BLOCKING AND FILLING SURFACE DRAINAGE DITCHES

TECHNICAL GUIDANCE DOCUMENT

Document No.: WRG 4A-1
Publication Date: 10/14/2015

Table of Contents

INTRODUCTION

Surface ditches are common in Minnesota and have drained and altered countless wetlands. When attempting to restore wetlands drained by surface ditches, it is usually necessary to place earth fills at strategic locations within the drainage ditch to block the flow of water. This wetland restoration strategy is commonly referred to as constructing a "ditch plug". While these earthen fills are often thought of as being only small, simple structures, ditch plugs are essentially small dams and must be designed and constructed accordingly.

Figure 1. Construction of an Earthen Plug Across Drainage Ditch

In addition to constructing appropriately located and designed ditch plugs, there is often a need or desire to also completely fill the entire reach of ditch within the planned restoration area. In certain landscape settings, this additional action will be necessary for the successful restoration of wetland hydrology.

APPLICATION

Drainage ditches remove excess water that collects on the land surface as well as in the soil profile. They provide a means to manage or lower water tables and can rapidly convey runoff from wetlands to areas downstream. Ditches can be just a few inches to many feet in depth, depending on topography and landscape setting.

Drainage ditches can be located in depressional wetlands, sloped wetlands, and wetland flats. As discussed in Section 3-4 and in Appendix 3-A of the Guide, each of these wetland types interact with surface and ground water to varying degrees depending on hydrogeologic factors such as soil characteristics, geologic setting, and water table position. It is important that the dynamic nature of a drained wetland's hydrogeology be understood to accurately determine effective design strategies for restoration. More specifically, it will be important to determine if a ditch plug alone will be

effective in restoring hydrology to the wetland or if the entire open reach of ditch through the wetland also needs to be filled in.

Ditch plugs should be located and designed to effectively restore hydrology to the drained wetland. The constructed plug should prevent the downstream functioning ditch system from affecting the wetland. This requires that a long-enough section of ditch be plugged and filled with compacted soil to block or cutoff any drainage effect from the downstream ditch.

When constructing ditch plugs, additional benefits can be achieved by also filling in portions of the ditch system immediately upstream and downstream of the plug. This will increase the overall length of fill and provide for a more effective plug without substantially increasing construction costs. In many cases, complete filling of a drainage ditch through a restored wetland should also be considered. This provides a more effective and permanent restoration of site hydrology and allows for recontouring and restoration of topography as part of construction.

Figure 2. Shallow Ditch Being Filled

DESIGN CONSIDERATIONS

Ditch plugs are small dams and must be designed and constructed accordingly. Their design should consider site topography, subgrade soils and required foundation treatments, stripping requirements, location and suitability of backfill materials, compaction requirements, embankment fill heights and slopes, settlement allowances, stabilization requirements, etc. Detailed discussions of these and other important items relating to embankment design and construction can be found in Section 4.5 Earthen Embankments of the Guide.

To effectively block and restore wetland hydrology, ditch plugs should generally be about **75 to 100** feet in total length. Considerations for increasing this length are necessary when more extensive lateral drainage effects from the downstream drainage system exist. This includes situations when the plug is located in sandy or organic soils. A plug's length may be decreased when restoring wetlands drained by shallow ditches that are generally less than 2 feet in depth. In these situations, the overall length of the plug within the ditch should not be less than **50** feet. To achieve these effective lengths, ditch plugs will need to have fairly broad tops widths (> 10 feet) and relatively flat side slopes (> 8 to 1).

The requirements for site preparation and stripping will be an important design component. The design should ensure that all vegetation, roots, sediment, organic matter, and other unsuitable soils are removed from the area under the plug prior to its construction. Because of the potential for excess accumulated sediments and organic matter within the ditch bottom, the design should consider deeper stripping depths at the bottom of the ditch as compared to ditch side slopes and bank tops (**Figure 3**).

At each planned plug location, an evaluation of requirements for stripping or foundation excavation and treatments should be made.

