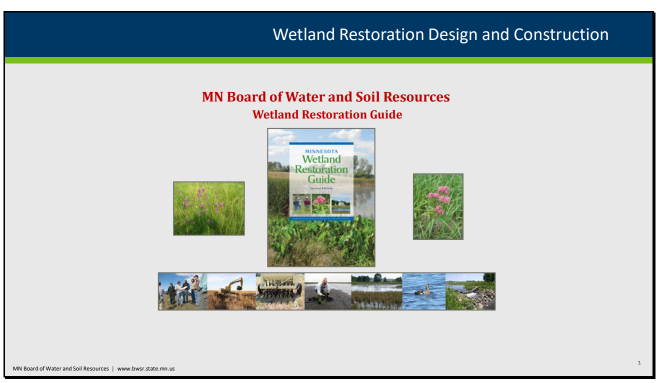
Slide 1

Slide 2

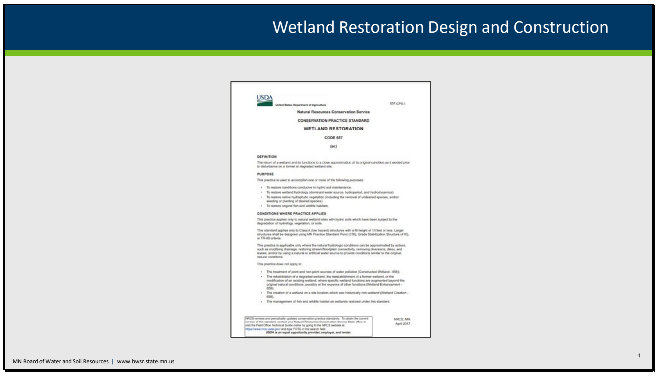
For this 2nd day of training, we are going to focus on the design and construction of the many identified wetland restoration strategies and tie that into some of the training items from yesterday.

Slide 3



A shameless plug here but the premise for much of what we will be covering today comes from the MN Wetland Restoration Guide. If you have not already explored this document and are interested in learning more about all aspects of the wetland restoration process, I would encourage you to do so. P.S. its on our website.

Slide 4



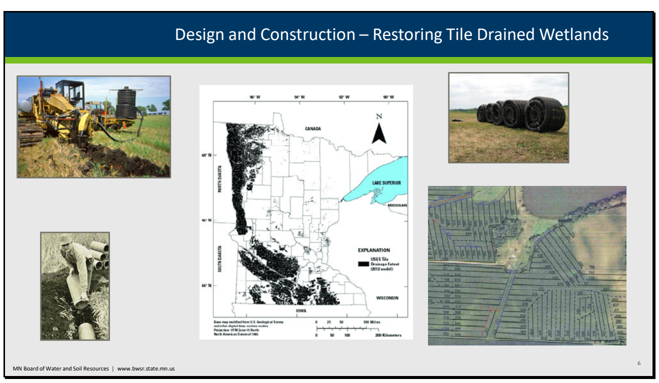
In addition to the WRG, we will also be including information from applicable NRCS Practice Standards and other EFOTG documents.

Slide 5

Here is an agenda of what we will be covering today.

There may be items you were hoping we would be covering as part of this training that we don't or don't do so in great depth due to time constraints. Be sure to chime in any time during the training via the chat box and ask questions or at the end of the day if time allows if you have questions or want more information. Or you can always reach out to me directly or ask additional questions as part of training assessment survey you will receive.

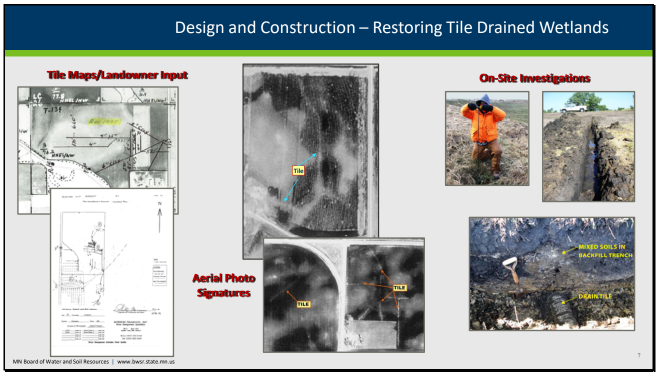
Slide 6



A large percentage of the wetlands within the agricultural regions of the state are drained by subsurface drainage tile.
These wetlands are drained by both older clay and concrete tile systems and with newer corrugated polyethylene tile.

Regardless of type of tile that exists, the ability to effectively disable existing tile drainage systems is necessary for successful restoration.

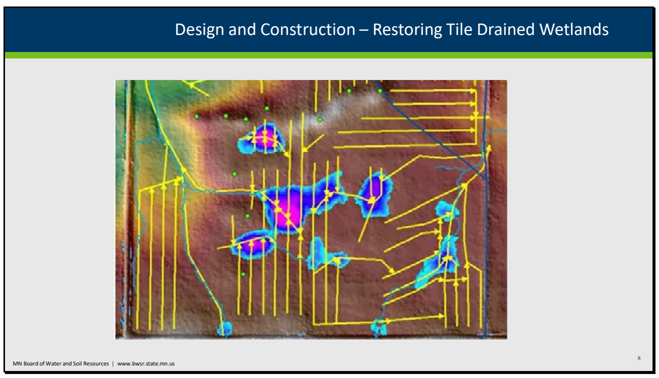
Slide 7



As discussed yesterday, to successfully evaluate and prepare a design for restoration it will be important to know and understand locations and scope of drainage tile systems that exist within a site.

This includes getting a hold of tile maps, locating tile via air photo reviews, and gathering tile information as part of necessary site investigations and landowner discussions.

Slide 8



Due to advances in tile materials and installation methods, more recent drain tile installations are often quite extensive.

This provides numerous additional challenges with respect to investigation and design.

Slide 9

Design and Construction – Restoring Tile Drained Wetlands

A functional design requires gathering enough site information to determine size(s), location(s), depth(s), tile material and tile flow directions.

The design must consider and address the following:

- **How and where to disable existing drain tile**
- **How to best manage expected wetland outflows/discharges**
- **When to construct and disable tile drainage relative to other work being conducted**
- **Strategies to protect neighboring properties, especially when they share in the use or benefit of the tile system(s) planned for disablement**

Slide 10

Design and Construction – Restoring Tile Drained Wetlands

Design/Construction Strategies to be Discussed

- **Blocking/Plugging Subsurface Drainage Tile**
- **Outletting (Daylighting) Upstream Drainage Tile**
- **Rerouting Upstream Drainage Tile**

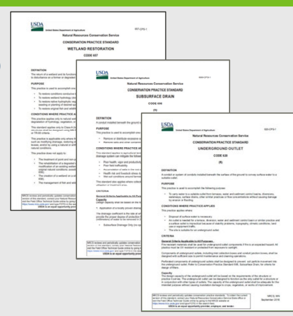
There are three related, but distinct wetland restoration strategies used to restore tile drained wetlands. We will be discussing all three in this part of the training.

Slide 11

Design and Construction – Restoring Tile Drained Wetlands

Applicable NRCS Practice Standard(s)

- **MN 657 Wetland Restoration**
- **MN 606 Subsurface Drain**
- **MN 620 Underground Outlets**
- **And Potentially Others**

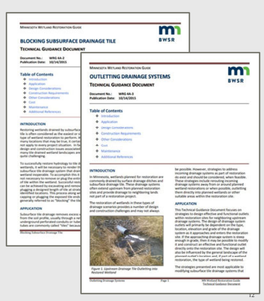


Slide 12

Design and Construction – Restoring Tile Drained Wetlands

Design Guidance/Resources

- **EFH Chapter 13**
- **EFH Chapter 13 (MN Supplement)**
- **MN WRG Chapter 4-3**
- **MN WRG Technical Guidance Document – 4A-2** ***Blocking Subsurface Drain Tile***
- **MN WRG Technical Guidance Document – 4A-3** ***Outletting Drainage Systems***
- **MN WRG Technical Guidance Document – 4A-4** ***Rerouting Drainage Systems***



Slide 13

Design and Construction – Restoring Tile Drained Wetlands

Factors That Will Influence the Design and Construction

- **Landscape Setting (depressional vs non-depressional wetland)**
- **Soils**
- **Topography**
- **Type, Size and Depth of Tile**
- **Tile Grade**

Slide 14

Design and Construction – Restoring Tile Drained Wetlands

Additional Factors to Consider

- **Concerns of Adjoining Property Impacts (upstream or downstream)**
- **Will an embankment be needed at a planned tile block location?**
- **Will the tile block be within a spillway or other area receiving surface flows?**
- **Will a wetland outlet be required, and will it utilize the existing downstream tile?**

Slide 15

Design and Construction – Restoring Tile Drained Wetlands

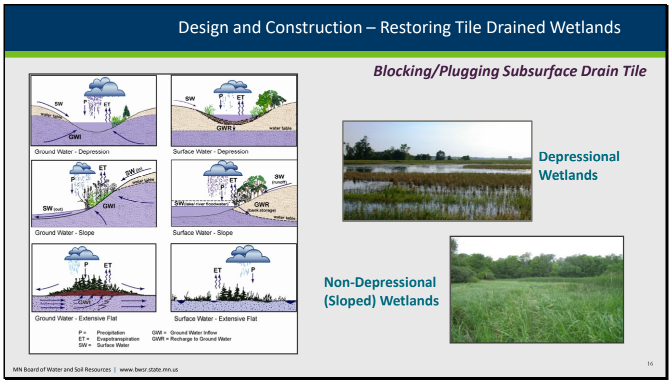
Blocking/Plugging Subsurface Drain Tile

- **It is generally not necessary to remove or plug the entire length of drain tile that exists within a site or a site's wetland.**
- **Restoration success is most often achieved by blocking (removing) and plugging select lengths of tile at strategically identified locations.**

First - we will talk about strategies to design and construct tile blocks.

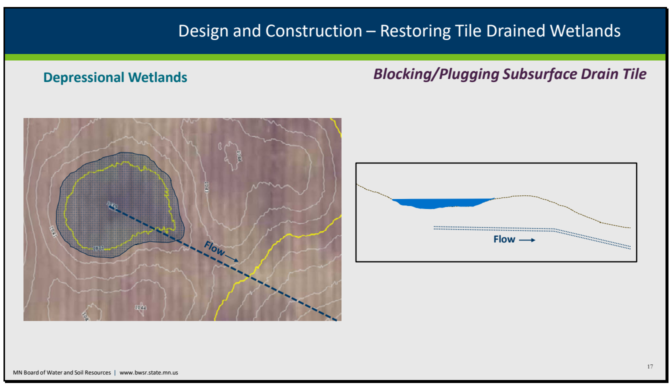
To successfully restore hydrology to tile drained wetlands, it will be necessary to disable or render inoperable the tile system draining the wetland.

Slide 16



It will be important to note and understand the landscape setting of the wetland system planned for restoration as that can influence the approach taken to design and construct the project.

Slide 17

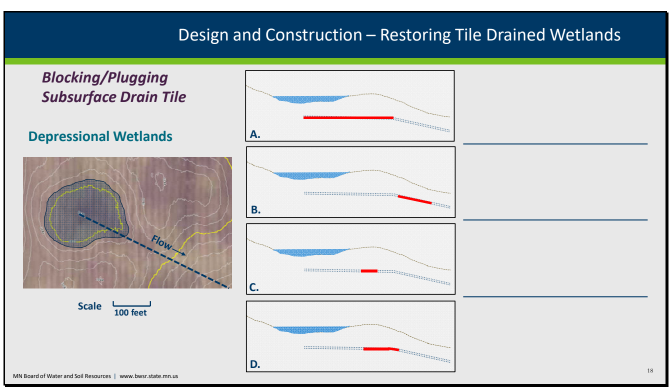


Let's discuss depressional wetlands first.

This is a common tile drainage scenario often associated with small depressional wetland settings. A single string of tile draining the wetland.

In this case, a tile block would likely be constructed to disable the tile and restore the wetland.

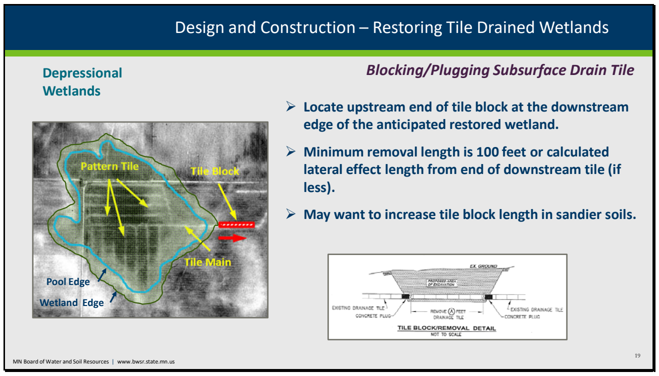
Slide 18



Take a moment and look at the plan map on the left, the plan scale and the four figures A thru D.

Place a check or other mark to the right of the figure, A, B, C or D that you think best reflects the necessary tile block/removal strategy that will successfully restore this wetland.

