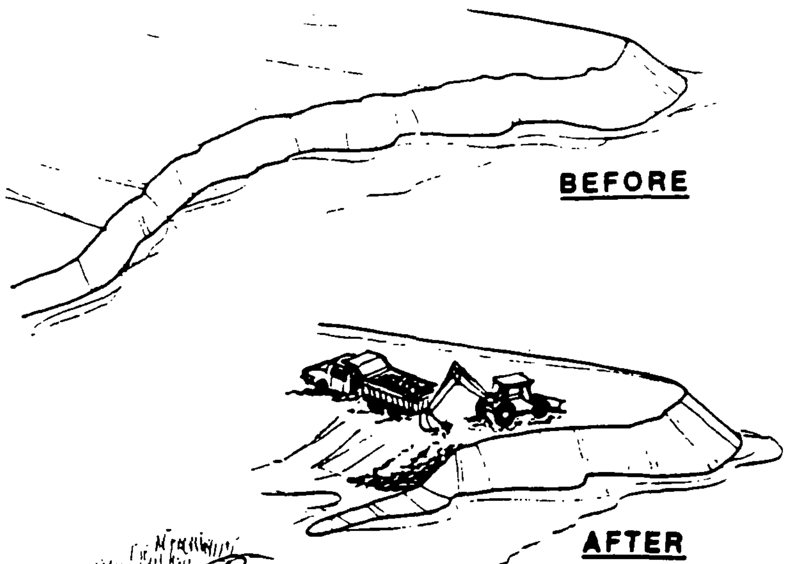


HUMMOCK WETLAND

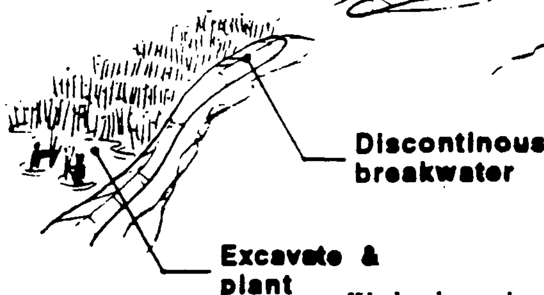
These designs allow portions of the project site to be in contact with the water table at all times. During dry years at least the low areas will be wet, and during wetter years all but the highest areas will be inundated. Creating this microtopographic relief will enhance ecological diversity and provide a more flexible fit to a variable water table regime. It could also relieve the potential problem of grading an area flat but to the wrong elevation.

Surface water

Wetlands can be created by applying surface water to dry land without excavating. This can be accomplished along existing lake and reservoir margins or in existing dry basins or flats.

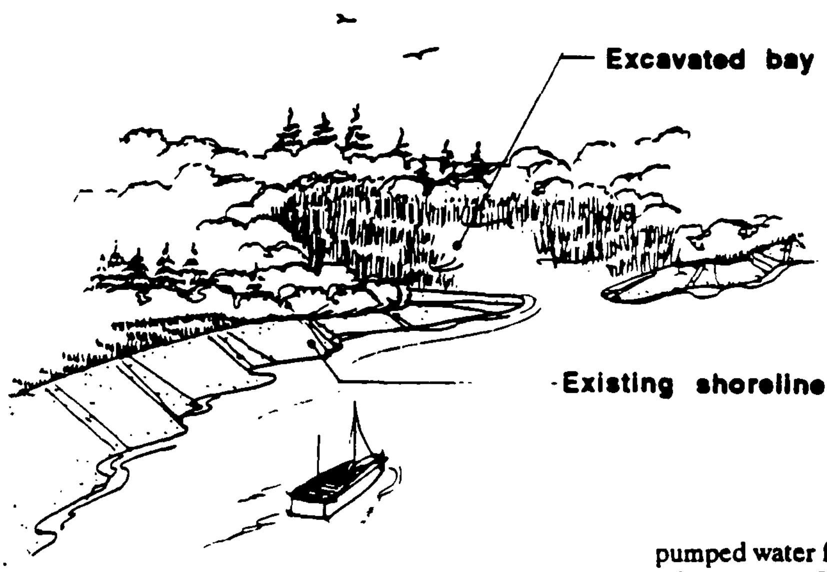


Lake and reservoir margins can be modified by reducing steep shoreline gradients and expanding the shallow water edge. It might be necessary to leave a small breakwater to allow vegetation establishment.