The source of fill material for the plug will also be an important design consideration. If not available from the immediate area, provisions for transporting suitable borrow from other areas of the project will be needed. To minimize

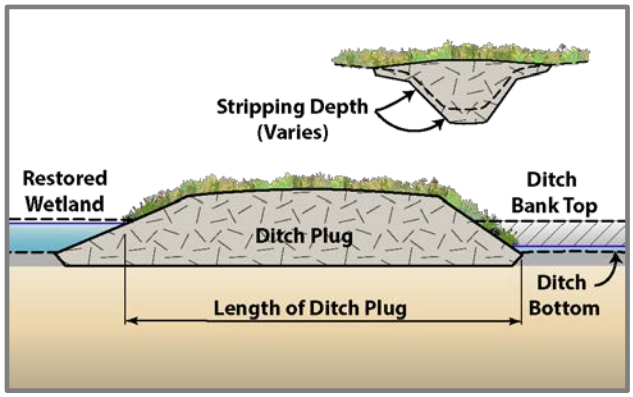

Figure 3. Ditch Plug Design Details

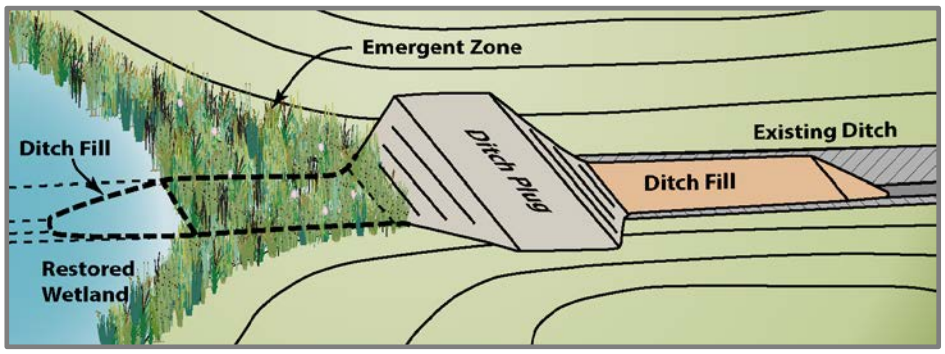

Figure 4. Ditch Plug Complimented with Adjacent Ditch Fills

construction costs, the effective length of a plug can be accomplished by finishing the grading with additional, random fills placed both upstream and downstream of the constructed plug (**Figure 4**). This design strategy allows for fairly broad embankments with flat slopes and provides for a natural looking aesthetic plug that not only successfully restores wetland hydrology but is also effective at addressing problems with rodent burrowing and potential wave action.

Generally, plugs should be designed as embankments and be constructed to prevent overtopping. In limited situations, ditch plugs can be designed to overtop and serve as a spillway for managing wetland discharges. This condition requires extra design precautions to ensure the plug will be stable and experience only infrequent flows across them. For that reason, flow-over ditch plugs are limited to smaller wetlands with limited watershed areas where discharge rates, volumes, and velocities are expected to be minimal. Additional discussion regarding the design of flow-over ditch plugs occurs in Section 4.4 Outlet Structures.

Ditch fills are often constructed in conjunction with ditch plugs. When used, ditch fills provide a more complete restoration and in some settings, may be necessary to provide for effective restoration of the wetland. They are typically more straightforward to design and construct than ditch plugs. When feasible, it is recommended to fill and recontouring the entire length of ditch through the wetland being restored.

Specific requirements for location, length, and methods to construct ditch plugs and fills will vary depending on type of wetland that is being restored and specific characteristics of a site including; topography, soils, and ditch configuration. Additional discussion on this follows.

Depressional Wetlands

Surface ditches are commonly used to drain depressional shallow to deep marsh or "pothole" wetlands. Typically, a single ditch will exit the wetland basin and a well-placed ditch plug may be all that is needed to effectively restore wetland hydrology. The design should ensure that the location and length of the ditch plug will prevent the functioning downstream drainage system from having continued drainage influences on the restored wetland basin. This requires careful consideration to the location and length of the plug with respect to the planned wetland edge, site soils, and topography. Ideally, the ditch plug should be located at or just downstream of the restored wetland's edge.

The placement of additional fills in the ditch just upstream and downstream of the plug will aide in its overall restoration effectiveness including helping to reduce or eliminate adverse drainage effects by the downstream ditch (**Figure 5**).