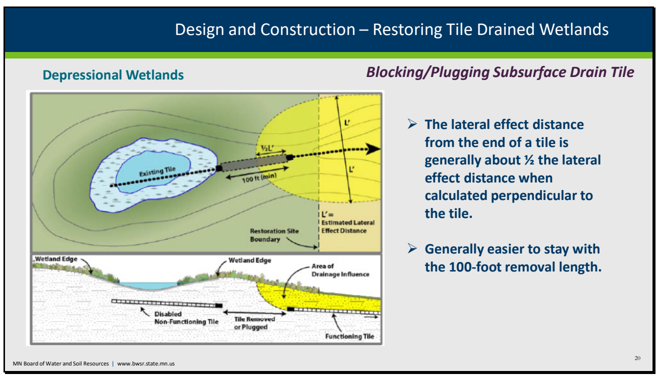
Slide 19



When restoring tile drained depressional wetlands

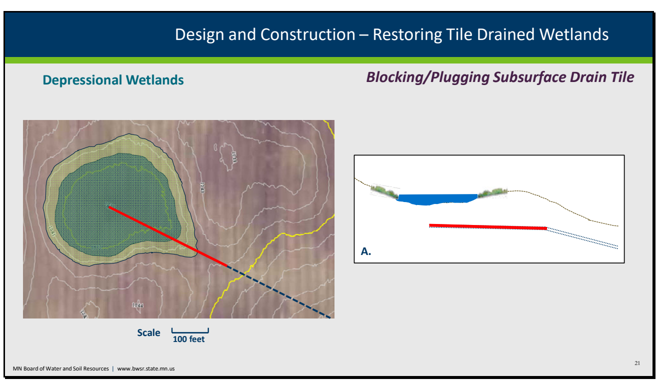
-

Slide 20



This diagram more clearly illustrates what is needed for blocking and plugging tile as part of a depressional wetland setting.

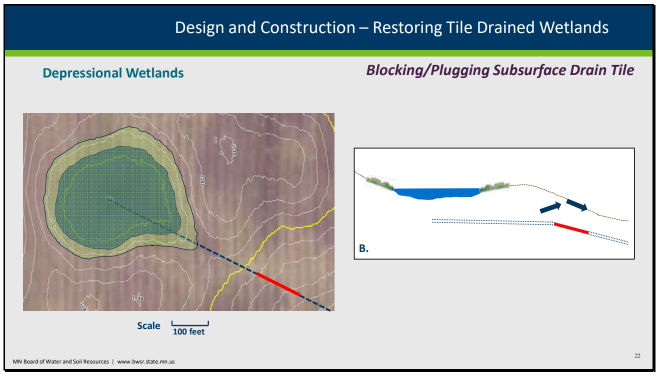
Slide 21



Back to our example

If you chose option A, you are not wrong, but probably would be removing more tile than necessary to effectively restore this wetland

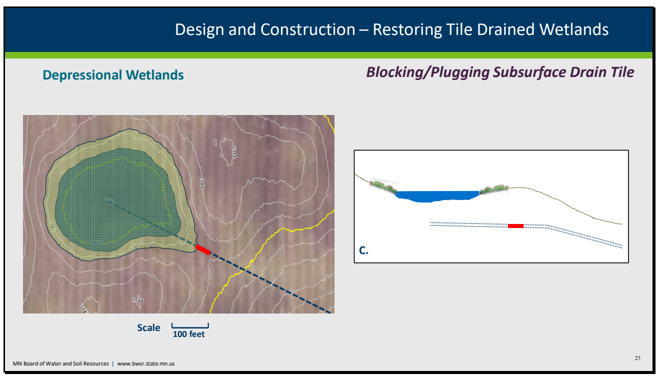
Slide 22



Option B might work but the block's location would probably be too far downstream. It could lead to a tile blowout on the downslope due to head pressure that will build up against the tile block.

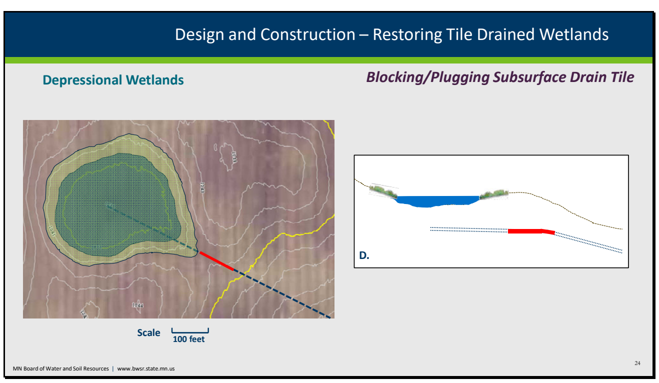
If that occurs, the wetland will again be drained and additional work will be needed to correct the problem.

Slide 23



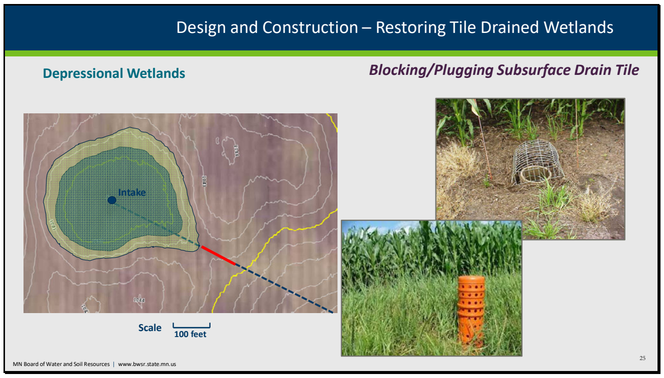
Good location but tile block will too short in length to be effective.

Slide 24



Option D is probably your best choice. It conforms to practice standards and associated design guidance for both length and location.

Slide 25

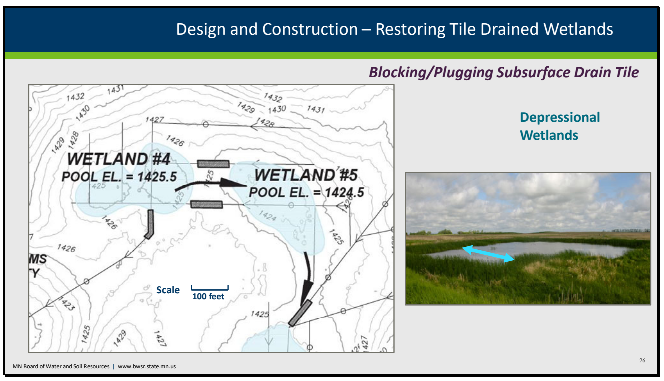


What if there is an intake within the depression? Should it also be removed? Chat box

Probably no great need to do so. May want to though as a safety precaution if it is big enough, say 10 inches or greater in diameter.

Certainly would want to remove any metal or plastic components that stick above ground.

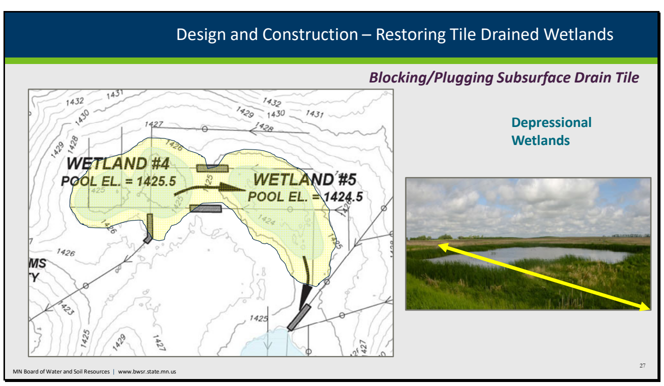
Slide 26



Restoring tile drained depressional wetlands is often not as simple as constructing one tile block. In many locations you will encounter multiple tile lines that need to be addressed.

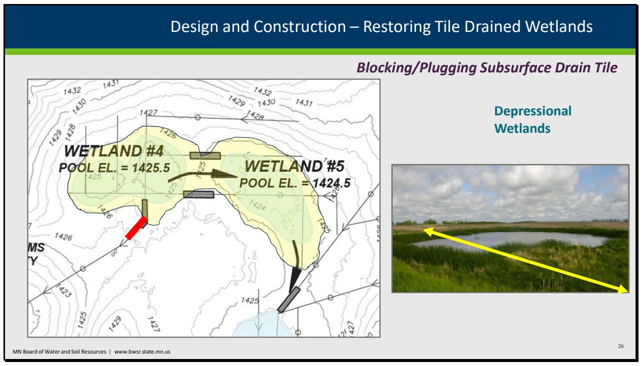
That said, does the tile block plan shown in this example appear to meet the design guidance? Go ahead and indicate yes or no in the chat box.

Slide 27



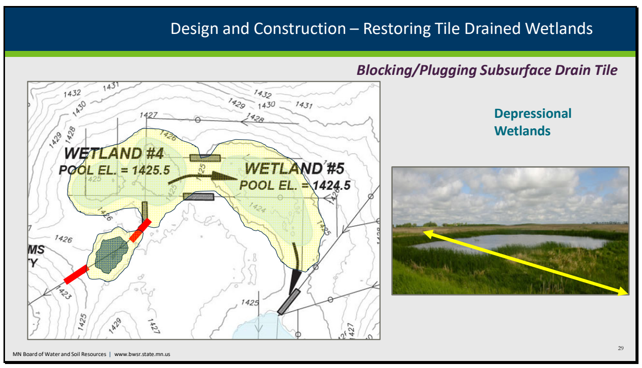
If we project the restorable wetland edge (not the normal pool), you can see at least one tile block that is not quite far enough downstream to be effective.

Slide 28



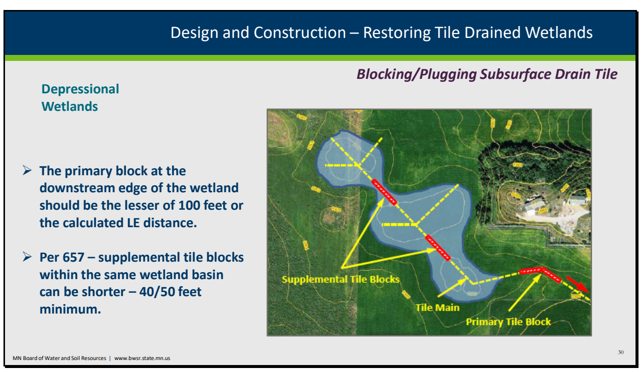
This would be a better location for it

Slide 29



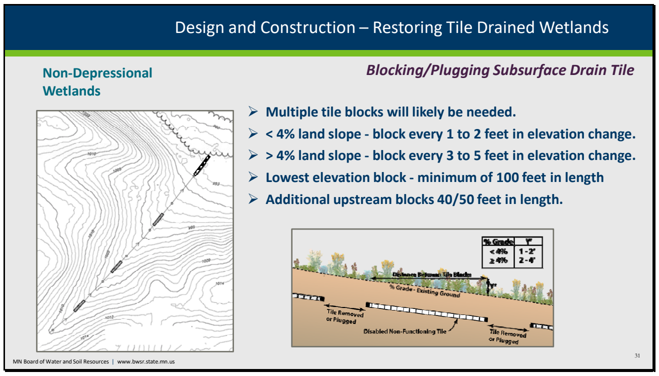
In fact, looking closer at the topography, a second, smaller wetland might also be restored if another tile block is added just downstream, as shown

Slide 30



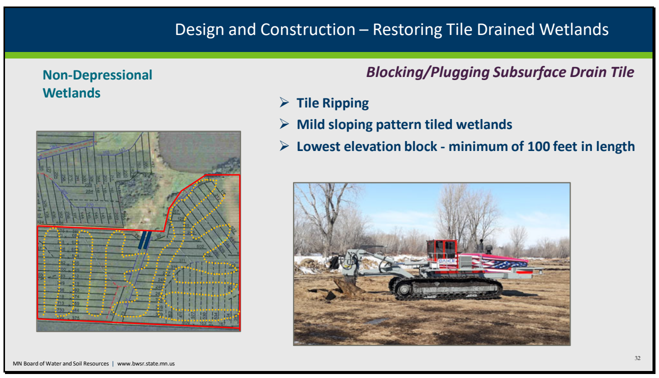
What do the practice standards and guidance documents say about these more complex depressional wetlands where multiple tile blocks may benefit the restoration?

Slide 31



Let’s now jump to tile drained non-depressional wetlands. A slightly different approach is needed when attempting restoration within these landscapes.

Slide 32



Constructing tile blocks can get expensive when many are needed. For more extensively or pattern tiled sloped landscapes, a combination of select tile blocks along with a strategic tile ripping pattern can provide a good construction alternative at a much lower cost.

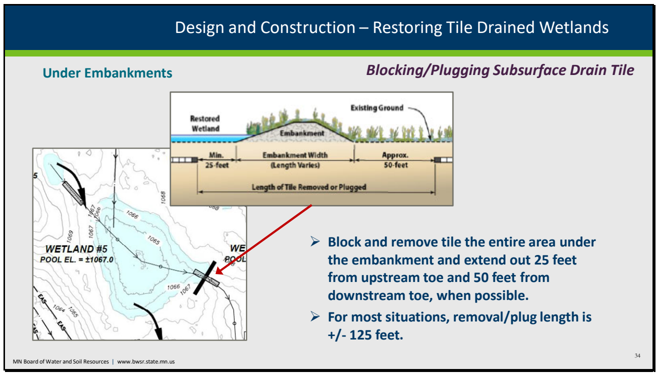
Slide 33

Works best for fields that are patterned tiled in organic soils. Works much better with CPE tile than with clay or concrete.

Knife pulls and stretches CPE tile and either flattens its ends or pulls sections of it out of the ground, as can be seen in the photo on the right.