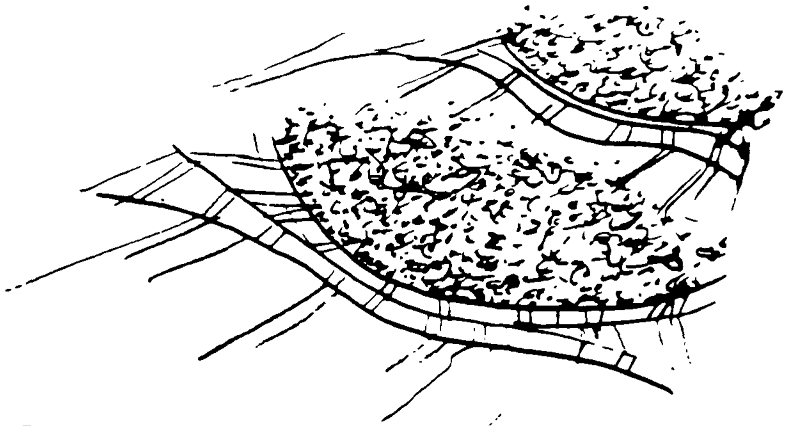


A reservoir margin can also be changed from smooth to one with bays. Water depth should be shallow to allow establishment of marsh plants, such as cattails, beaked sedge, manna grasses, or other species.

Wetland creation on reservoirs and lakes can only be successful where water is maintained at a relatively constant and predictable level during every growing season. Water supply reservoirs that are drawn down more than 3 to 5 feet in summer have shores that are too dry for wetland creation.

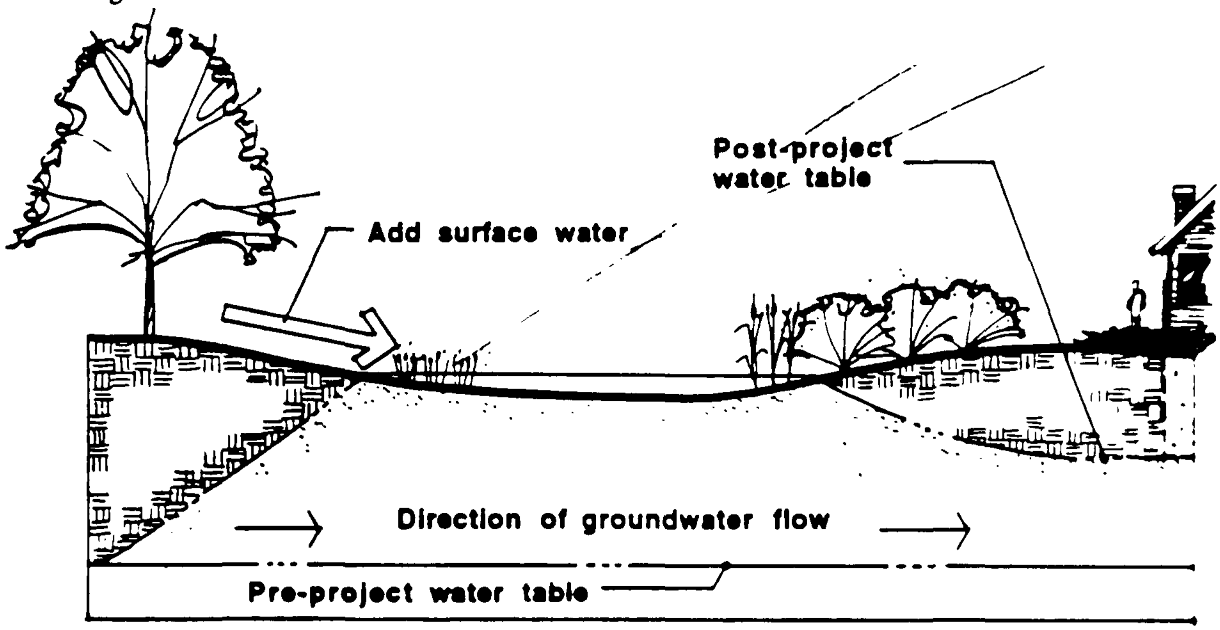


In some circumstances, marshes can be created by applying surface water to level, low-lying areas or to sloping areas on which low dikes have been built. The water supply can be from irrigation ditches or tailwaters, urban stormwater runoff, treated water from industrial or municipal water treatment plants, pumped water from ground water wells, and other sources. Water must saturate and, if possible, inundate the soil surface for a long period of time during the growing season. This can occur only if the soil permeability rate and site grade are low enough to allow available water to remain on the soil surface.