Certain depressional wetlands are surface water dependent and not affected by groundwater. Drainage ditches constructed through these wetlands may have penetrated through an impervious bottom substrate into an underlying pervious soil layer. This can further aide in removing hydrology from the wetland. In these settings, a ditch plug alone will often be ineffective at restoring functional hydrology. An effective restoration requires that the ditch through the wetland also be completely filled in attempt to recreate the seal between the wetland and underlying pervious soils. This usually occurs in surface water dependent wetlands where the surface hydric soils or substrates are underlain with sand or sand lenses.

Wetland outlet structures, vegetated spillways in particular, can influence the location and layout of earthfills used to restore wetlands. Additional discussion on this occurs in Section 4.5 Earthen Embankments.

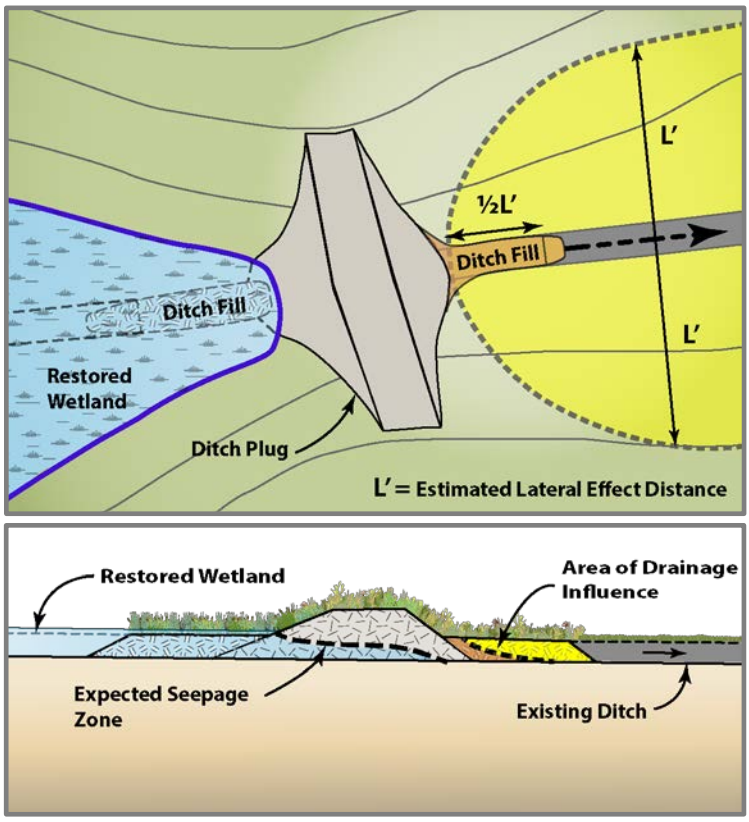

Figure 5. Ideal Location and Design Layout for a Ditch Plug in a Depressional Wetland Settings

Sloped Wetlands

Because of the moderate to steeply sloping topography associated with sloped wetlands, a single ditch plug is likely to be ineffective at restoring hydrology to the wetland. The restoration of sloped wetlands requires at least one ditch plug at the bottom or lowest elevation of the ditch with additional plugs, spaced periodically apart, on the remaining portions of the ditch.

Information on site soils, grade or slope of the land, and specific locations and depths of existing ditches is needed for a functional design. For each reach of open ditch that exists, the design objective should be, at minimum, to construct multiple ditch plugs spaced so they exist every **one** to **three** feet of vertical slope relief of the land surface. This stepped or segmented approach to performing ditch plugs helps to reduce excessive hydraulic "head" differences from one plug to the next and more evenly distributes restored hydrology throughout the sloped wetland area.

The restoration of ditch drained sloped wetlands can provide a number of design and construction challenges

The entire reach of open ditch between the constructed plugs should also be filled in to ensure full restoration of the site and to help prevent excessive ponding against any of the constructed plugs (**Figure 6**).