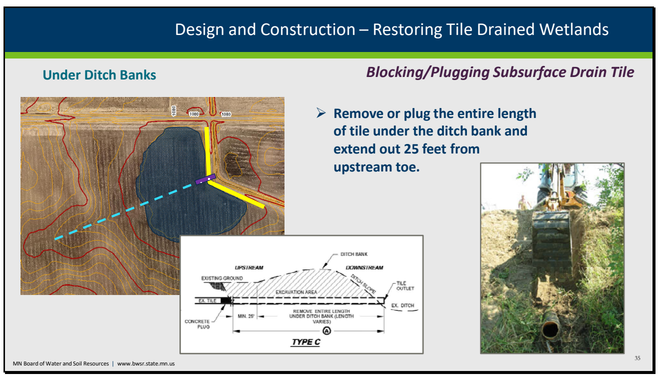
For certain locations, this approach to construction does a pretty good job at disabling the entire tile drainage system.

Slide 34



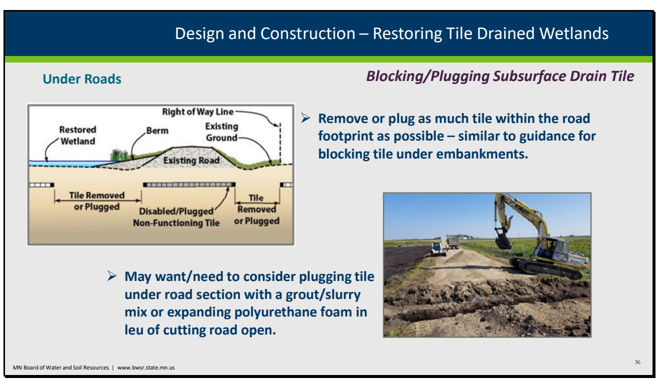
Removing and blocking tile under embankments

Slide 35



Ditch banks – similar to embankments

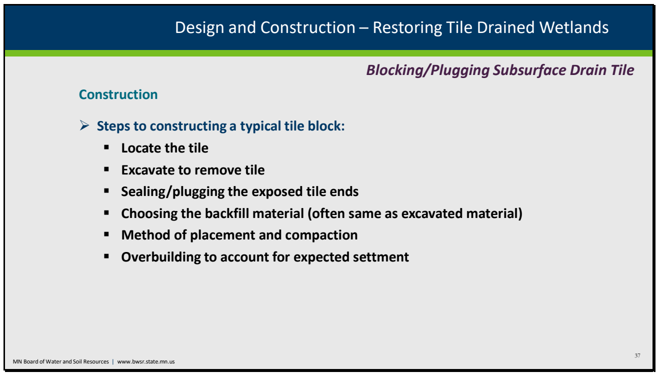
Slide 36



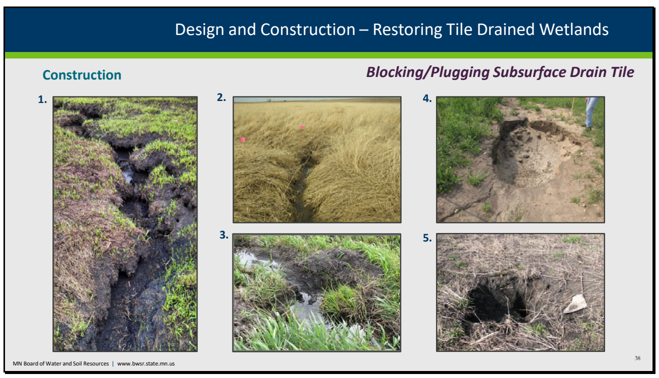
In some cases you may find it necessary to block a tile under some type of road. Your options can include:

- Removing and plugging portions of the tile on each side of the road (diagram)
- Excavating and removing the tile thru the road (picture)
- Excavating to expose the tile and pumping/filling the portion under the road with a grout/slurry mix or expanding polyurethane foam

Slide 37



Slide 38

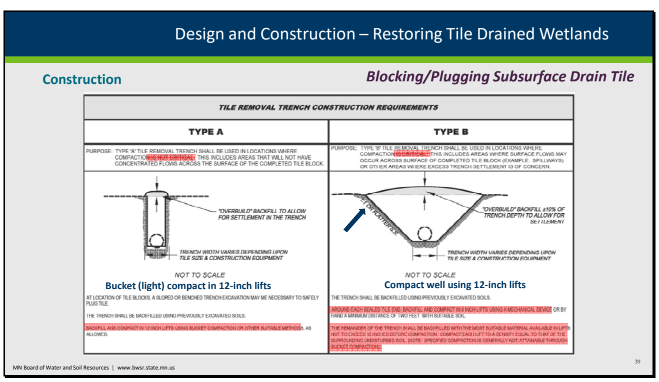


While that sounds fairly straightforward, things can go wrong if tile blocks are not properly designed and constructed. These are all pictures of tile blocks that have gone bad for one reason or other.

Pictures 1, 2 and 3 represent poorly backfilled and compacted tile block trenches that ended up settling and resultant surface flows thru the area has caused scouring to occur.

Pictures 4 and 5 represent tile ends that were not sealed and left open. Soil was pulled into the open tile ends and these sink holes resulted.

Slide 39



Because not all tile blocks need to be constructed in the same manner, we provide as part of our designs to two options for their construction. These are reflected within the two typical details that are shown. Each tile block we want constructed references one of these two tile block types.

Type B is the more stringent method and is called for when settlement of the tile block location will be of concern (under embankments, within spillways/flow areas, etc. see highlighted text.

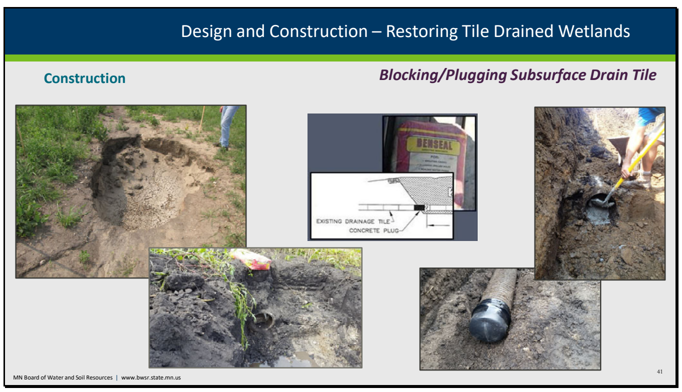
Type A is easier to construct and is allowed in the correct situations and locations.

Personally, I like having both of these options provided as part of a design as it makes it easier to communicate construction requirements with the contractor. This helps explain why the simpler type A construction method cannot be used in certain areas.

Slide 40

First step is to locate the tile then to excavate and remove the required length of tile material

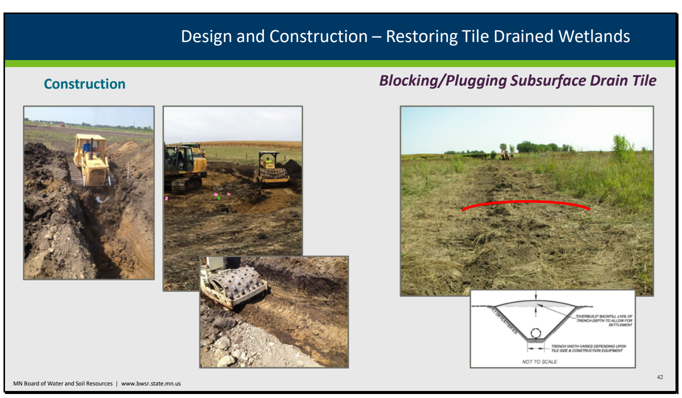
Slide 41



Next would be the plugging or sealing of the exposed tile ends. Several methods can be used to accomplish this

This is important as if not done, sink holes will often result as soil gets pulled into the exposed tile ends.

Slide 42

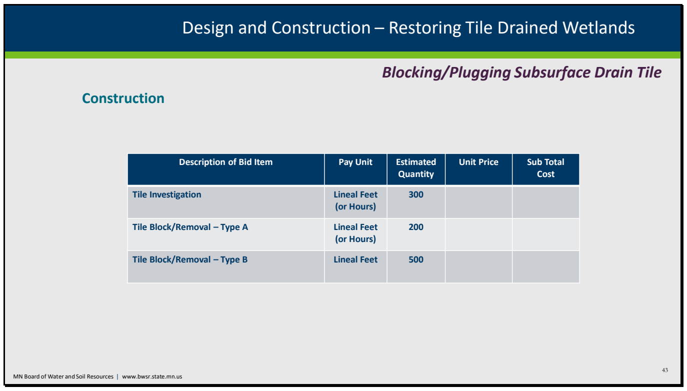


Remove and dispose all plastic tile.

Break clay and concrete tile sections into small pieces and incorporate into backfill. Backfill and compact the excavated trench per specification

Ensure a crown or overbuild exists as settling will occur. This is especially important in areas where surface flows are expected.

Slide 43



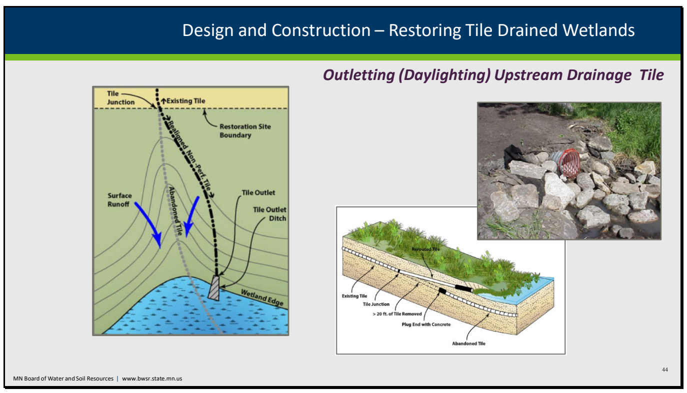
Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Tile Investigation	Lineal Feet (or Hours)	300		
Tile Block/Removal – Type A	Lineal Feet (or Hours)	200		
Tile Block/Removal – Type B	Lineal Feet	500		

Generally speaking, these would be the potential bid items used when constructing tile blocks.

We would show type A and B tile blocks as two different line items as it should be less expensive to construct a type A block that it would be a type B block.

As working with tile often results in unexpected surprises (i.e. an unknown extra tile line is discovered or it takes extra time to find the tile to be blocked), it is advised to bid these items either by the hour or lineal foot as it is common to see quantity changes here as a result of construction.

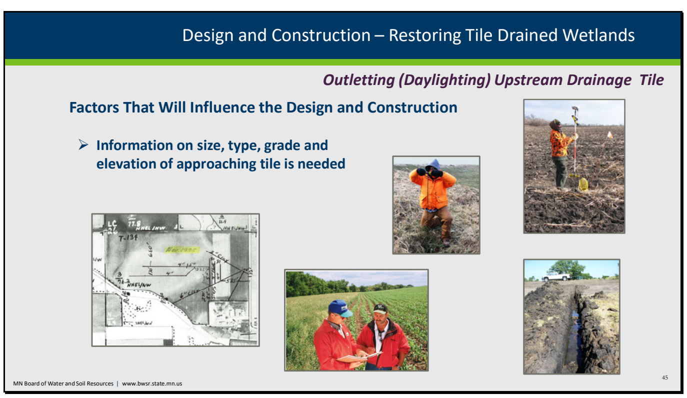
Slide 44



When attempting to restore wetlands in a tile drained landscape, you will often encounter tile from adjoining, upstream areas that enter or flow into a project site.

Daylighting or outletting the upstream tile into the site is often desired and should be considered when possible

Slide 45



Daylighting a tile only works if it is high enough in elevation as it approaches the site or planned wetland.

Slide 46

Design and Construction – Restoring Tile Drained Wetlands

Outletting (Daylighting) Upstream Drainage Tile

Factors That Will Influence the Design and Construction

- **Topography**
- **Tile type, size, and depth at planned junction**
- **Tile grade upstream of junction**
- **Land use/cover type in area of new tile**
- **Hydrology of planned restored wetland (expected bounce)**

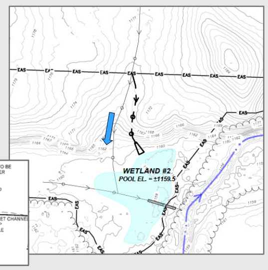
Slide 47

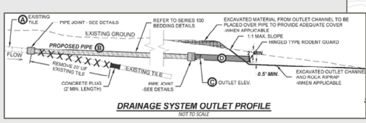
Design and Construction – Restoring Tile Drained Wetlands

Outletting (Daylighting) Upstream Drainage Tile

Design

- **Almost always requires a length of new tile/pipe installed at a flatter grade**
- **Perforated vs. non-perforated tile/pipe?**
- **Ensure outlet elevation is high enough (varies)**





Slide 48

Design and Construction – Restoring Tile Drained Wetlands

Outletting (Daylighting) Upstream Drainage Tile

Design

- **Design analysis needs to ensure new tile/pipe will not reduce upstream tile capacity**

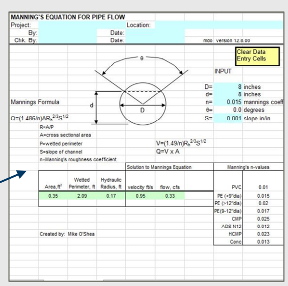
Example

Ex tile upstream of outlet:

- **Size – 6 inch clay**
- **Grade - .32%**
- **Flow – 0.32 cfs**

Proposed Outlet:

- **Size – 8 inch CPE**
- **Grade - .10%**
- **Flow – 0.33 cfs**

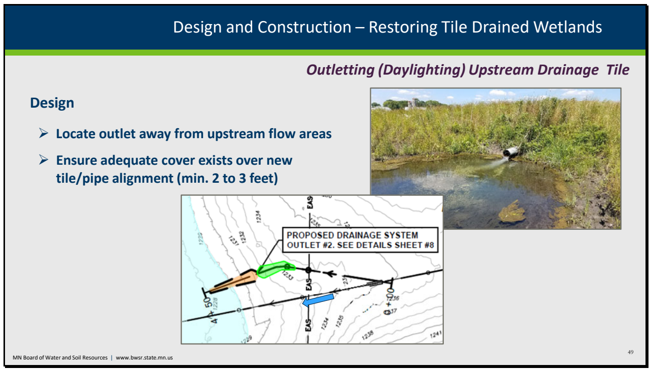


Generally – Manning's equation is used for tile flow calculations

There are tables, graphs, various types of calculators that can be used to simplify this

A NRCS prepared spreadsheet is shown. It does simple calculations for both pipe and ditch (second tab)

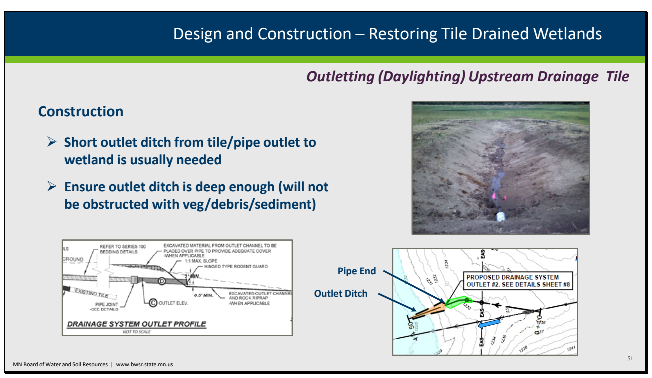
Slide 49



Slide 50

The 620 PS does include a table showing minimum lengths of CMP sleeves as function of sleeve diameter.