EARTHEN DIKE WETLANDS

Marsh or wet meadow creation is also possible where the water table is relatively close to the ground surface. In this situation, the addition of surface water will cause the local water table to rise to the soil surface, creating a ground water mound.



Soil cores should be collected and tested for permeability rate in a laboratory (see page 14). Soil permeability rates greater than 1/2 inch per day can cause water to disappear into the soil faster than it can be replenished. At this rate, one-half an acre-foot of water per day would be lost from a 12-acre wetland. Where a large volume of water is lost into the ground, off-site impacts should be considered. The water will flow downgradient and can cause water tables to rise in adjacent areas, affecting nearby agricultural areas or homes with basements. Because ground water flow rates are usually slow, impacts may take months or years to occur. Where percolation rates are high it may be possible to mechanically compact the soil. This is an expensive option and should be chosen only after consultation with a soil engineer.

The water to be applied to a land surface should have low salinity, because water will be lost by evapotranspiration and solutes will accumulate in the wetland. What begins as a freshwater wetland can become saltier over time, causing a change in the flora, fauna, and wetland functions. A worst-case scenario would be salt accumulation leading to the unanticipated death of the desired plant species. Where moderate- to high-salinity water (conductance greater than 500 to 800 umhos/cm⁻) is to be used, salt-tolerant marsh species, such as alkali bulrush, three-square and hardstem bulrush should be planted.

Basins created for surface water application can be graded to create topographic relief that enhances site diversity. However where permeability rates are rapid, grading could increase permeability and should be discouraged. Where soil permeability rates are low and surface water of known salinity is available, applying surface water can be an easy method of creating wetlands.

Restoring Wetland Soils

Hydric soils, by definition, occur when anaerobic conditions exist in a soil. Creating the appropriate hydrologic regime is all that is necessary to promote the process of wetland soil restoration or creation.

Applying topsoil, organic matter or fertilizer as a soil amendment is usually not required because most wetland plant species do not require abundant nutrients. This can save considerable expense. In certain cases, such as for germinating water sedge (*Carex aquatilis*) plants for peatland restoration, the original peat soil appears to be ideal material for a seedbed. However, for restoring riparian vegetation, the placement of topsoil can be a negative factor keeping the seeds of cottonwoods and other species from contacting bare mineral soil, which is the preferred germinating surface.

Establishing the Vegetation

Because the vegetation provides many of the wetland functions, such as wildlife habitat and streambank stabilization, successfully establishing the desired plant species is essential to project success. If the appropriate hydrologic regime is restored or created, a well designed planting plan should be successful. The planting plan should include the species to be introduced, plant source, timing for planting each species, location in the wetland for each species based upon its water requirements, and if necessary a weed removal plan. A number of common wetland plants have been described on pages 15 through 21. The most common propagation and planting techniques are presented here.

Field collection of wetland plant seeds

Seeds can be collected from existing wetlands. Seeds should be cleaned and, for most species, stored moist or wet in a refrigerator over the winter. Seeds can also be stored in cloth bags in the field. Most seeds need a cold period before germination can be expected. Seeds stored dry for more than a few months may need a long period of wetting before they are germinable. Dry storage over winter will not appreciably reduce viability for most species. Seeds of different species should be kept in separate containers, so that each species can be seeded into the appropriate water regime. This will save seed.

Seeds can simply be spread onto the site, but this method has many risks. Seeds wash away along wave-affected shores and in rainstorms. Many species are hard to seed under water. Success of seeding for many species, such as sedges (*Carex* spp.), is very low. However, success with most marsh species, and with cottonwoods and some willows, can be high in the appropriate habitat.

Species such as cottonwoods and willows produce seeds early in the summer, and the seeds live for a short period, ranging from 1 to 6 weeks. These seeds should be collected as soon as they are ripe and sown onto a prepared, moist, mineral soil seedbed. Overwinter storage is not possible.