Non-Depressional Wetland Flats

Non-depressional wetland flats typically consist of vast areas of peat or organic soils. Extensive ditch systems are often used to drain wetlands in this type of landscape setting. When restoration of these wetland types is possible, the construction of multiple ditch plugs and fills is usually needed.

The soils that are often associated with these types of wetlands generally have relatively high permeability rates therefore; it is recommended for effective restoration of wetland hydrology that at least **150** feet of open ditch be plugged and filled at each desired location. If less permeable soils exist, the length of the plug/fill block can be reduced but should not be less than **100** feet.

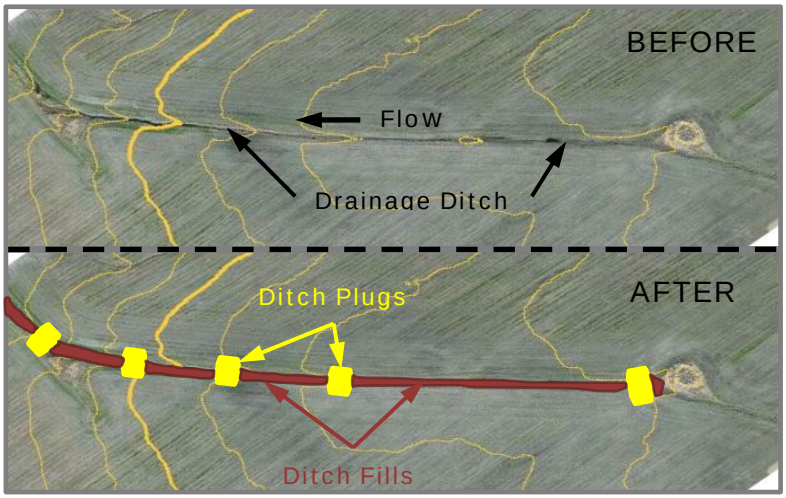

Figure 6. Ditch Plug/Fill Design for Sloped Wetland Setting – 2 Foot Contours

In addition, when attempting to restore non-depressional wetland flats that are large in size, some grade or elevation drop may exist across the landscape. While this elevation change may seem subtle, the effective restoration of wetland hydrology to these landscapes may require that multiple plugs and fills be considered to address this elevation change. For this situation, refer to the discussion on sloped wetlands above for applicable design guidance, however, it may be necessary to alter the design criteria with plugs instead spaced every **one** foot of vertical slope relief.

Strong consideration should be given to completely backfill open ditches between constructed ditch plugs to ensure full restoration of these wetlands.

Figure 7. Importing Material to Fill Ditch thru Non-Depressional Wetland

PROJECT BOUNDARIES/PROPERTY LINES

Special consideration is needed when planned ditch plugs and fills are in close proximity to project or property boundaries. Depending on site soils and the downstream land use, it may be necessary or beneficial to incorporate specific design measures to address and prevent potential adverse impacts to the adjoining, downstream lands. This can often be accomplished in one of two ways.

The first method is for any planned ditch plugs to be offset from the project/property line by at least **25** feet to allow for a short reach of the ditch to remain functioning within the project boundary. Leaving a short reach of the existing drainage ditch

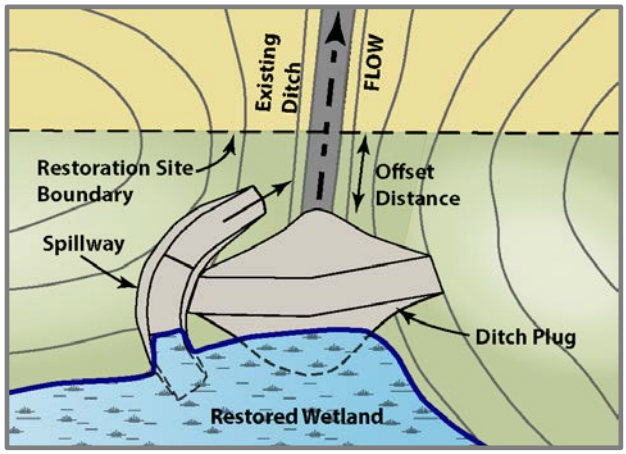

Figure 8. Ditch Plug Offset from Property Line

intact between the plug and property line may help prevent negative off-site hydrologic impacts as a result of the restoration while at the same time allowing wetland outlets including spillways to be constructed where they can safely discharge and outlet into the ditch before exiting the property (**Figure 8**).