Slide 51



Slide 52

Design and Construction – Restoring Tile Drained Wetlands

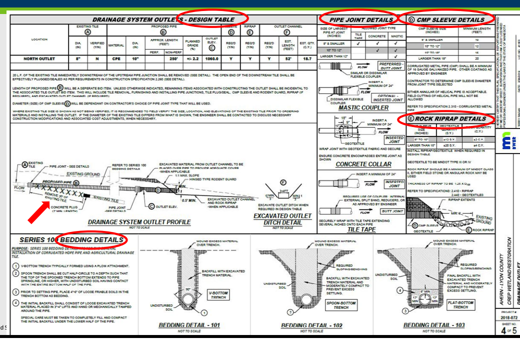
Outletting (Daylighting) Upstream Drainage Tile

Construction

- Riprap often needed to prevent scouring

Slide 53

Design and Construction – Restoring Tile Drained Wetlands



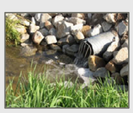
Review Design Table components

Slide 54

Design and Construction – Restoring Tile Drained Wetlands

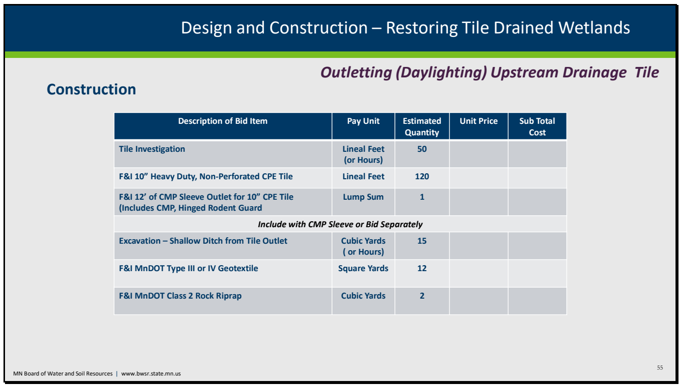
Construction

Outletting (Daylighting) Upstream Drainage Tile



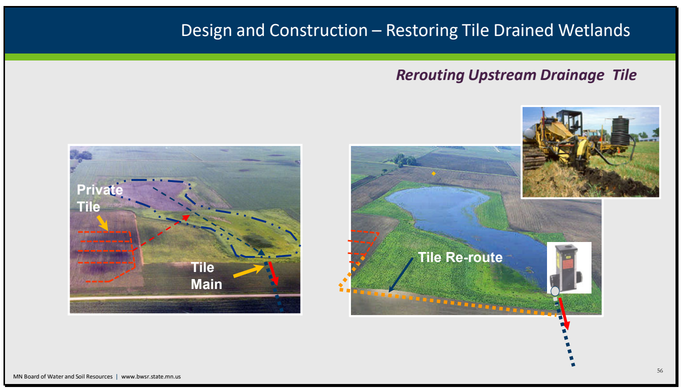
On this slide are 5 pictures of constructed tile outlets into restored wetlands.
Place a check mark or other symbol below those images that you think are appropriately designed and constructed.

Slide 55



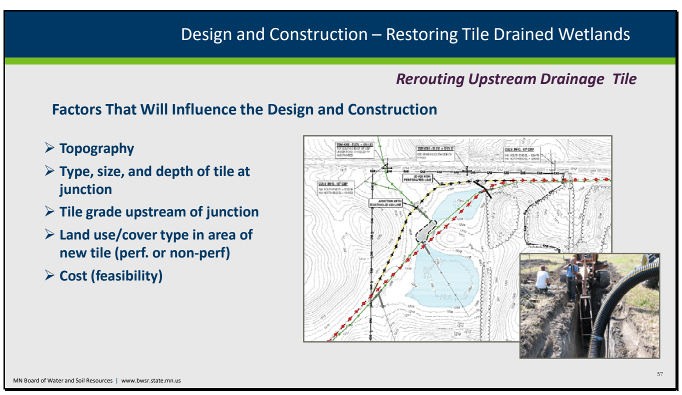
Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Tile Investigation	Lineal Feet (or Hours)	50		
F&I 10" Heavy Duty, Non-Perforated CPE Tile	Lineal Feet	120		
F&I 12' of CMP Sleeve Outlet for 10" CPE Tile (Includes CMP, Hinged Rodent Guard	Lump Sum	1		
Include with CMP Sleeve or Bid Separately				
Excavation – Shallow Ditch from Tile Outlet	Cubic Yards (or Hours)	15		
F&I MnDOT Type III or IV Geotextile	Square Yards	12		
F&I MnDOT Class 2 Rock Riprap	Cubic Yards	2		

Slide 56



If the approaching tile is too low in elevation to allow it to be daylighted, if feasible, consider rerouting the tile around or away from the planned wetland.

Slide 57



As with designing a tile outlet, ensure the rerouted tile will not reduce the capacity of the approaching tile

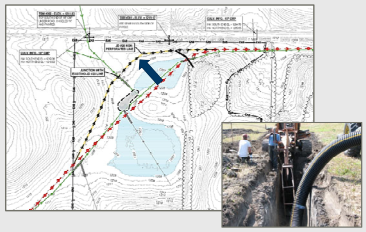
Slide 58

Design and Construction – Restoring Tile Drained Wetlands

Rerouting Upstream Drainage Tile

Factors That Will Influence the Design and Construction

- **Avoid routing new tile through planned wetland area**



Explain why
1. Not accessible for maintenance
2. Joints might leak
3. Will be buoyant at times and could float

Slide 59

Design and Construction – Restoring Tile Drained Wetlands

Rerouting Upstream Drainage Tile

Construction

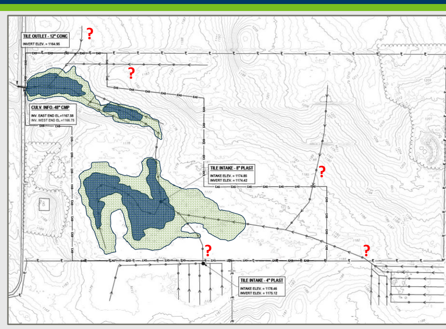
Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
F&I 10" Perforated CPE Pipe	Lineal Feet	200		
F&I 10" Non-Perforated CPE Pipe	Lineal Feet	350		

Slide 60

Design and Construction – Restoring Tile Drained Wetlands

Addressing Incoming, Upstream Drainage Tile

- **Manipulate incoming tile and daylight into site**
- **Reroute incoming tile around/away from site/planned wetland(s)**
- **Do nothing – leave tile as is and consider wetland unrestorable**

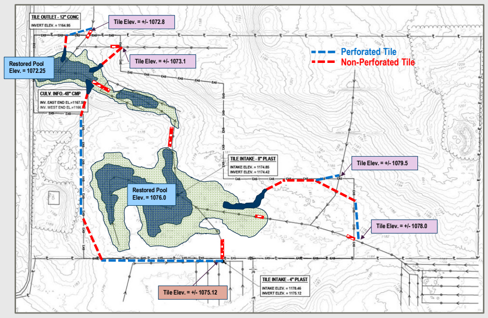


This example shows 5 different locations where incoming tile from upstream areas enter into a planned restoration site. As we discussed, the options to address this scenario include:

Slide 61

Design and Construction – Restoring Tile Drained Wetlands

Addressing Incoming, Upstream Drainage Tile



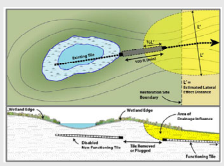
The restoration plan includes daylighting all 5 of the approaching tile lines.
Discussion and cooperation with neighboring landowners was needed.
A combination of perforated and non-perforated tile will be used.

Slide 62

Design and Construction – Restoring Tile Drained Wetlands

Summary

- **The minimum length of tile block allowed per PS 657 and EFH 13 is 40 feet, unless at bottom of a non-depressional wetland or outlet of a depressional wetland, then its the lesser of 100 feet or lateral effect distance from anticipated wetland edge to downstream tile/outlet.**

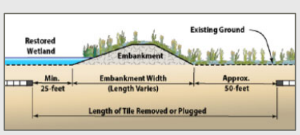


Slide 63

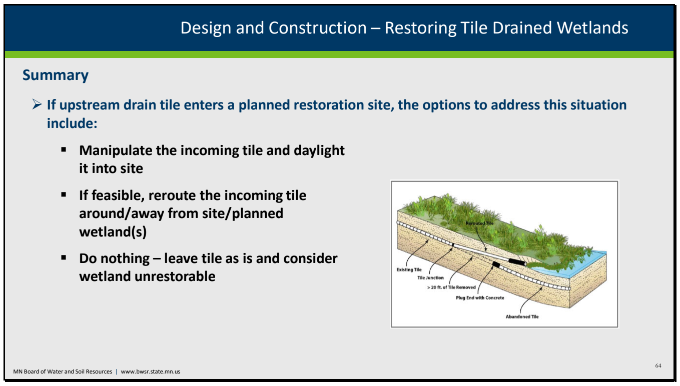
Design and Construction – Restoring Tile Drained Wetlands

Summary

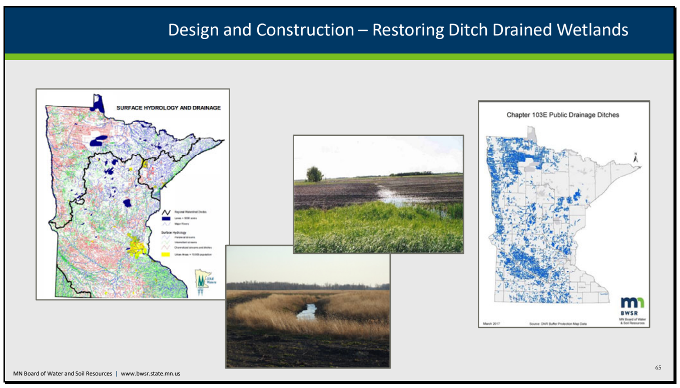
- **If located under an embankment, remove the entire length of tile under the embankment along with an additional 25 feet upstream of embankment and 50 feet downstream of embankment, when possible.**



Slide 64



Slide 65



Compared to drainage tile, a much greater and more diverse landscape in MN is affected by surface drainage.

Slide 66

As discussed yesterday, it will be important to know and understand locations and elevations of the surface drainage systems that exist.
More so than with tile drainage, the biggest challenge with restoring ditch drained wetlands is avoiding adverse impacts to adjoining properties.
One problem with ditches as they tend to be located along property lines, especially in flatter landscapes where topography has less of an influence on a ditch's location.

Slide 67

Design and Construction – Restoring Ditch Drained Wetlands

Design/Construction Strategies to be Discussed

- **Filling Drainage Ditches**
- **Plugging Drainage Ditches**
- **Design and Construction of Ditch Plugs, Earthen Embankments and Berms**

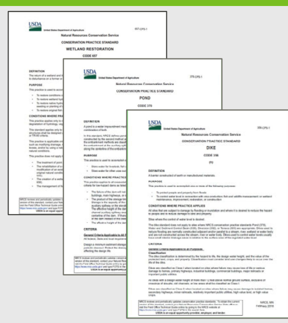
Agenda for this portion of the morning's training

Slide 68

Design and Construction – Restoring Ditch Drained Wetlands

Applicable NRCS Practice Standard(s)

- **MN 657 Wetland Restoration**
- **MN 356 Dike**
- **MN 378 Pond**
- **MN 410 Grade Stabilization Structure**
- **And Potentialy Others**

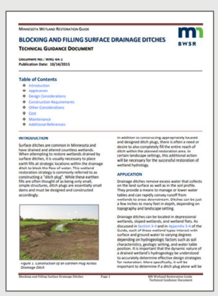


Slide 69

Design and Construction – Restoring Ditch Drained Wetlands

Design Guidance/Resources

- **EFH Chapter 13**
- **EFH Chapter 13 (MN Supplement)**
- **MN WRG Chapters 4-3 Drainage System Modifications**
- **MN WRG Technical Guidance Document – 4A-1** ***Blocking and Filling Surface Drainage Ditches***
- **MN WRG Technical Guidance Document – 4A-4** ***Rerouting Drainage Systems***
- **And others**



Slide 70

Design and Construction – Restoring Ditch Drained Wetlands

A functional design requires gathering enough site information to determine size(s), location(s), elevations and flow direction(s) of existing ditch systems as well as specific soils information at planned ditch plug and potential borrow area locations.

