

Planning activities grade into construction activities as planning, construction staking, the pre-bid conference, and contract award(s) follow one another. Probable delays before equipment actually moves on site include minimum advertisement periods for public agencies, contractor's scheduling on other jobs, and inclement weather. Since the final construction activity is planting vegetation or improving growing condition for native vegetation, and both should be accomplished during spring or early summer, project schedules and construction time frames must be carefully established and clearly understood by planners and contractors. Generally, construction is most rapid in dry seasons, typically late summer and fall, in which case planting should be delayed until the following spring. In the interim, flooding the system may be useful to check grades, elevations, sealing and operation of piping and water control structures, electrical accessories, and other facilities. Identified errors or problems can then be corrected before vegetation is placed in the pools the following spring. If bentonite was used, the pools should be flooded until just prior to planting to avoid cracks and leaks.

Construction activities include clearing and grubbing, excavation, grading, transporting and placing fill, compacting, placing sand, gravel, or rock riprap, installing liners, placing and tilling in sealing substances, disposing of waste or excess fill, building or installing water control structures and piping, installing electrical facilities and other utilities, planting wetlands vegetation, seeding, and mulching or sodding disturbed areas,

Schedules for various phases of construction should be agreed to prior to any activities so that moving equipment in and starting work do not interfere with other planned activities on site and nearby site disturbance is kept to a minimum. Dry weather, generally late summer and fall, is typically optimal for construction and the job may be finished quickly. During wet seasons, contractors may only be able to work for 2 to 3 days and then be idle for days or weeks, dragging out the period when the site is disturbed; erosion may be high and construction activities disrupt other site work. Scheduling should also include consideration of neighboring landowners and land uses to cause as little disturbance to them as possible. Even though it may seem advantageous to have heavy equipment working at night to complete the job, disrupting the neighbors relaxation or sleep will set the seeds for future problems.

Prior to construction planners may need to

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1. investigate and, if necessary, divert or pump water from the site
2. mark any trees with flagging that should be left or limbed or anything other than clearing
3. identify locations of silt barriers (with fence or straw bales) needed, and insure that contractors comply with regulations and any special requirements
4. Discuss equipment types and numbers with contractors to insure expeditious work activities; improperly sized equipment will increase construction time and costs and may inhibit accurate construction. For example, top width of the dikes will be at least as wide as the bulldozer blade because it is difficult for the operator to build anything less. If the site is wet, at least two dozers or other machines should be used since one will often be needed to extract the other after it mires down. Obtaining a unit off-site each time the dozer is stuck will cause needless delays. If the site is very wet, a dragline using supporting mats is generally more efficient than dozers and scrapers or backhoes.

The system planner or a construction supervisor familiar with all aspects of the project (including design objectives and management plans) should be on-site or at least monitor activities on a daily basis. Invariably, some aspect has been overlooked or is not anticipated, and modifications will be necessary (see Figure 1). If someone knowledgeable is not available, contractors may stop work activities until advised, or independently modify the plans. In the first case, valuable time will be lost; but in the second, major errors could occur that could be costly to correct and contractors may be unwilling to absorb the extra costs.

Specific construction activities vary substantially with site conditions, type of wetlands, and construction equipment and work force. However, construction supervision is primarily insuring that the contractor adheres to construction drawings and specifications and developing and agreeing to modifications as necessary to accommodate unforeseen circumstances. Modifications should be approved by the system planner or someone familiar with the technical specifications, future management plans, and requirements before adoption. Though construction supervision is as varied as different projects, general guidelines and precautions are applicable to a variety of wetlands construction activities.

Topsoil should be removed and stockpiled for later use during the early stages of clearing. If a wetlands soil is removed for later use, store it underwater to avoid oxidizing and releasing bound metals or other substances that could detrimentally impact the new system if they were re-dissolved. All permeable soil materials, organic matter, rocks, trash, or debris should be removed in preparing a solid, impermeable foundation for dikes and other structures. Stream beds must be widened and deepened, and all stones, gravel, or sand removed to the clay foundation so that fill material will bond properly. Natural holes or holes caused by clearing and grubbing should be cleaned out and filled with suitable fill material. In each instance, the objective is to insure that clay fill materials will abut and bond to a clay foundation to insure continuity of the impervious materials.

Waste or spoil materials that will not be needed for fill should be placed in boundary areas, sloped and contoured to blend into the surroundings, and stabilized by seeding or sodding. Excess earth could be used to provide knoll overlooks, nesting islands, wider parking areas and visitor stops, visual and/or auditory screening, or any other imaginative use that will not interfere with the principal functions of the new wetlands.

Construction should always follow contract specification as closely as possible. In

many wetlands, slight deviations may not be critical; but if the system will be used for wastewater treatment, grading must meet the specifications in the plan within described tolerances to achieve proper functioning of the system. Out-of-tolerance lateral bed slopes may not only cause ponding, but are likely to cause channeling or short-circuiting that reduces the effective treatment area in the cell and depresses performance. Similarly, improper grading along the cell length could make it impossible to set and maintain proper water depths, as well as causing channeling and short-circuiting. Obviously, inability to manage water depths would severely retard establishing or managing the desired plant community and retard functioning of any type of wetlands.

Specifications on dike materials and dimensions are established to reduce or eliminate leakage or seepage and to insure dike integrity under expected water pressures. Failure to follow specifications on materials, top width, base width, or slopes could result in weak or leaky dikes or highly erodible slopes that may be difficult to stabilize. Installing the clay core and culverts or controls in the dikes must also be done carefully, with proper fill compacting to prevent seepage.

