OUTLETTING DRAINAGE SYSTEMS

TECHNICAL GUIDANCE DOCUMENT

Document No.: WRG 4A-3
Publication Date: 10/14/2015

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INTRODUCTION

In Minnesota, wetlands planned for restoration are commonly drained by surface drainage ditches and subsurface drainage tile. These drainage systems often extend upstream from planned restoration sites and provide drainage to neighboring lands not part of a restoration project.

The restoration of wetlands in these types of drainage scenarios provides a number of design and construction challenges and may not always be possible. However, strategies to address incoming drainage systems as part of restoration do exist and should be considered, when feasible. These strategies include rerouting incoming drainage systems away from or around planned wetland restorations or when possible, outletting them directly into planned wetlands or other suitable areas within the restoration site.

Figure 1. Upstream Drainage Tile Outletting into Restored Wetland

APPLICATION

This Technical Guidance Document focuses on strategies to design effective and functional outlets within restoration sites for neighboring upstream drainage systems. The design of drainage system outlets will primarily be dependent on the type, location, elevation and grade of the drainage system as it approaches and enters the restoration site. If the approaching drainage system is steep enough in grade, then it may be possible to modify it and construct an effective and functional outlet directly onto the restoration site. The design will also be influenced by the general landscape of the planned outlet's location and, if part of a wetland restoration, the type of wetland being restored.

The strategies presented are most applicable to modifying subsurface tile drainage systems that

enter a restoration site. These strategies may also apply to surface drainage ditches, however, opportunities will be limited to select locations.

Drainage system outlets are generally designed and constructed to discharge directly into wetland areas that are planned for restoration. Outlets are not limited, however, to wetland restoration areas. Water quality benefits can be achieved when drainage systems are outletted into other areas of a restoration site, including floodplains and other riparian areas, where a suitable vegetative buffer and soil conditions exist that can receive and treat drainage system discharges.

> Significant water quality benefits can be achieved when daylighting tile drainage systems into restored wetlands or other areas of a restoration site

Before a decision is made to outlet an upstream drainage system into a restoration site, it will be important to understand the potential benefits and consequences associated with this restoration strategy. They include, but may not be limited to:

Benefits

- This strategy is generally less expensive and easier to implement and maintain than to reroute a drainage system around or away from restoration areas
- The upstream drainage system can provide a supplemental source of hydrology to planned wetland restorations
- Treating and filtering drainage system discharges as part of a restoration design can provide significant water quality benefits
- Outletting and storing drainage system discharges as part of the restoration design may provide flood control benefits
- Planned outlets may improve performance of the associated drainage system, reduce future drainage system maintenance costs, and possibly eliminating the need for future drainage system improvements
- The construction of free flowing "unforced" outlets allow the upstream drainage system to be more effectively monitored

Consequences

- The incoming drainage system may provide too much hydrology to restored wetlands limiting their potential to have seasonal water level variations or natural drawdown cycles
- The incoming drainage system may provide excessive sediment, nutrients, etc., and impair the water quality of restored wetlands
- There is a potential to more readily introduce undesirable plant and aquatic species into restored wetlands from the upstream watershed

When outletting an upstream drainage system is not possible or desired, an alternative restoration strategy may be to reroute the incoming drainage system around or away from the planned restoration areas. In limited situations, it may be possible to consider using drainage lift stations to convey upstream drainage system discharges into planned wetlands. Additional information on these and other wetland restoration strategies can be found in Technical Guidance Documents as part of Appendix 4-A.

Restoration strategies that include modifying incoming drainage systems need to consider cost and considerations for long term maintenance. These strategies should be considered only if feasible and no other more practical alternatives exist, such as additional land acquisition.

DESIGN CONSIDERATIONS

The primary design objective will be to ensure that a functional outlet will result that will not adversely affect the restoration site or compromise drainage benefits of upstream properties. It will also be necessary to determine if the effects of outletting an upstream drainage system into a planned wetland are in-line with restoration goals established for a project.

Through investigation and design, it should be determined that the upstream drainage system, as it approaches the project, is high enough in elevation and with modifications, it can outlet at a desired location within the restoration

> Drainage benefits of adjoining properties should not be adversely affected by planned drainage system modifications

site. This requires certain information be known about the drainage system including its size, location, elevation and grade. It also requires having information of the restoration site including elevations and locations of planned restoration practices. If outletting directly into and as part of a planned wetland restoration, location and elevation information of the wetland and its landscape setting or type is needed.