The design must consider and address the following:

- **How and where to fill and/or plug existing ditch systems**
- **How to best manage wetland outflows/hydrology discharges**
- **When to construct and disable ditch drainage relative to other work being conducted**
- **Strategies to protect neighboring properties, especially when they share in the use or benefit of the ditch system(s) planned for disablement**

Slide 71

Design and Construction – Restoring Ditch Drained Wetlands

- **To successfully restore hydrology to ditch drained wetlands, it will be necessary to disable or render inoperable the ditch system draining the wetland**
- **Restoration may require a complete filling of the ditch system and/or simple ditch plugs at strategically identified locations**

Slide 72

Design and Construction – Restoring Ditch Drained Wetlands

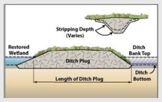
Ditch Fill

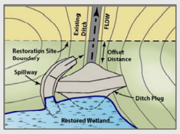
What is a ditch fill and how is different than a ditch plug
Placing grading of loose material into a ditch with light to moderate compaction
Often includes using spoil material from existing ditch banks

Slide 73

Design and Construction – Restoring Ditch Drained Wetlands

Ditch Plug





In contrast, ditch plugs can be thought of small dams strategically located and constructed across a ditch.
In limited situations, plugs can be designed to have wetland discharges flow over them.
Most often though, a vegetated spillway is constructed around one or both ends of the plug to manage wetland outlfows.

Slide 74

Design and Construction – Restoring Ditch Drained Wetlands

Factors That Will Influence the Design and Construction

- **Landscape Setting (depressional vs non-depressional wetland)**
- **Geomorphic Condition (groundwater or surface water supported wetland)**
- **Soils**
- **Topography**

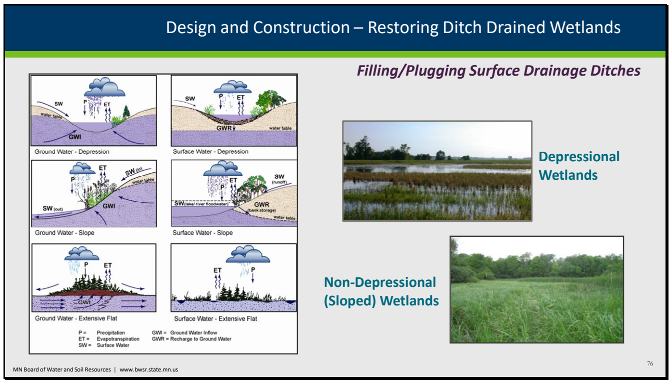
Slide 75

Design and Construction – Restoring Ditch Drained Wetlands

Additional Factors to Consider

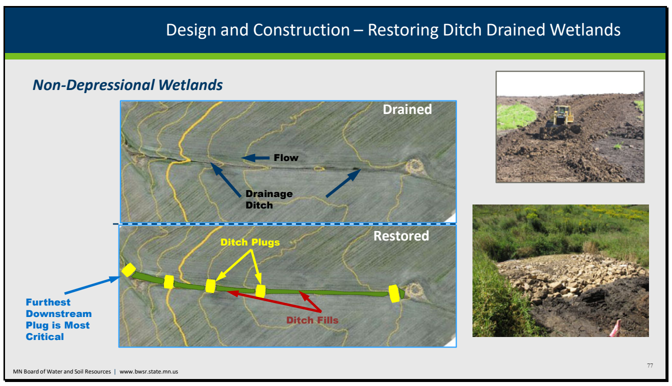
- **Contributing Drainage Area and size of Wetland**
- **Concerns of Adjoining Property Impacts (upstream or downstream)**

Slide 76



When and where to construct ditch plugs vs ditch fills varies depending on the wetland landscape setting

Slide 77

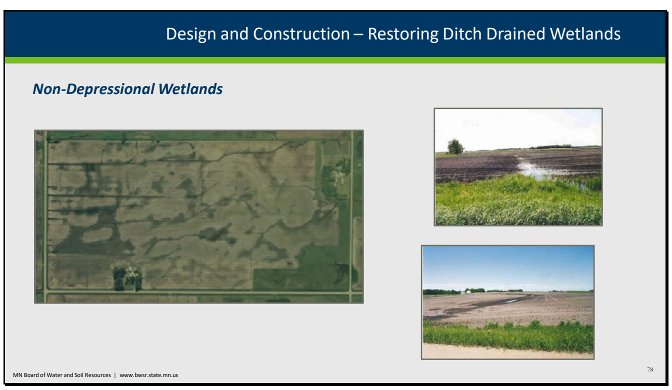


For moderate to more steeply sloped landscapes, a combination of ditch plugs and ditch fills will often provide the best results.

The most downstream end/ditch plug is most critical as at that location a deeper, open ditch system usually exists and concerns of scour erosion will need to be addressed in the design.

Some type of erosion control BMP or armored spillway is often needed here.

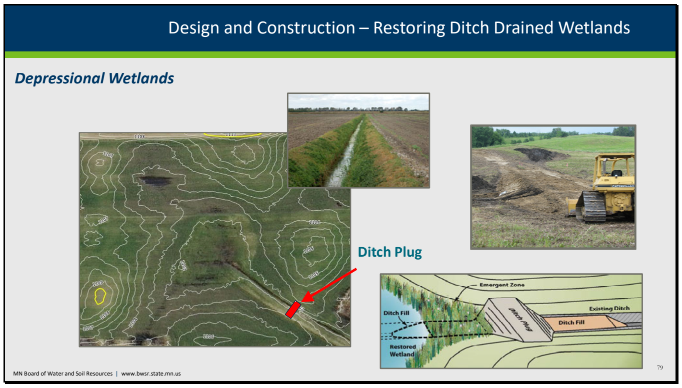
Slide 78



In mild to moderate sloping landscapes, ditch filling alone might be an appropriate construction strategy for restoration.

And again, a ditch plug might need to be considered at the bottom end of any disabled drainage ditch as part of an effective design.

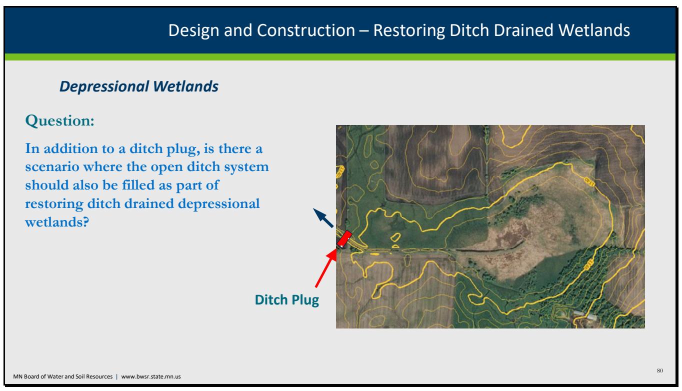
Slide 79



Depressional wetlands

Like with most tile drained depressional wetlands, a single plug at the outlet edge of the basin will generally be the minimum needed for hydro restoration

Slide 80



Enter yes or no in the chat box

Slide 81

Yes, in a surface water supported landscape setting, restoration success may also require a complete filling of the open ditch system. Next Slide

Slide 82

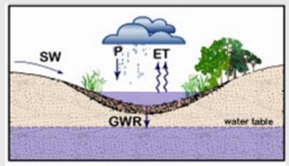
Design and Construction – Restoring Ditch Drained Wetlands

Depressional Wetlands

Surface Water Supported

- *Seasonal Wetlands*
- *Sedge meadows*
- *Marshes*

Geomorphic Landscape Setting



Surface Water - Depression

Slide 83

Design and Construction – Restoring Ditch Drained Wetlands

Depressional Wetlands

Additional Reasons to Fill Open Ditches in Depressional Wetlands

- **Safety**
- **Eliminates potential deep-water habitat (nuisance aquatic species)**
- **More natural restoration of topography**
- **Because NRCS practice standard (657) says you should (when feasible)**

Slide 84

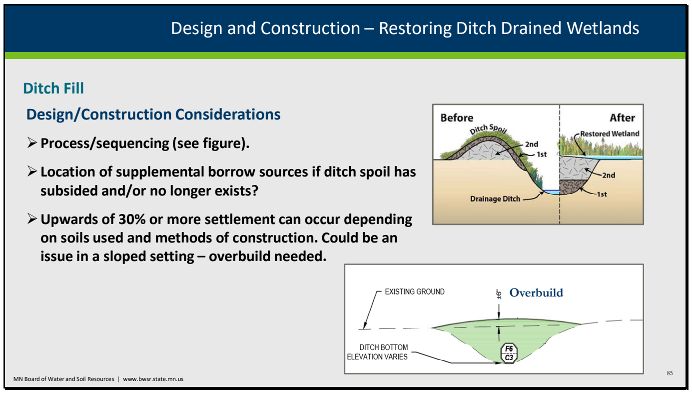
Design and Construction – Restoring Ditch Drained Wetlands

Design/Construction Considerations

vs.

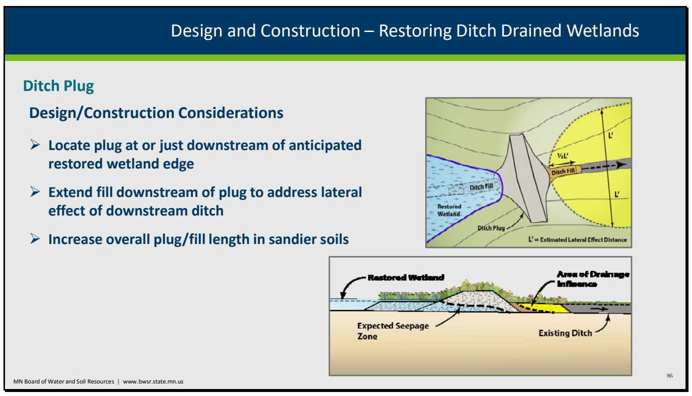
Significant difference between how ditch fills and plugs are designed and constructed

Slide 85



Ditch Filling

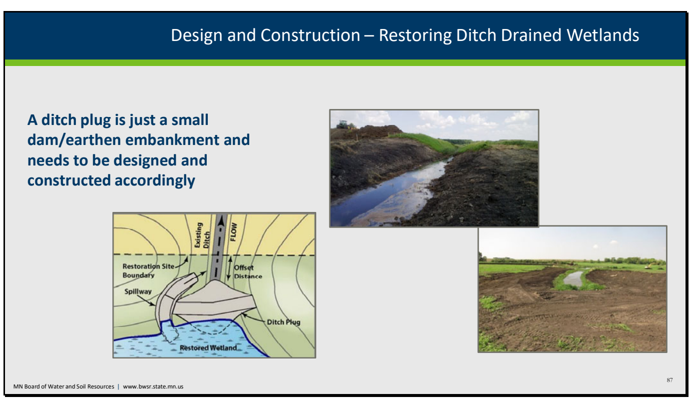
Slide 86



What about Ditch Plugs

The design concept behind ditch plugs is very similar to that of tile blocks.
Generally, the length of fill within the ditch should be the lesser of 100 feet or ½ the calculated lateral effect distance.
The length of fill can include a combination of a ditch plug and downstream ditch fills.

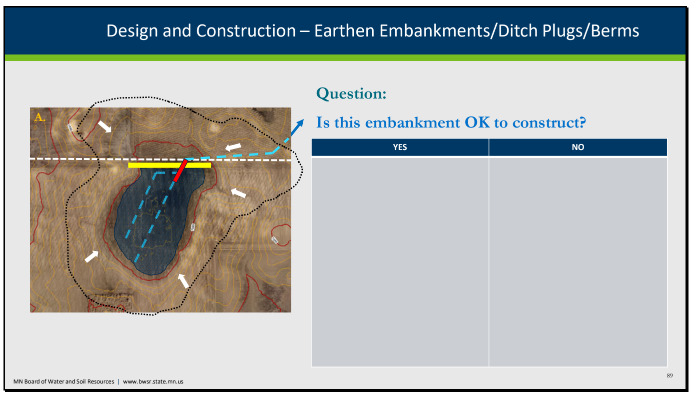
Slide 87



Slide 88

Going to Segway a bit here and discuss the role that earthen embankments can play when restoring wetlands and then we will discuss design and construction strategies for embankments, berms and ditch plugs.