An alternative is to work with the adjoining property owner and install additional drainage provisions just within the adjoining property to ensure protection against hydrologic effects of the adjoining restoration project. A single tile line or ditch, offset and parallel to the project boundary, will usually suffice. The length, size and offset distance from the project boundary are design parameters that, in addition to regulatory compliance, need consideration.

CONSTRUCTION REQUIREMENTS

Requirements for site preparation, topsoil stripping, foundation treatments, location and suitability of borrow materials, compaction, settlement allowances, finished grades, and for methods to stabilize the constructed fills and other disturbed areas are all important aspects of the construction process.

If constructing both ditch plugs and ditch fills, separate construction requirements unique to each restoration design strategy are needed. These requirements should be clearly stated as part of prepared construction plans and specifications and then adhered to as part of construction.

Ditch Plugs

Site preparation and stripping requirements for ditch plugs is a critical first step in their construction and must be carefully completed. All vegetation, roots, sediment, and organic matter should be removed from the area under the plug prior to its construction. Existing vegetation should be carefully evaluated prior to stripping. If it contains weeds or other undesired vegetative species consideration should be given to burying it as part of any associated ditch filling (see ditch fill discussion below).

Figure 9. Ditch Area being Stripped Prior to Plug Construction

Additional excavations to remove unsuitable soils within the ditch bottom will need consideration as part of the stripping operations. Depending on conditions, it may be necessary to dewater the ditch within the construction area to facilitate proper construction conditions and to achieve specified compaction requirements for ditch fills.

Figure 10. Ditch Plug under Construction

Figure 11. Compaction of Constructed Ditch Plug

The selection, placement, and compaction of fills will be an important part of a ditch plug's construction. Fills should be placed in lifts and compacted per requirements of the plan and specifications. The initial first few feet of fill material will typically be the most difficult to compact due to location and conditions at bottom of the ditch. Additional discussion of compaction requirements for embankments occurs in Section 4.5 Earthen Embankments.

Some settlement of the compacted fills as part of the ditch plug's construction will occur. Under ideal conditions with good backfill material and compaction methods, settlement amounts of 5 to 10 percent of the total fill height should be expected. Under less than ideal conditions, settlement amounts of 10 to 15 percent are possible. More settlement will occur in the center of the ditch where fill heights are greater. The finished grading of the plug should be overbuilt and crowned to account for the expected settlement (**Figure 12**).

Figure 12. Finished Ditch Plug with Crown in Middle

DITCH FILLING AND RECONTOURING

Stripping of the existing ditch bottom or side slopes will usually not be necessary when constructing general ditch fills. Existing ditch spoil material, if present, can simply be pushed into the ditch to accomplish the filling. If the spoil bank contains invasive or other undesired vegetation, it is recommended to have the contractor first remove and push into the ditch the surface layer of ditch spoils to ensure the undesired vegetation gets placed towards the bottom portion of the ditch fill and adequately buried (**Figure 13**).

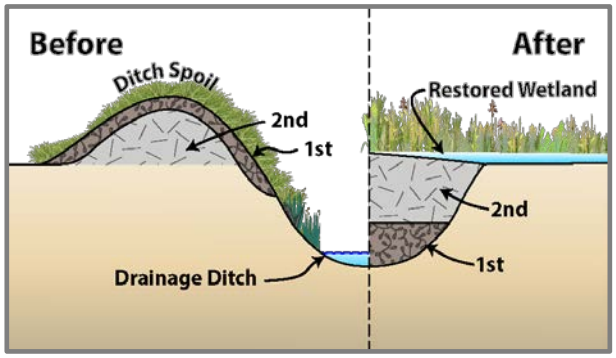

Figure 13. Construction Sequence to Address Invasive or Undesired Vegetation on Ditch Bank

Because ditch spoils decompose, settle, erode, and are often spread into adjoining fields, the quantity of available ditch spoil material is often less than what is needed to completely fill a ditch. When complete filling of a ditch is desired, careful selection of alternative sources of fill or borrow material often becomes an important design and construction consideration. Travel routes and further compaction of wetland soils is an issue that may need consideration if borrow materials are hauled from areas away from the ditch.