It will also be important to ensure the planned wetland will be capable of accepting the additional hydrology from the above drainage system and not be "overloaded". To determine this, an analysis should be conducted of all hydrologic inputs, wetland storage capacities, and potential capacities and condition of the wetland's outlet. In some situations, a comprehensive hydrologic and hydraulic study is needed to determine this.

Design strategies for outletting drainage systems into a restoration site will vary somewhat depending whether the system being outletted is a surface ditch or a subsurface drainage tile.

Outletting Surface Drainage Ditches

Ditches are generally constructed with flatter grades than subsurface tile and opportunities to outlet them into restoration sites are usually limited. Ditch outlets will likely be limited to larger restored wetlands where adequate detention storage and outlet structure capacity is available to handle discharges from the incoming ditch. Determining an appropriate elevation for the planned wetland along with the size, type and hydraulic capacity of its outlet will be important elements of the design.

There may be limited situations where the alignment and grade of the incoming ditch can be modified as part of the design to provide a functional and stable outlet. This often includes flattening the grade of the incoming ditch to stabilize the system and provide an opportunity to create a more natural riparian system with the restoration project. Otherwise, this strategy is likely limited to select sites where hydrology can be restored with little or no adverse impacts to the existing, upstream ditch system.

Outletting Subsurface Drainage Tile

Subsurface drainage tile from upstream areas often enters restoration sites with grades that are steep enough to allow manipulation and construction of a functional outlet. These outlets can discharge directly into planned wetlands or at the ground surface somewhere within the restoration project. This typically includes installing a new, short length of tile at a flatter grade so it can be raised in elevation to achieve the desired outlet elevation (**Figure 2**).

Several options for tile material can be considered when installing new tile as part of a planned outlet. In most tile outlet situations, single wall corrugated polyethylene (CPE) tile will be the preferred tile material due to its installation flexibility and costs. In some situations, it may be necessary or desired to use a more durable plastic pipe product such as dual wall corrugated polyethylene (HDPE), polypropylene (PPE), or polyvinyl chloride (PVC). This is especially true in situations where installation depths are greater or where more durable pipe is deemed necessary as part of the design analysis.

The design also needs to consider whether perforated or non-perforated tile should be used. When installed through areas that will be in

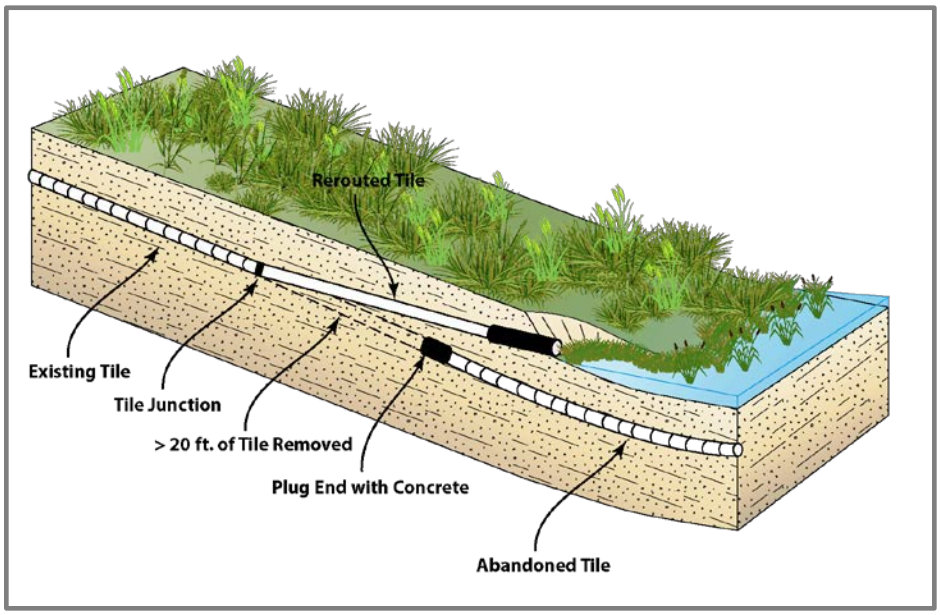

Figure 2. Modifying a Tile Drainage System to Outlet into Restored Wetland

permanent native vegetation or trees, non-perforated tile is recommended to avoid potential issues with roots plugging the tile line. For this reason, it is often desired to replace the entire reach of existing tile that must remain functioning through a restoration site with non-perforated tile. This may be more tile than necessary to achieve a functioning outlet but can limit future tile maintenance work and associated site disturbances.