Slide 89

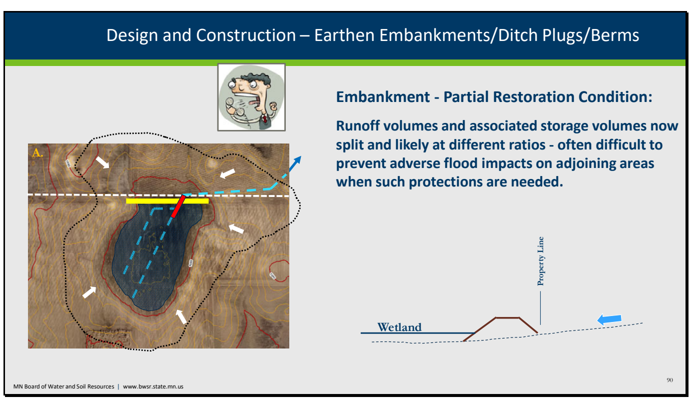


Landowner to the south of white dashed line wants to restore this tile drained depressional wetland. Tile flows out to the NE.

North landowner wants nothing to do with it the restoration and does not want to be impacted.

Is this planned embankment (yellow line) and tile block (red line) scenario OK to build?

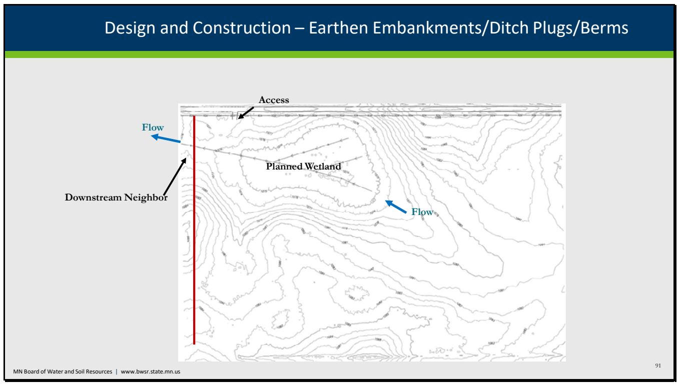
Slide 90



Maybe, but not likely.

Property to the north will need to be adequately drained by downstream tile system. A detailed hydrologic analysis would be needed to determine that.

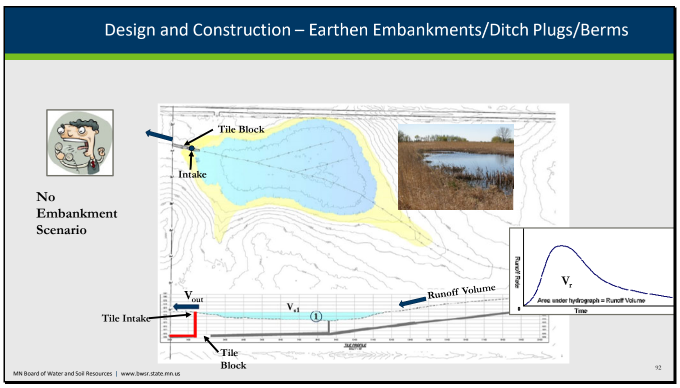
Slide 91



Here is just one example in which an embankment may be necessary and beneficial to restoration outcomes.

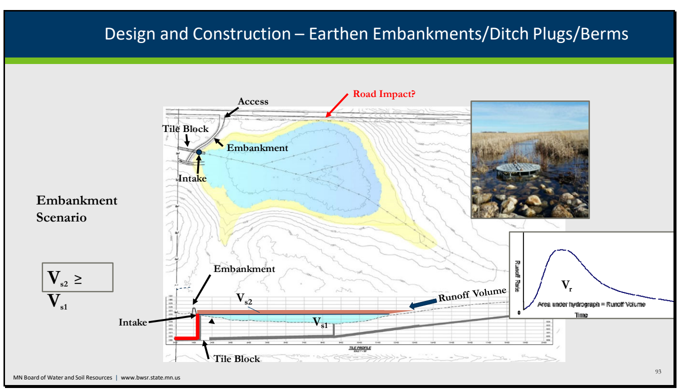
Explain site

Slide 92



Assuming that runoff volumes from the contributing drainage are relatively the same (pre vs. post restoration) – where will that runoff go if prior storage volume within this drained basin is gone (restored pool)?
Onto the neighbor – is that OK?

Slide 93



The volume of storage provided between the normal restored pool and new emergency runout (detention storage volume) should equal or exceed that which existed in a drained condition.

Note the planned embankment also function, continued access into the site.

Slide 94

Slide 95

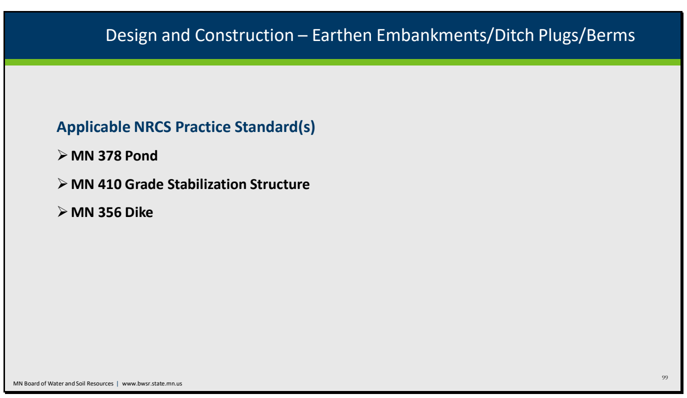
Before we get into design and construction specifics, let's maybe review a few of the major challenges and long-term maintenance issues that can result when using embankments in a wetland setting.

Slide 96

Slide 97

Slide 98

Slide 99

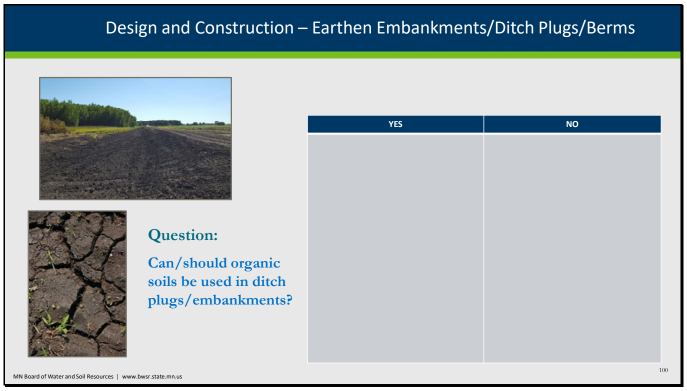


These are the applicable NRCS practice standards for embankments in a wetland/impoundment environment.
They do vary a bit from each other so become familiar with each of them.

Not going to go into great deal with the content of these practice standards due to lack of time allotted for this portion of the training event.

I will however discuss some of the more important aspects of wetland restoration embankment design and construction which, in combination with the practice standards and other technical resources, will hopefully provide you with sound design and construction guidance.

Slide 100



Before we get into design specifics, a quick question for you to answer.

Can organic soils be used in the construction of earthen embankments.

Yes - Dike (356) PS does allow organic soils for certain low head, embankments. Class III dikes less than 6 feet in height.
Class III dikes/embankments include those site where little to no offsite damage would occur as a result of failure.

Slide 101

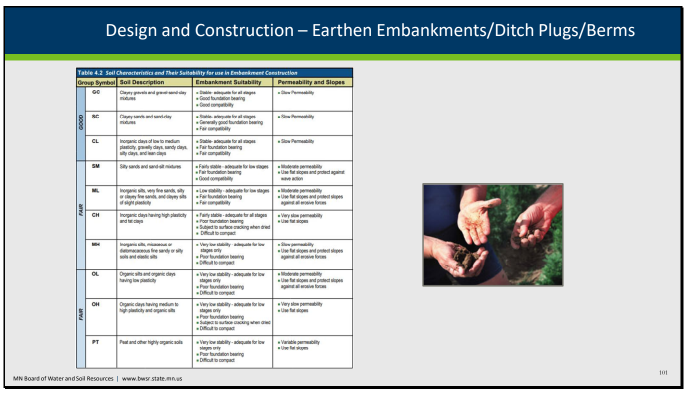
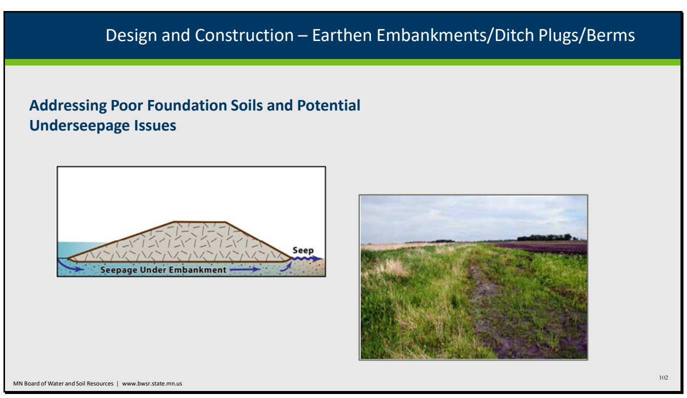


Table 4.2 Soil Characteristics and Their Suitability for use in Embankment Construction

	Group Symbol	Soil Description	Embankment Suitability	Permeability and Slopes
GOOD	GC	Clayey gravels and gravel-sand-clay mixtures	▪ Stable- adequate for all stages ▪ Good foundation bearing ▪ Good compatibility	▪ Slow Permeability
GOOD	SC	Clayey sands and sand-clay mixtures	▪ Stable- adequate for all stages ▪ Generally good foundation bearing ▪ Fair compatibility	▪ Slow Permeability
GOOD	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays	▪ Stable- adequate for all stages ▪ Fair foundation bearing ▪ Fair compatibility	▪ Slow Permeability
FAIR	SM	Silty sands and sand-silt mixtures	▪ Fairly stable - adequate for low stages ▪ Fair foundation bearing ▪ Good compatibility	▪ Moderate permeability ▪ Use flat slopes and protect against wave action
FAIR	ML	Inorganic silts, very fine sands, silty or clayey fine sands, and clayey silts of slight plasticity	▪ Low stability - adequate for low stages ▪ Fair foundation bearing ▪ Fair compatibility	▪ Moderate permeability ▪ Use flat slopes and protect slopes against all erosive forces
FAIR	CH	Inorganic clays having high plasticity and fat clays	▪ Fairly stable - adequate for all stages ▪ Poor foundation bearing ▪ Subject to surface cracking when dried ▪ Difficult to compact	▪ Very slow permeability ▪ Use flat slopes
FAIR	MH	Inorganic silts, micaceous or diatomacaceous fine sandy or silty soils and elastic silts	▪ Very low stability - adequate for low stages only ▪ Poor foundation bearing ▪ Difficult to compact	▪ Slow permeability ▪ Use flat slopes and protect slopes against all erosive forces
FAIR	OL	Organic silts and organic clays having low plasticity	▪ Very low stability - adequate for low stages only ▪ Poor foundation bearing ▪ Difficult to compact	▪ Moderate permeability ▪ Use flat slopes and protect slopes against all erosive forces
FAIR	OH	Organic clays having medium to high plasticity and organic silts	▪ Very low stability - adequate for low stages only ▪ Poor foundation bearing ▪ Subject to surface cracking when dried ▪ Difficult to compact	▪ Very slow permeability ▪ Use flat slopes
FAIR	PT	Peat and other highly organic soils	▪ Very low stability - adequate for low stages only ▪ Poor foundation bearing ▪ Difficult to compact	▪ Variable permeability ▪ Use flat slopes

The key to most successful embankment designs is the use and placement of appropriate soils for the given site conditions.
For most applications, your GC, SC and CL soils will provide the best results.

Slide 102



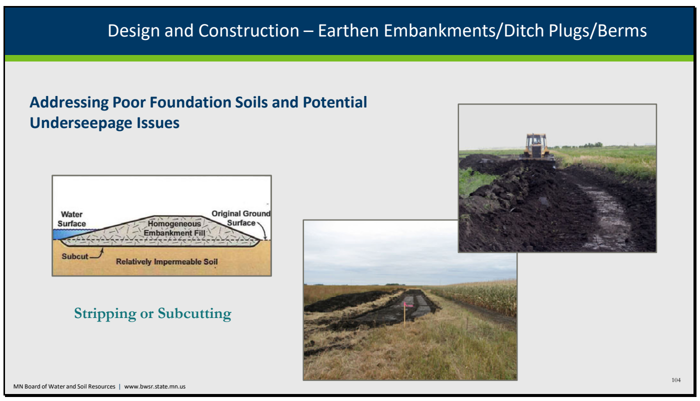
Regardless of site conditions or suitability of potential borrow soils, the embankment design should ensure minimal underseepage in attempt to prevent piping or undermining of the underlying foundation soils.

Foundation improvements may be needed to address these concerns as well as to ensure a stable foundation exists for the planned embankment.

Slide 103

In addition to review of existing soils data, this often requires some form of geological investigation at both potential ditch plug and embankment locations as well potential borrow locations.

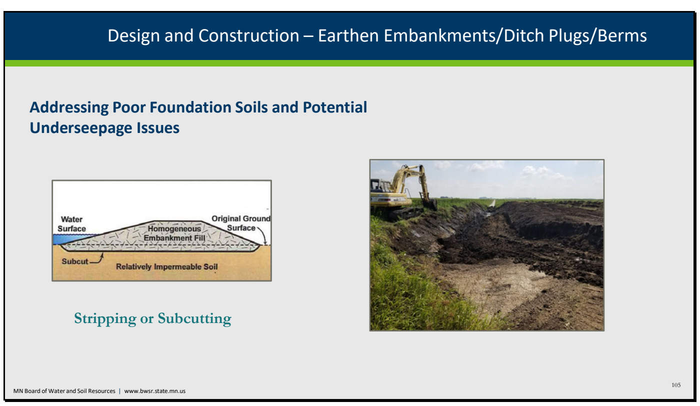
Slide 104



For many shallow wetlands, all that may be needed to address foundation issues is the stripping or subcutting of the first 6 to 12 inches of topsoil under the embankment footprint.