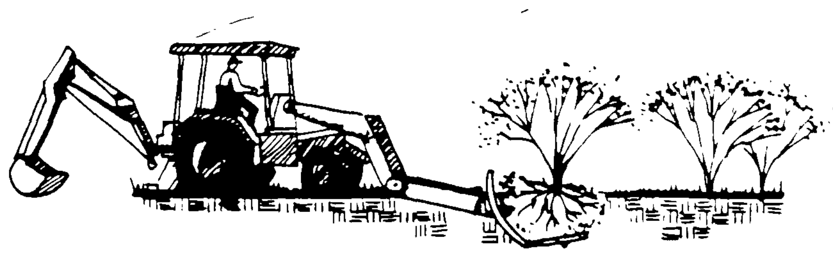
Nursery grown seedlings

Plants can be propagated in a nursery using field collected seeds. The seeds can be germinated in spring, grown in small pots, and transplanted to the field after the last frost. Because many wetland plants are rhizomatous, they spread rapidly. Planting seedlings is more costly than direct seeding, but will produce more predictable results. Seedling mortality can be high where heavy waterfowl use or frost-heaving occurs.

Many species have seeds that require specific treatments to germinate, for example, a period of washing to remove chemical seed coat germination inhibitors, or seed coat scarification. This is best done under controlled, indoor conditions. Species like alder (*Alnus* spp.) form symbiotic relationships with soil bacteria. Sterile potting soil used in greenhouses will not grow field hardy plants. Soil must be collected from under existing alder plants in the field, and small amounts used to inoculate each pot in which seedlings are grown. Remember that because peat mining destroys wetlands, organic soil sources other than peat, such as leaf compost, are recommended.

Whole plant collection

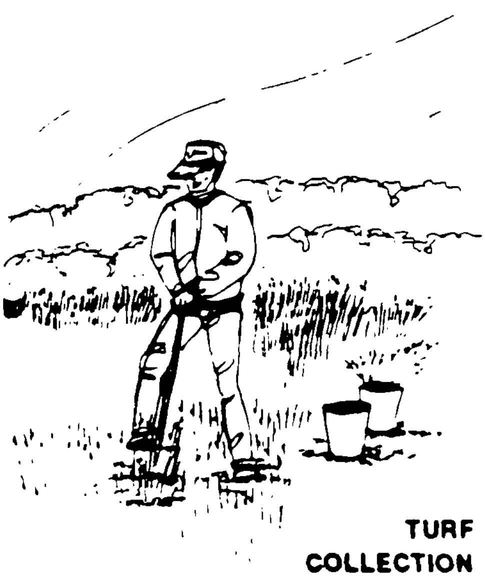
Individual whole plants or sections of turf can be excavated with machinery like a front-end loader. These methods are best used for whole woody plants, bulrush clones, and sedge turfs. Care must also be taken not to destroy the wetland from which plants are collected. Transplanting should occur immediately, without storage.



WHOLE PLANT COLLECTION

Sections of turf a few inches in diameter, called *plugs*, can also be collected from existing wetlands with an auger or shovel and trans-planted to a new wetland. This is labor intensive, but the trans-plants have very high survival rates when placed in the correct hydrologic regime.

Plants collected during the summer will be susceptible to desiccation because they retain their full leaf area but lose much root mass during transplanting. To reduce water loss, prune stems and leaf area back approximately 50% and keep the root mass moist.