When installing new tile at flatter grades, cover heights over the tile can be an issue. A minimum of 2.5 feet of soil cover over the tile is recommended. This often requires moving the new reach of tile away from the existing tile alignment to areas of higher ground where adequate cover exists and a functional outlet can be constructed. It is also important to avoid locating surface outlets for tile in areas where concentrated surface flows from an upstream drainage area may exist, such as in a draw or waterway (**Figure 3**). Otherwise, the outlet can be subject to potential issues with erosion and scouring from upstream surface runoff.

Because this design strategy often includes changing tile grades and possibly even tile materials, it will be important to compare flow rates of the existing tile vs. the proposed re-aligned tile to ensure that upstream drainage benefits will neither be impaired nor significantly improved by the planned changes to the tile drainage system. In most situations, this design objective can be achieved simply by increasing the size of the new, flatter reach of tile to the next available size. For example, if the existing, incoming tile to the wetland is a 6 inch line, an 8 inch tile installed at a slightly flatter grade will likely provide similar flow capacities. As options for tile size, materials, lengths, and grades vary, an analysis of full-flow pipe capacities may be warranted to ensure the most practical and economical design. A hydraulic comparison of tile flow rates using varied sizes, materials, and grades can easily be accomplished thru the use of any simple tile drainage capacity tools including manufacturer's literature, nomographs, on-line calculators, etc.

> To compensate for reduced tile flow capacities, a larger sized tile is often needed when flattening tile grades at planned outlets

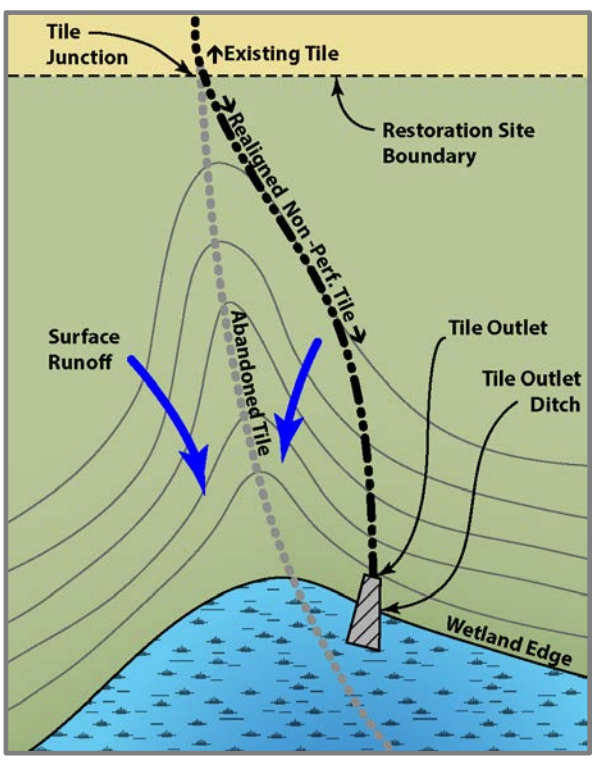

Figure 3. Planned Tile Outlet Realigned and Located to Avoid Flows from Upstream Runoff

Various options exist for configuring the actual tile outlet. This decision will predominantly be influenced by the landscape setting at the outlet's location. A discussion of design considerations for outlets within three different landscape settings follows.

Depressional Wetlands:

Outletting upstream drainage tile into a restored depressional wetland setting is common and usually easily accomplished. The general strategy should be to design and construct a free flowing or unforced outlet to be at or just above the planned restored wetland's normal water surface. Depending on topography, a short ditch may be needed to ensure adequate cover exists over the tile at the outlet and to convey tile discharges to the planned wetland. Material from the ditch excavation can be placed and graded above the end of the installed tile to add additional cover over it, if needed.

Avoid locating the outlet too far upstream of the planned wetland unless tile discharges will be stable and not cause excessive erosion as those discharges travel downslope towards the wetland.

Floodplains and Riparian Buffer Areas:

Outletting upstream drainage tile into floodplains and riparian buffer areas provides opportunities to

address and improve water quality while also providing opportunities to restore wetlands in these unique landscape settings. In most cases, floodplains and riparian buffer areas will generally be flat in elevation with respect to the adjacent, upstream lands providing good opportunities to construct tile outlets at the edge of these areas.

It will be important to consider the potential for the tile outlet to scour or erode the floodplain or riparian zone soils. The expected tile flow rates and durations, width and condition of the floodplain or buffer zone, along with the depth and condition of the associated riparian system (river, creek, ditch, etc.) will be important design considerations. In some locations, a point source discharge associated with a free flowing tile may not be advisable.