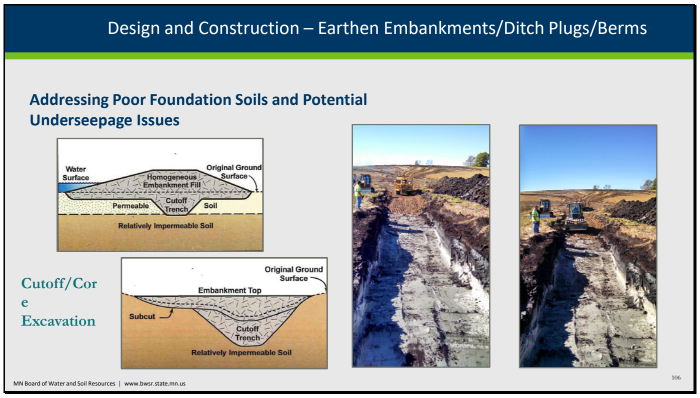
This work is often considered as part of a salvaging and spreading topsoil construction item.
Shown on these photos is topsoil stripping for an embankment scenario.

Slide 105



Shown on this photo is topsoil stripping for a ditch plug scenario.

Slide 106



In more extreme cases, a foundation cutoff or core trench may be needed.

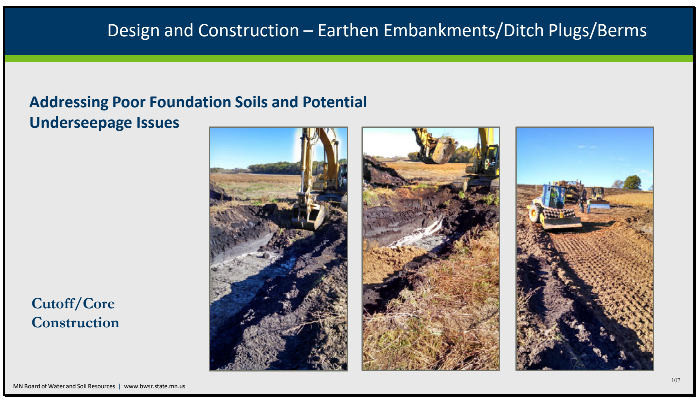
The core depth is usually excavated to intercept and connect with a deeper, relatively impervious soil layer.

The minimum core width is 4 feet but shall be wide enough to accommodate construction equipment used.

In these two photos you can see good quality material is being used as core trench backfill, being placed in lifts and being properly compacted.

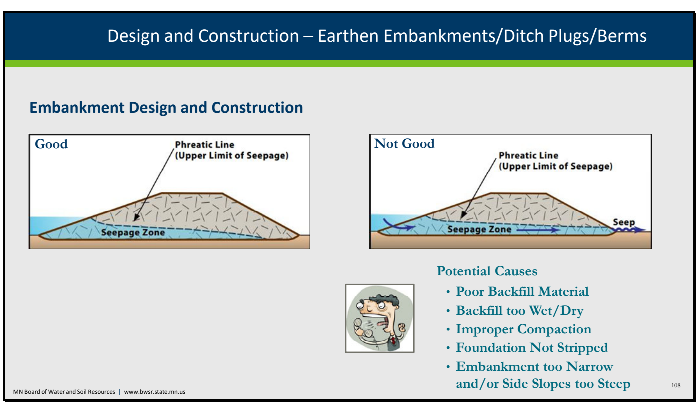
Can anybody in the chat box identify what might be wrong though with the cut off trench being constructed in the two photographs?
Core trench side slopes should be no steeper than 1(H):1(V)

Slide 107



A little better job with the core excavation in these photos as the side slopes have been flattened and appear to be closer to the required minimum 1:1 side slope.
Backfill is of quality material with good compaction in appropriate lifts.

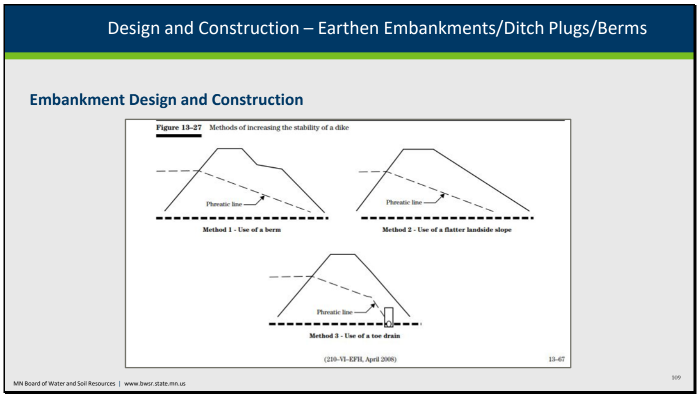
Slide 108



The embankment design should ensure the developed phreatic line does not exit along the embankment's backslope.

In addition to a potentially upset downstream landowner, internal erosion or piping can occur eventually leading to more significant issues including failure of the earthen structure.

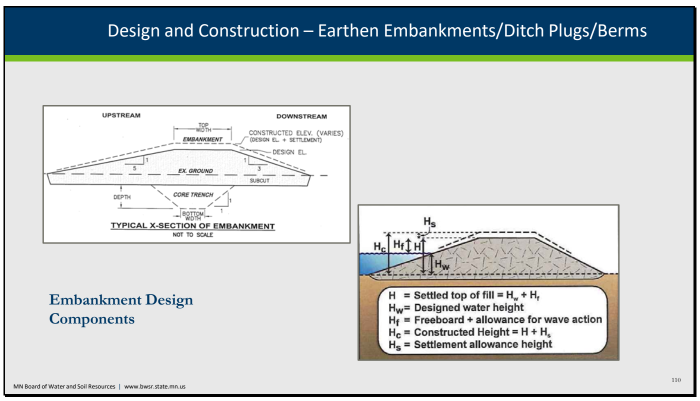
Slide 109



To best address this concern, especially in a wetland setting, it is a good idea to be more conservative with an embankment's geometry than allowed by the practice standards. Recommended minimums include a 10-foot top width, 5:1 front slope and 3:1 back slope. It might even be advisable to construct a berm against the emb backslope to further widen and cover the phreatic line.

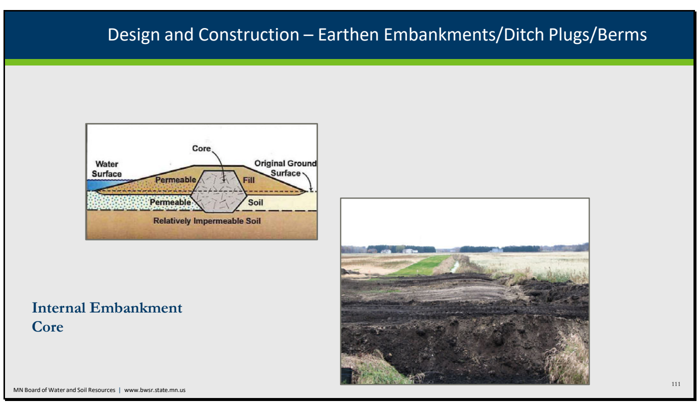
In more extreme cases, a toe drain could be considered (as shown).

Slide 110



Constructed embankment heights should be dictated by required and necessary freeboard and settlement percentage, as directed by the practice standards.

Slide 111



Where good quality backfill for the core is in limited supply, a zoned fill type of embankment could be considered.

Slide 112

The practice standards also indicate that in certain situations berms may be needed against an embankment to help address stability.

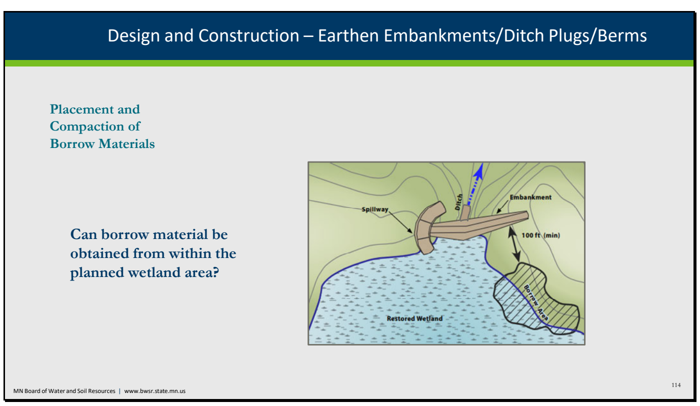
This is most applicable when constructing steeper sloped embankments, as allowed by the practice standards.

However, berms can be beneficial in other ways as they can serve to protect the embankment from potential wave action associated with deeper wetlands or even new restorations yet void of emergent vegetation. Can also serve as a deterrent to muskrats (more on this later).

Slide 113

It will be important to use a quality on-site soil for borrow material.

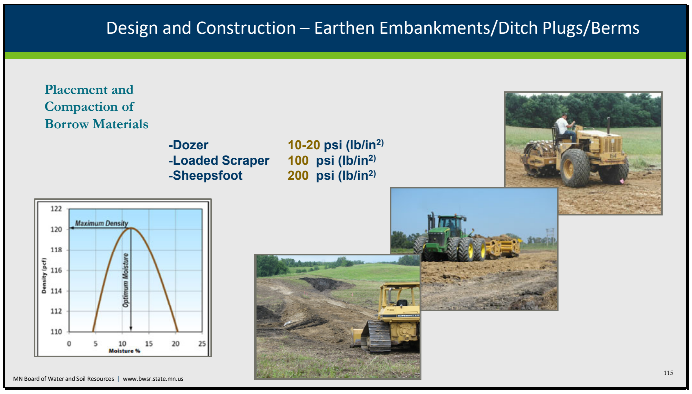
Slide 114



Do not allow borrow areas or any other permanent excavations such as wetland scrapes to be near the US or DS side of a planned embankment. The reasons for this relate to embankment stability, underseepage issues and minimizing deep water habitat near embankments as a deterrent to burrowing rodents (muskrats).

Suggested that a 100-foot minimum buffer distance be considered.

Slide 115



Just as important is ensuring the borrow material has adequate moisture content and is appropriately placed and compacted.

The three methods of compaction most often used are 1) Tracked compaction with a dozer, 2) rubber-tired compaction using a loaded truck or scraper, or 3) or sheepsfoot or other similar roller device.

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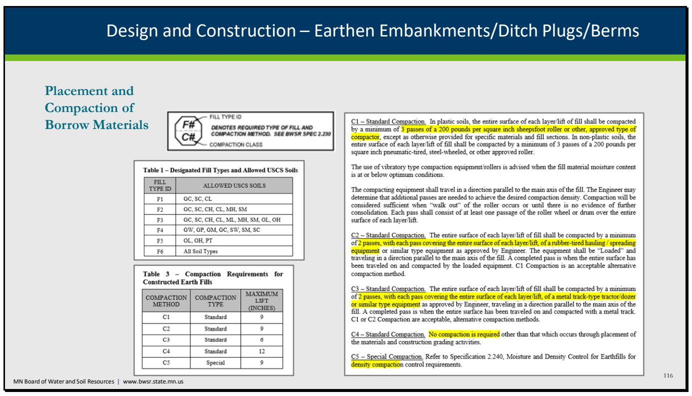

Table 1 – Designated Fill Types and Allowed USCS Soils

FILL TYPE ID	ALLOWED USCS SOILS
F1	GC, SC, CL
F2	GC, SC, CH, CL, MH, SM
F3	GC, SC, CH, CL, ML, MH, SM, OL, OH
F4	GW, GP, GM, GC, SW, SM, SC
F5	OL, OH, PT
F6	All Soil Types

Table 3 – Compaction Requirements for Constructed Earth Fills

COMPACTION METHOD	COMPACTION TYPE	MAXIMUM LIFT (INCHES)
C1	Standard	9
C2	Standard	9
C3	Standard	6
C4	Standard	12
C5	Special	9

C1 – Standard Compaction. In plastic soils, the entire surface of each layer/lift of fill shall be compacted by a minimum of 3 passes of a 200 pounds per square inch sheepsfoot roller or other, approved type of compactor, except as otherwise provided for specific materials and fill sections. In non-plastic soils, the entire surface of each layer/lift of fill shall be compacted by a minimum of 3 passes of a 200 pounds per square inch pneumatic-tired, steel-wheeled, or other approved roller.

The use of vibratory type compaction equipment/rollers is advised when the fill material moisture content is at or below optimum conditions.

The compacting equipment shall travel in a direction parallel to the main axis of the fill. The Engineer may determine that additional passes are needed to achieve the desired compaction density. Compaction will be considered sufficient when "walk out" of the roller occurs or until there is no evidence of further consolidation. Each pass shall consist of at least one passage of the roller wheel or drum over the entire surface of each layer/lift.

C2 – Standard Compaction. The entire surface of each layer/lift of fill shall be compacted by a minimum of 2 passes, with each pass covering the entire surface of each layer/lift, of a rubber-tired hauling / spreading equipment or similar type equipment as approved by Engineer. The equipment shall be "Loaded" and traveling in a direction parallel to the main axis of the fill. A completed pass is when the entire surface has been traveled on and compacted by the loaded equipment. C1 Compaction is an acceptable alternative compaction method.

C3 – Standard Compaction. The entire surface of each layer/lift of fill shall be compacted by a minimum of 2 passes, with each pass covering the entire surface of each layer/lift, of a metal track-type tractor/dozer or similar type equipment as approved by Engineer, traveling in a direction parallel to the main axis of the fill. A completed pass is when the entire surface has been traveled on and compacted with a metal track. C1 or C2 Compaction are acceptable, alternative compaction methods.