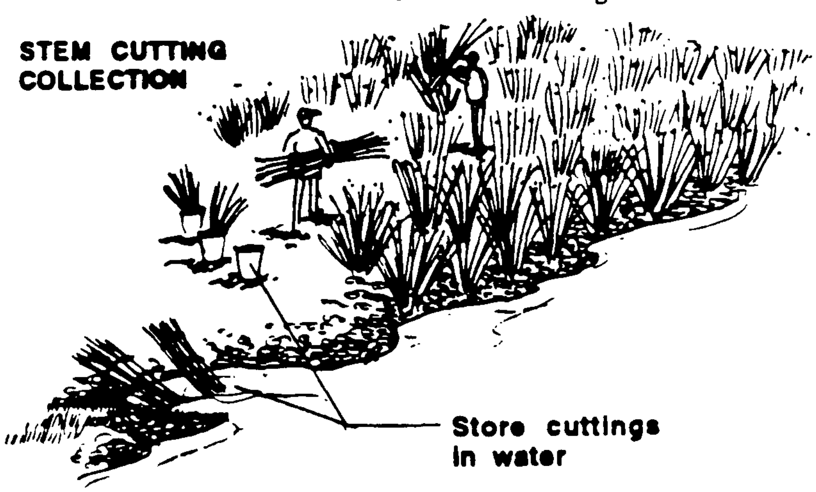
TURF COLLECTION

Stem cuttings

Willows, cottonwoods, and many other woody species have adventitious buds along their stems from which new leaves, stems, or roots can grow. Stems of dormant plants should be collected with pruning shears. High success has also been proven with summer cuttings.

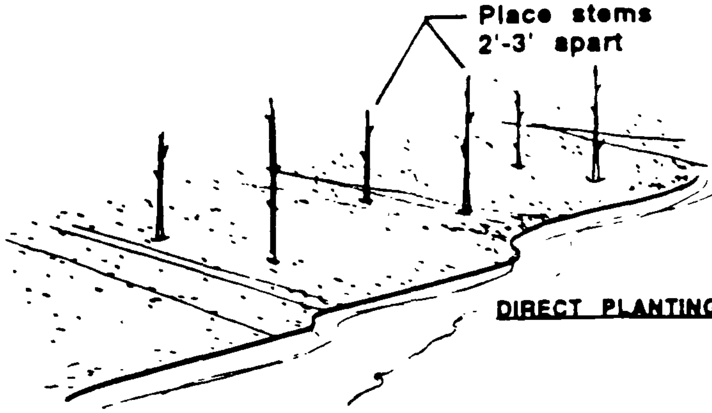
Cuttings should be at least 18 inches in length, and many studies have shown that the larger the diameter of the cutting, the higher the probability of survival, because larger stems contain more stored food for root and leaf growth. Cuttings 1/2 inch to 2 inches in diameter are recommended.

STEM CUTTING COLLECTION

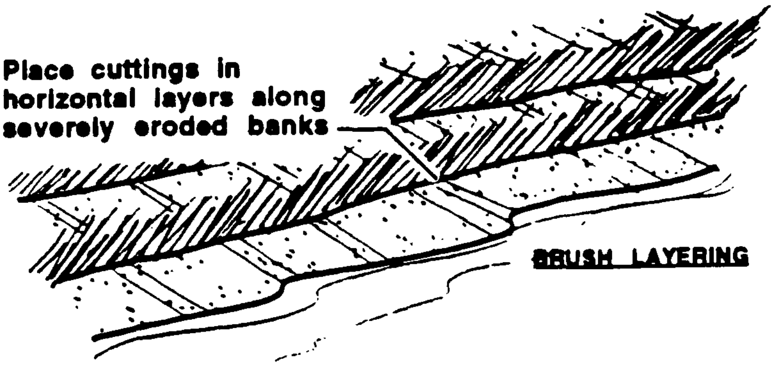


Cuttings must be stored with their bottom ends in water and never allowed to dry. They can be sent to a nursery for rooting in pots or planted in the field directly, without pre-treatment. These cuttings are easy to collect. Plantings should be spaced approximately 2 to 3 feet apart.

For planting, use a heavy metal rod to open a vertical hole larger in diameter than and approximately 2/3 the length of the cutting, insert the cutting, and close the hole. The cutting must be within 10 inches of the mid-summer water table and in most instances must reach the earlier summer water table.

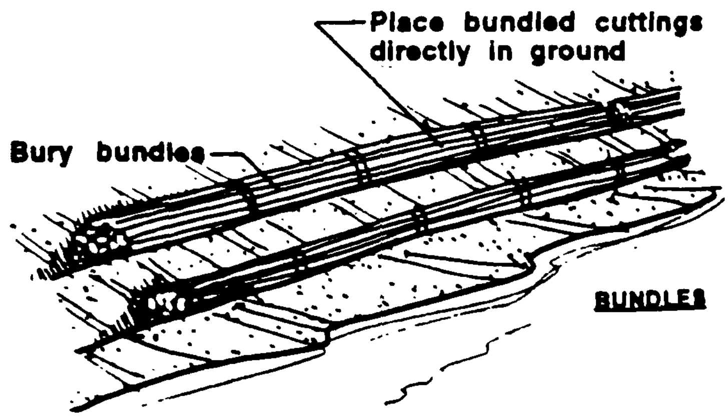


Stem cuttings can also be planted in *bundles* or *layers* and buried along the banks. These methods are variations on the method described above, require larger numbers of stems, and are recommended only for intensive treatments along rapidly eroding banks.