When maximum water quality benefits are desired or where the condition or width of the floodplain or buffer zone prevents the construction of a direct, free flowing tile outlet, other options to outlet the tile can be considered. This includes constructing a shallow ditch or installing a perforated tile to create a slow drainage weep along the edge of the floodplain or riparian buffer zone. The weep should belong enough in length to distribute tile discharges across a broad area (**Figure 4**). This restoration practice, also referred to in other forms as a "saturated buffer" can also help reduce nitrate and phosphate loading into riparian surface waters.

The benefits of this strategy are that tile discharges will be allowed to infiltrate and saturate a larger portion of the floodplain or buffer zone which in turn helps to improve water quality. This strategy also aides in more effectively restoring drained and altered wetlands that may exist in these landscape settings. The length of the shallow ditch or weep tile and means to distribute upstream tile discharges into it become the essential elements of this design. If perforated tile is used for the weep in lieu of a shallow open ditch, it is recommended to backfilling the tile trench with aggregate (drainage rock) as it will improve the overall performance of this type of outlet.

It will be important to ensure the ground surface where the drainage weep is located is lower in elevation than the flowline of the incoming tile as it enters the restoration site. A hydraulic analysis of this type of design may be necessary to ensure proper performance.

Excessive sediment inputs from the upstream drainage system can be a problem for these types of outlets. It may be desired to incorporate a means to periodically flush and remove accumulated sediment from the tile system if this is a concern.

Sloped Wetlands:

Outletting upstream drainage tile onto a sloped wetland setting provides a number of design challenges. A point source tile outlet on a sloped landscape may result in undesired scouring of areas downstream of the outlet. Sloped wetlands can be more effectively restored if discharges from the upstream drainage system are spread uniformly across a broad area within the upper

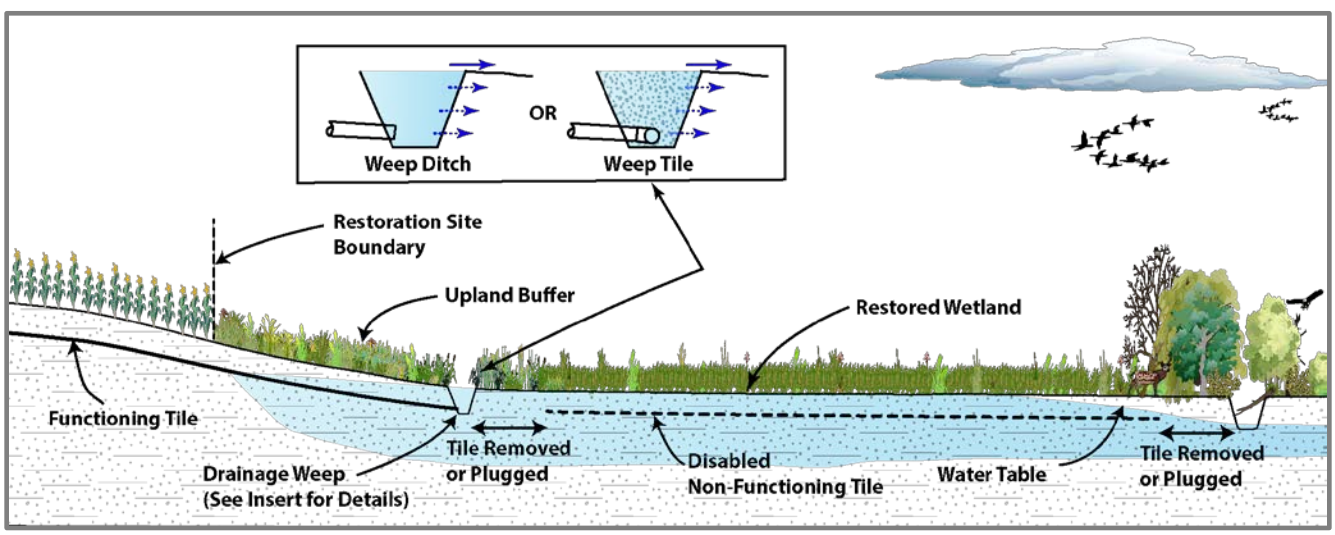

Figure 4. Drainage Weep Constructed at Edge of Floodplain or Riparian Buffer

reach of the sloped wetland setting. This can be accomplished by utilizing a drainage weep similar to what was discussed above for floodplains and riparian buffer areas. The difference being the weep would be located on slope and along a specified contour.

Regardless of wetland landscape setting or outlet type, when outletting subsurface tile lines it is inevitable that appropriately designed and constructed tile blocks will be needed as part of the project design. This restoration strategy is discussed further in Technical Guidance Document 4A-2, Blocking Subsurface Drainage Tile.