Meeting permeability specifications is important in all wetlands. Be careful that contractors do not excavate deeper than planned and penetrate an impermeable layer into a permeable layer. Permeability testing should be agreed upon prior to construction, and frequent testing is necessary during construction. Compacting in situ or fill material must be done with proper equipment and only when moisture conditions are satisfactory. If necessary, sprinklers may be used to achieve proper soil moisture conditions before and during compacting. Bentonite or soda ash blankets must be carefully installed and tilled into the bottom following specifications in the designs to insure proper functioning. If synthetic liners are used, installation must follow manufacturers' instructions for bed material, sealing (liner-to-liner and liner-to-piping and controls), and insulating material above the liner. Construction equipment and workers can easily puncture synthetic liners and clay blankets unless special precautions are communicated and followed. Once final grading and compacting has been accomplished or a liner installed, equipment should not be permitted on the cell bottom or dike sides, and foot traffic should be minimized.

If parent or fill materials are very fine clays that easily powder after disturbance, plan to flood the system and dewater it before final grading. Preliminary flooding is also the most simple method to check grade and structure elevations throughout the system. Final grading before flooding may need to be repeated since it is not unusual for settling to cause elevation differences of 15 to 30 cm in cell beds and occasionally on dikes.

Installing water control structures may be as simple as laying PVC pipes, or as complex as building forms and pouring concrete in place. In either case, correct elevations and adequate support are critical to future management ability. Correct proportions of cement and sand and approved temperatures are important in achieving design strength for concrete structures. Appropriate adhesives, bonding techniques, and curing temperatures are required to insure correct joining of plastic piping. As always, specified elevations for each and every segment of pipe or portion of a concrete structure are especially important. Generally, wetlands system operation is dependent on gravity flow that is only possible if design elevations are achieved in all aspects of the system.

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conditions, species, and planting season, detailed information is provided in the following chapter. In general, planting supervision, as with other construction activities, is principally insuring that contractors adhere to contract specifications so that design objectives will be achieved.

Optimal planting conditions for cut materials or seed are created by shallow flooding, followed by dewatering but not complete drying — leaving soft, moist soil conditions. Common pitfalls include improperly storing planting materials — too dry or too warm or too long — careless handling and poor orientation. Planting stock should not be dug more than 2 days before planting and should be stored and transported in a cool, dark, humid environment. Damaged stock may perish or take longer than normal to begin growth and wetland plant roots are as sensitive to damage as any garden plant. Rows must run perpendicular to the direction of flow to improve coverage and reduce channeling, even though it may be easier to operate equipment up and down the long axis of each cell. After planting is completed, flood the cell with 1 to 2.5 cm of water, but insure that water depths do not overtop cut stalks or the new plantings may die. As new growth begins, water levels may be slowly raised, but should not overtop the new growth.

Hand or natural seeding is less expensive, but much less reliable for starting the new plant community. Germination rates of many wetland plant seeds are less than 5%, so large quantities must be collected and distributed. Whether hand or natural seeding is used, the pond should be shallow flooded in late winter and early spring and dewatered at the onset of warm weather to establish warm, moist mud conditions. Careful monitoring and regulation of water levels at or just below the pond bottom is important in order to maintain the proper soil moisture conditions for germination and sprouting. After the new growth has reached 10 to 12 cm, water levels should be raised to between 2 and 4 cm above the substrate to inhibit or kill terrestrial species, but should not overtop wetlands plants.

Trees or shrubs along the perimeters should be installed after a good grass cover has become established in the event that re-grading and re-seeding should become necessary because of erosion or other problems. Generally, trees or shrubs should not be planted on dikes unless the dike is very large and root growth is not likely to impugn the integrity of the dike. Similarly, fencing for livestock or security should not be installed until after disturbed areas have become well covered with stabilizing vegetation.

All control structures, piping, wiring, pumps and other electrical facilities, seals, water levels, and flow distribution should be tested for proper operation or elevations before formal acceptance. Plant survival can be estimated by observing the percentage of plants with new and vigorous growth evident. Since some aspects — settling, subsidence, leaks, or seepage — may not become apparent until some time after initial operation, planners should establish a test or start-up period with the contractor and arrangements that may be needed to correct problems. Elevation variances will largely become apparent with initial flooding, as will problems with piping and controls. However, seeps or leaks may be undetected for fairly long periods, and plants showing good growth initially may die later from any number of factors. Since some of these are controlled by project personnel (i.e., water depths) planners should obtain agreements with contractors on remedial actions and responsibilities.

Any erosion on dikes, spillways, around control structures, or in the upper ends of cells should be immediately filled with clay or soil materials, compacted, and re-seeded or re-sodded as necessary. Before the vegetation provides a protective screen, wave action may erode dikes or earthen fills and temporary log booms or slat fencing may be needed. If seepage or leaks are detected, water levels should be lowered immediately. Depending on the location, adding additional sealing material, bentonite, or soda ash may correct the problem. However, leaks around control structures or at the base of a dike will require excavation of fill materials and replacement with compacted, impervious clays. If a synthetic liner was used, additional panels may need to be added and securely bonded to previous panels.

In summary, proper construction supervision is principally having a knowledgeable person ensure that construction drawings and specifications are followed precisely and developing and documenting modifications as necessary. Since experience levels and work quality may vary substantially between contractors, time and effort required for supervision will also vary, but close attention to details is always a prudent investment. Since few contracts fully describe every component, a considerable amount of faith and trust between planners and contractors is essential. However, even the best contractors may misunderstand or misinterpret drawings and specifications, or more likely, encounter unforeseen situations, and readily available advice or directions will save time and expense and possibly, future management capabilities. Supervision also includes frequent and thorough inspections of all aspects of the project during start-up and immediate attention to any problems. In as much as some problems may not be identified until after the contractor has moved off site, good working relationships between the construction supervisor and the contractor are important in implementing remedial actions before minor faults become major failures.