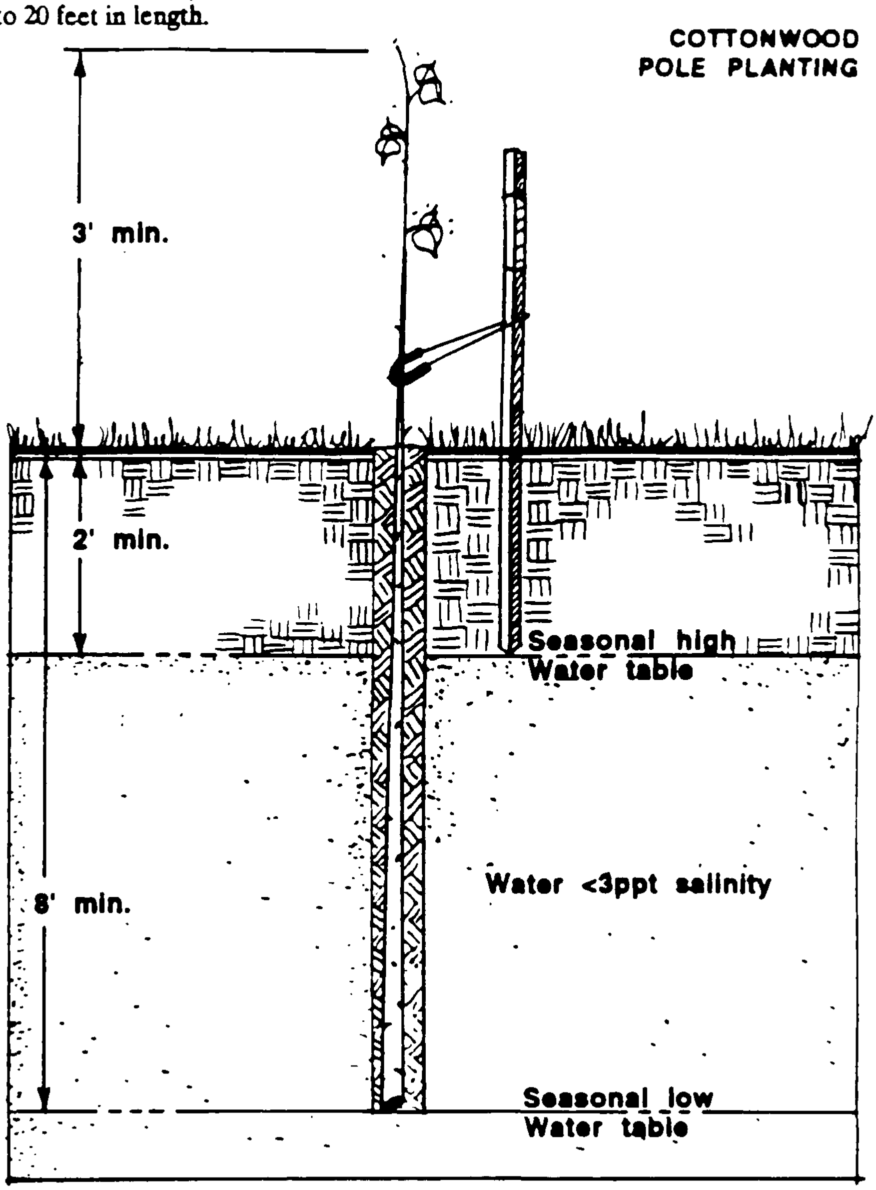
Pre-rooted cuttings from nurseries are more expensive, but have a very high chance of survival in the appropriate hydrologic regime. They should be carefully planted into larger holes.

Many researchers advise planting stems at least 18 inches deep, and on reservoir shores or streambanks where erosion potential is high planting to 30–36 inches is appropriate. This will necessitate very long stem cuttings.