CONSTRUCTION REQUIREMENTS

The success of a planned drainage system outlet will be determined by its location, construction techniques used, type of outlet, and methods used to stabilize discharges at the tile outlet. The construction plans that are prepared to address these items should include requirements and specifications for all related construction components including the excavation and grading of open ditches and/or installation of drainage tile.

When installing new drainage tile, the construction plans should include requirements for how the junction of the new tile and the existing tile will be made. Changes to tile material, size and grade often occur at these junctions and proper joint construction is necessary to avoid problems with joint separation. Separated joints can allow excessive soil to be pulled into the tile system and cause settling or sinkholes of the above soils. To address this, it is recommended that the tile junction be held securely with couplers, tape, or by other means, and grouted with enough concrete to securely hold it in place. If the new tile is large enough, slide it over the existing tile by at least 6 inches before securing the joint.

It is also recommended when constructing the tile junction that the open end of the existing, downstream disabled tile is sealed with a tile cap or grout. If left un-sealed, soils can be pulled into the tile and create a “sink hole” at the ground surface.

When constructing a direct outlet, the tile end should be protected from damage due to fire, ice, animals, etc. This typically entails installing a corrugated metal pipe (CMP) sleeve at the end of the tile to serve as the actual, exposed outlet. It is recommended that the size of the CMP sleeve should be slightly larger than the tile to allow it to be slid over the tile as it is installed. The sleeve should be slid approximately one to two feet over the end of the tile with the joint properly secured or grouted (**Figure 5**). For example, an 8 inch CPE tile would require a 10 inch CMP sleeve.

The CMP sleeve should be of an appropriate length to provide a stable outlet as it projects out of ground. This requires that approximately two-thirds of the sleeve length be covered by backfill. **Table 1** provides recommended lengths for varying sizes of CMP sleeves.

Table 1. Recommended CMP Sleeve Lengths at Tile Outlets

Diameter of CMP Sleeve (inches)	Minimum CMP Sleeve Length (feet)
8 and smaller	10
10 and 12	12
15 and 18	16
21 and larger	20

As an alternative, metal end sections (aprons) can also occasionally be used as a protective outlet device for the tile. Regardless of the type of outlet, a hinged-type rodent guard should be installed on the outlet device to keep animals out of the upstream tile system.

Depending on size of tile, expected flow velocities, and durations, the use of geotextile material and rock riprap may be necessary to prevent excessive scouring at the tile outlet (**Figure 6**).

Figure 5. Metal Sleeve Placed over Tile at Outlet (pre-grouting)

Figure 6. Riprap Protection at Tile Outlet

OTHER CONSIDERATIONS

- Despite the best planning and site assessment efforts, sizes, grades, and locations of existing tile lines or even their existence altogether may be uncertain for many project sites. As such, certain assumptions may have to be made as part of the design. In such situations, the construction plan should ensure enough flexibility and funding exists as adjustments during construction are often needed. In other cases, tile investigations should be performed using a tile probe or excavation equipment to gather accurate information prior to completing the design.
- When excessive sediment inputs from an upstream drainage system is anticipated (ex. upstream system contains open intakes), it may be desired to construct a small sediment pond between a planned tile outlet and restored wetland. Periodic removal of accumulated sediment from this area can improve overall function of the downstream, restored wetland.
- 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.
- It will be important to understand the legal implications of any planned actions to manipulate an existing drainage system. This includes determining whether the drainage system is part of a public drainage system or governed by a private drainage agreement. If so, certain legal and administrative functions may need to be addressed as part of the planning and design process. Additional discussion on this topic occurs in Section 4-9 Construction Related Laws, Regulations and Permits.

COST

The cost for constructing outlets for upstream drainage systems varies and is primarily dependent on the size and length of tile necessary to construct the outlet. The costs to make the necessary tile junctions and blocking tile at the junction are usually considered incidental to the tile installation. Consideration of potential additional costs for installing a protective metal sleeve, rodent guards, geotextile and rock riprap, along with excavating an outlet ditch and performing final grading work with methods to stabilize the construction area (seeding and mulching) are needed.

MAINTENANCE

Drainage system outlets need periodic inspection to identify and correct any identified problems. Problems can include excessive erosion or scouring of the outlet channel, excessive sediment deposition, or settling of the backfill material over any installed tile. Depressions or “sink holes” at the soil surface in the vicinity of any tile junctions may be an indication of a failed tile junction. This usually becomes a problem when tile is incorrectly sealed or blocked at the exposed tile ends.

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 outlets for subsurface drainage systems along with other drainage manipulation strategies are provided in Appendix 4-B**.**