It is recommended that some amount of compaction be conducted of general ditch fills to prevent excessive settling. The initial first few feet will typically be the most difficult to compact due to location and potential presence of water in the ditch. Depending on conditions, it may be necessary to allow the contractor to build a base within the ditch bottom of one to three feet of material before requiring any compaction. Beyond that, general compaction of soils placed in the ditch using lifts of about 12 inches will yield the best results. With consideration to construction conditions and methods for placement and compaction, settlement rates of up to 20 percent or higher can be expected for ditch fills, especially in areas where organic soils are used.

When filling ditches within sloped wetlands, it will be important to overbuild the ditch fills so that upon their settling, they still remain slightly higher than the surrounding wetland. This helps to evenly spread or distribute restored hydrology to the surrounding sloped wetland soils and to prevent surface runoff from overtopping and eroding the constructed fills.

OTHER CONSIDERATIONS

- When necessary, provisions for obtaining borrow materials to construct ditch plugs and fills will be needed. Discussion and consideration for obtaining supplemental borrow material from within areas of the planned wetland occurs in Section 4.6 Sediment Removal, Scrapes, and Other Excavations.

- Design consideration is needed to address potential issues with wave or rodent damage to constructed ditch plugs. Additional discussion on this topic occurs in Section 4.5 Earthen Embankments.

- As wetlands and their respective watersheds get larger, the need to manage runoff from the restored wetland often require that ditch plugs be constructed in conjunction with spillways and/or other outlet structures to safely transfer runoff from the wetland to the downstream ditch system. The type of outlet used will likely influence the location and design of ditch plugs and associated ditch fills.

- Other considerations for filling open ditches as part of restoration construction include concerns for hunter safety and removing deep water habitat from a project, which can create a condition for potentially undesirable aquatic species, such as fathead minnows, to survive over the winter.

- Consideration is needed to address stabilizing areas of the restoration site that are disturbed during construction. All disturbed areas should be seeded with consideration for additional stabilization on slopes and in other areas where concentrated flow may occur. This can

include the use of straw mulch, erosion control blankets, hydro mulching, etc.

COST

The cost to construct ditch plugs and fills varies and is primarily dependent on the amount of site preparation work and earthfills needed to accomplish restoration goals.

Costs to construct ditch plugs will generally include stripping the area under the plug, transporting, placing, compacting and finish grading of fill materials, and methods to stabilize the completed fills (seeding and mulching). The size (height and length) of the plug will directly affect fill volumes and cost. Required subgrade improvements (core trench) and more direct means of stabilizing the completed fills (erosion control blankets, hydro seeding-mulching, etc.) will add additional costs.

Costs to fill a ditch will vary depending on length and size of the ditch and whether fills need to be hauled from alternative borrow areas to supplement existing spoil quantities. The costs associated with grading, hauling, placing, and compacting fill materials needs consideration when determining the extent of ditch fill needed. Due to the difficulty of measuring fill volumes, ditch fill work is recommended to be completed at an hourly rate or per lineal foot of ditch filled. When possible, consider filling ditches with excavated materials from other construction actions such as excavation of core trenches, spillways, sediment removal areas, etc.

Seeding of the disturbed areas is optional and likely dependent on type of wetland restored. For example, seeding and stabilizing the disturbed ditch fill area within a sloped wetland setting is critical to success, whereas it becomes less important in a depressional wetland setting

MAINTENANCE

Locations where ditch plugs and fills are constructed will need periodic inspection to identify and correct problems. Various problems can include excessive erosion, scouring, or sloughing of the constructed fills, excessive settling of backfill materials, seepage thru constructed ditch plugs, wave or rodent damage, and poor establishment of vegetative cover.

ADDITIONAL REFERENCES

Other Related Technical Guidance Documents can be found in Appendix 4-A of the Minnesota Wetland Restoration Guide.

Standard Engineering Drawings to aide in the design of ditch plugs and fills along with other drainage manipulation strategies are provided in Appendix 4-B**.**