Pole plantings

Cottonwood trees can be successfully planted into banks high above streams by using stem cuttings up to 20 feet in length. Poles should be collected only in areas where there are abundant cottonwood saplings. Stems three or more inches in diameter should be collected. Store stems with their butt ends in water at all times. Some researchers have found the best success after soaking pole ends for 10 to 14 days in a root stimulator, although others have found that the application of fertilizers, hormones, and fungicides has no survival benefit. Poles should be planted into a hole augered to the water table and backfilled completely. If the ground water has high salinity (> 3 ppt), pole planting is not recommended. The pole must be staked to prevent wind damage and fenced to protect against browsing deer, beaver, and rabbits.



Natural plant invasion

Many wetland plant species are readily dispersed by wind and wildlife and will naturally invade the site. Species such as cattails, pondweeds, *Chara*, many rushes, and early successional annuals, such as species of willow herb and *Veronica*, readily invade without being planted. In creating or restoring marsh ecosystems, planting nothing can sometimes result in the development of a complex plant community. This is not suggested, however, for restoring or creating riparian, wet meadow, or peatland wetlands. Natural invasion should be the chosen method only when wetlands exist nearby to provide a seed source.

The benefit of not planting is cost savings, but there are also many drawbacks. There is no way to predict which plant species will invade and dominate the wetland, how many years may be necessary for desired species to invade, and what weeds could become abundant before the desired vegetation is established. In some cases, natural invasion may be so slow that planting may later be required to fulfill permit requirements or to derive the ecological functions for which the wetland was built. If not included in the original budget, these additions may prove difficult to accomplish.

Soil seed bank

Wetlands that have been drained within the last 20 years may retain a viable wetland plant *seed bank*. This can be determined by collecting soil samples and sieving the material to identify seeds. Viability can be tested in a lab by applying tetrazolium to the seed embryo. An alternative, less precise method is to place samples in watertight containers and maintain soil saturation for several months to determine which species germinate. Dormant seeds may require long periods of soaking, scarification, or other treatments to germinate. If viable and germinable wetland plant propagules occur in the soil seed bank, a planting plan may not be necessary.

If mitigation is being performed for a permitted wetland fill and the wetland replacement project is type-for-type and will be located nearby, every effort should be made to salvage the top 12 inches of soil and transport this *live topsoil* to the replacement site. This soil contains plant roots, rhizomes, tubers and seeds. Often these plant propagules can resprout or germinate to rapidly form a plant cover on the new site. If the soil must be stored for more than a few weeks in a season other than winter, it should be covered and kept cool. The longer the storage period, the less value the material has for supplying plant propagules. The value of live topsoil is in its plant propagules.

There are drawbacks to wetland soil stockpiling. For example, wetland soils are usually hard to spread. They may contain the seeds of undesirable weed species, such as canada thistle or purple loosestrife; that can establish quickly on the new surface. If the weed content is unknown, the soil should not be used. In some cases, rapid decomposition of soil organic matter can release a superabundance of nutrients, which can lead to abundant algal growth and unpleasant odors.

Monitoring to evaluate project success

Evaluating the project is essential for determining the successful and unsuccessful project attributes. Don't hastily judge project success or failure. What looks disastrous the first year may end up successful, and what looks successful may be a short-lived phenomenon. Certain agencies may require a mitigation bond be held until project success is demonstrated. In these cases, proving success is critical.

The first monitoring should determine whether corrective actions are necessary and should occur immediately after construction. Questions to be answered by careful monitoring are:

Is the hydrologic regime appropriate and self-sustaining and will it persist?

If the wetland persists will it perform the functions for which it was designed?

What type of wetland ecosystem will this be in 5 or 25 years?

To answer these questions, every monitoring program must at least evaluate the following parameters:

1. acreage of wetland created or restored.
2. hydrologic regime of different portions of the site, especially compared to that proposed,
3. success of plantings,
4. volunteer plants established, particularly weeds that could create long-term problems,
5. functions that could be or are performed by the wetland,
6. remedial actions necessary to deal with problems, particularly with the hydrologic regime and plants.

It is suggested that five permanently marked plots be established during the first year in each of the proposed community types. Within each plot, collect data on the hydrologic regime, canopy cover of each plant species present, and whether the soils are hydric. The success of plantings in each plot should be determined.

The interaction of the hydrologic regime with the created land surface should be judged with a series of ground water monitoring wells and staff gauges. If the water table and/or surface water levels are as planned, most likely the project will succeed.

Careful observation is required to determine whether the project goals of functional replacement are successful. This will require establishing stations to measure particular attributes of interest, including water chemistry, wildlife use, and others. Although several aspects of the project turn out differently than planned, the project may still be a success from a functional perspective.

Routinely field-checking the plantings will help detect problems. The most common problems relate to inappropriate hydrologic regimes where the plantings occurred.

Many plantings cannot be considered successful until at least one year after planting. Plants that appear healthy during the second summer and that occur in the appropriate hydrologic regime are likely to survive. Remember to consider measuring the hydrologic regime in the planting area as a means of determining whether the habitat is suitable. Be prepared with temporary wavebreaks if necessary, or with supplemental watering during a hot, dry summer. Waterfowl, particularly geese, can eat large numbers of plantings in a short time and fencing may be necessary.

Summary

Restoring and creating wetlands in the Rocky Mountain West requires a multi-disciplinary approach. Potential sites should be carefully chosen to fulfill project goals of providing wetland functions, a particular wetland community type, and the appropriate size of wetland. Sites should be chosen and evaluated by collecting data to document the existing and potential hydrologic regime, soils, and vegetation. The data must be used by the project planner to determine if problems critical to wetland development occur at the site. These could include a ground water table that is too deep, soils with high salt content, or large weed populations. Study reference wetlands to clarify the site potential and guide project planning.

Restoring and creating the appropriate interaction between land and water is the most important element of project design. Accomplishing this will produce the hydrologic regime necessary for formation of hydric soils and the establishment of desired hydrophytes on the site. The goal should always be to produce a self-perpetuating wetland.

Because the hydrologic regime of many ground water and surface water systems in the West fluctuates greatly between dry and wet years and because water is scarce, careful project planning is essential. There is usually little room for error. With careful data collection, evaluation, and planning, many successful projects have been designed and implemented throughout the West. Restoring and creating wetlands provides a means of improving wildlife habitat, cleaning water, and providing flood control and other important ecological functions in the Rocky Mountain West.

Notes

Appendices

Nurseries for wetland plants

Colorado

Fort Collins Nursery
Wholesale Division
2224 N. Shields
Fort Collins, CO 80524
(303) 484-1289

Green Acres Nursery
4990 McIntyre St.
Golden, CO 80403
(303) 279-8204

Little Valley Nursery
13022 E. 136 Ave
Brighton, CO 80601
(800) 221-3241 toll free
(303) 659-6708

Upper Colorado Environmental Plant Center
U.S.D.A. Soil Conservation Service
P.O. Box 448
Meeker, Colorado 81641
(303) 878-5003

Idaho

Silver Springs Nursery (wholesale)
HCR 62, Box 86
Moyie Springs, ID 83845
(208) 267-5753

Aberdeen Plant Materials Center
U.S.D.A. Soil Conservation Service
P.O. Box 296
Aberdeen, ID
(208) 397-4133

Montana

Bitterroot Native Growers Inc.
(Roxa French)
445 Quast Lane
Corvallis, MT 59828
(406) 961-4991
(406) 961-4626 fax

Bitterroot Nursery
521 East Side Highway
Hamilton, MT 59828
(406) 961-3806

Lawyer's Wholesale Nursery
950 Hwy. 200 West
Plains, MT 59859
(800) 551-9875 toll free
(406) 826-3883

Montana Environmental Plant Center
U.S.D.A. Soil Conservation Service
Route 1, Box 1189
Bridger, MT 59014-9718
(406) 662-3579

New Mexico

New Mexico Environmental Plant Center
U.S.D.A. Soil Conservation Service
1036 Miller Street SW
Los Lunas, NM 87031
(505) 865-4684

North and South Dakota

Bismarck Environmental Plant Center
U.S.D.A. Soil Conservation Service
P.O. Box 1458
Bismarck, ND 58502
(701) 223-8536

Lincoln Oaks Nursery
P.O. Box 1601
Bismarck, ND 58502
(701) 223-8575

Utah

Lone Peak State Nursery
Utah Dept of Natural Resources
14650 South Prison Road
Draper, UT 84020
(801) 571-0900

Additional Reading

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Wetlands. Journal of the Society of Wetland Scientists contains many articles on wetland restoration and creation.

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