C4 – Standard Compaction. No compaction is required other than that which occurs through placement of the materials and construction grading activities.

C5 – Special Compaction. Refer to Specification 2.240, Moisture and Density Control for Earthfills for density compaction control requirements.

For BWSR designs and construction plans, we have created 6 categories of allowable USCS soils that can be used as fill and designating that for each embankment to be constructed.

We also designate a compaction method for each embankment with C1 thru C3 being the most common.

Review highlighted text.
For C2 or C3 compaction, a higher level or better compaction method is allowed.
NRCS uses slightly different nomenclature as part their designs but the end results and requirements are similar.
What's important here is to consider each ditch plug and embankment independently and make good decisions with respect to how it is to be constructed.

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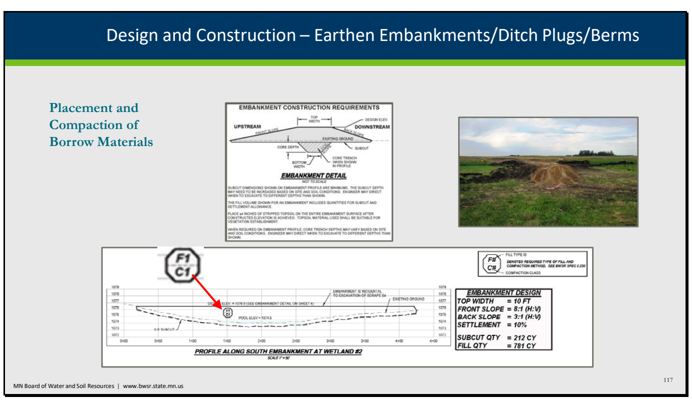
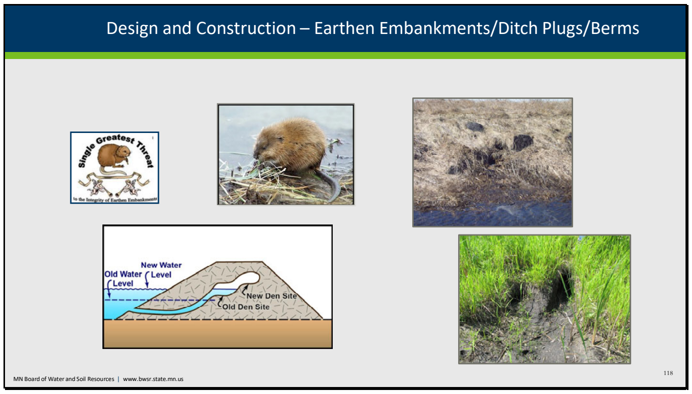


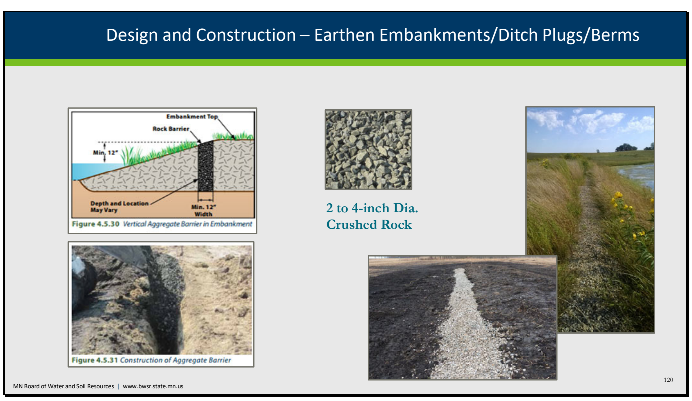
Slide 118



Slide 119

Front side berms and flatter embankment slopes can help in shallower wetland settings

Slide 120



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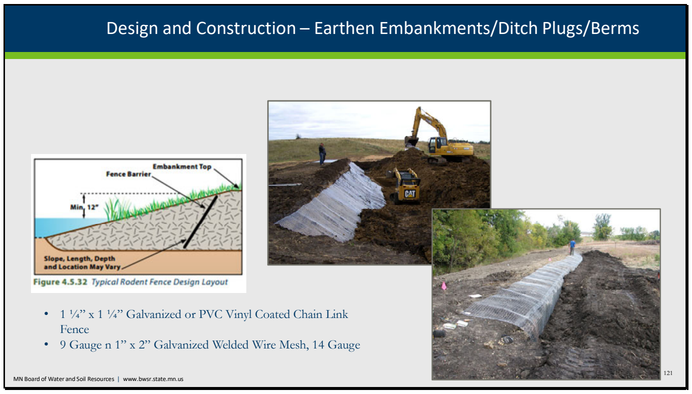
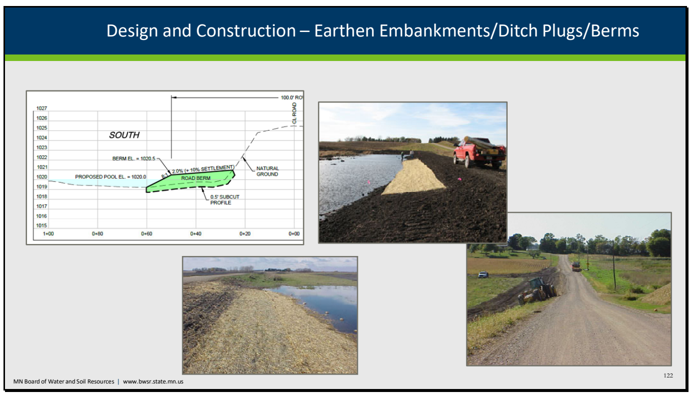


It is unclear how long buried fencing will last at a given location
May not be a good long-term means of protection

Slide 122



Slide 123

Slide 124

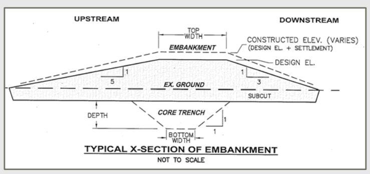
Design and Construction – Earthen Embankments/Ditch Plugs/Berms




And lastly – Adding 4 to 6-inches of Topsoil, Seeding and Mulching and/or other erosion protection is final step.

Slide 125

Design and Construction – Earthen Embankments/Ditch Plugs/Berms

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Design and Construction – Earthen Embankments/Ditch Plugs/Berms

Ditch Fills

Often considered as being incidental to other excavation pay items. In other words, not a direct pay item.

Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Fill Existing Ditch System	Lineal Feet (or Hours)	900		

If listed as having a lineal foot pay unit, an approximation of the expected cubic yards per lineal foot will usually be provided to help with determining scope of work and associated cost.

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Design and Construction – Earthen Embankments/Ditch Plugs/Berms

Ditch Plugs and Embankments

Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Salvage and Spread Topsoil (P)	Cubic Yards	120		
Earthfill – Embankment (P) (CV) *(includes subcut volumes and allowances for settlement)*	Cubic Yards	1,460		
Excavation – Core Trench	Cubic Yards	650		
Earthfill – Core Trench (CV)	Cubic Yards	650		

- *Generally, all compacted earthfills will be treated and payed as a Compacted Volume (CV) quantity.*
- *The above grade portion of embankments will usually be designated as a Plan Quantity (P) item – treated as a fixed quantity with quantity adjustments only occurring thru prior approval from Project Technical Representative.*

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Design and Construction – Earthen Embankments/Ditch Plugs/Berms

Ditch Plugs and Embankments

Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
F&I Rodent Protection Fence	Lump Sum (or Lineal/Square Feet)	1		
F&I Rock Trench for Rodent Protection	Lineal Feet	500		
Seeding – Wetland Construction Mix	Acres	3		
Mulching	Acres	2		

- *Other disturbed areas of the site will often also need to be seeded.*

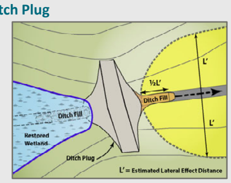
Slide 129

Design and Construction – Earthen Embankments/Ditch Plugs/Berms

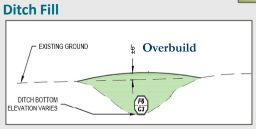
Summary

- Ditch plugs and ditch fills are often used in combination with each other to effectively restore ditch drained wetlands.

Ditch Plug



Ditch Fill



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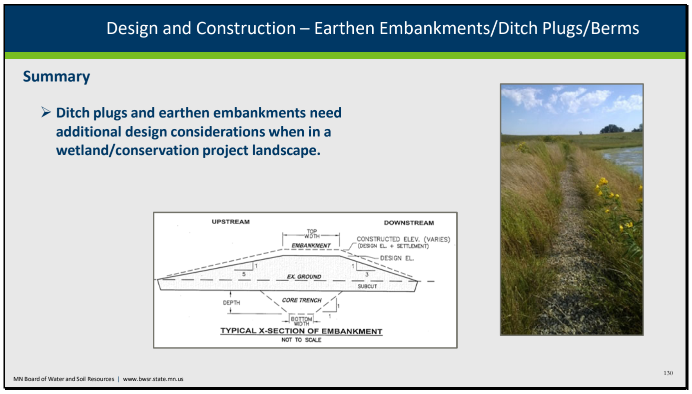


Slide 131

There is often a desire to excavate within a wetland that is planned for restoration.

The reasons for excavating wetland soils as part of restoration are varied and can include:

Slide 132

Often requires a detailed assessment of sediment depths which can vary greatly within locations around a wetland

Slide 133

Design and Construction – Sediment Removal/Other Wetland Excavations

Improve wetland function or enhance vegetation diversity

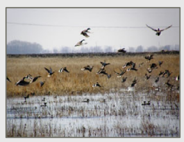
- Removing monolithic stands of hybrid cattail, reed canary grass, or other undesired vegetation
- Removing topsoil that is laden with nutrients and pesticide

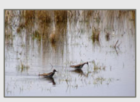
Slide 134

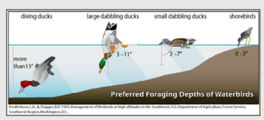
Design and Construction – Sediment Removal/Other Wetland Excavations

Improve wildlife habitat

- Improve/enhance wetland depths and provide microtopography
- Restoring the historic water storage capacity





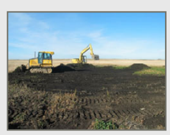


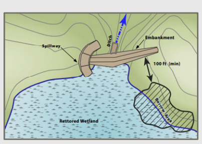
Slide 135

Design and Construction – Sediment Removal/Other Wetland Excavations

Obtain necessary borrow material

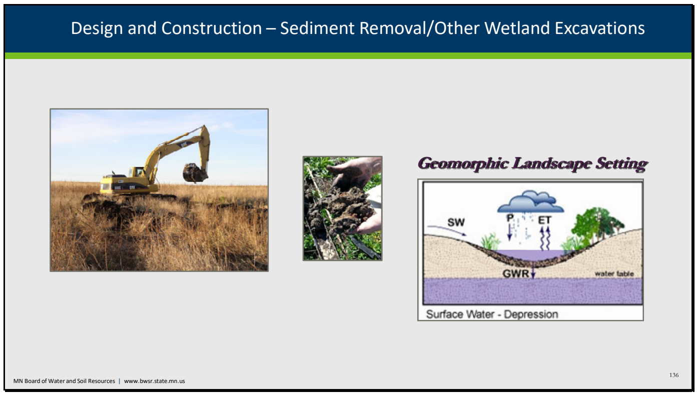
- For planned ditch fills or other grading areas
- For embankments or berms (when suitable)





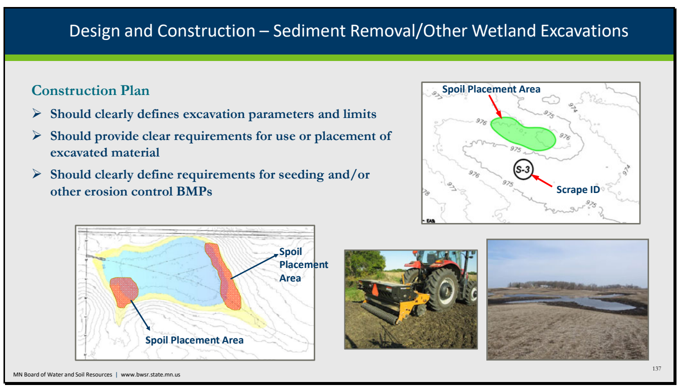
Assessing the suitability of excavated soils for their intended purpose will be an important aspect of this strategy.

Slide 136

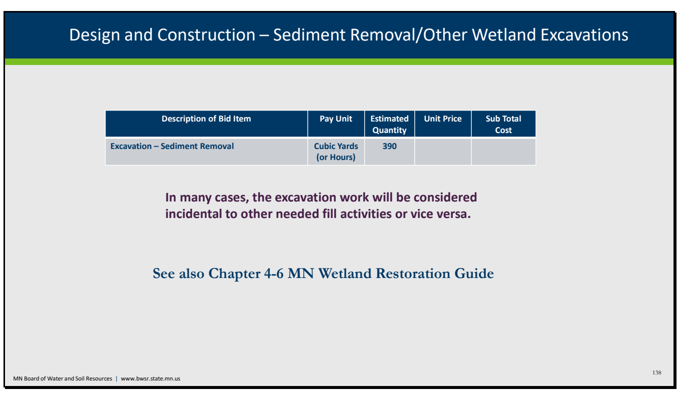


Before any plans are made to excavated within a wetland, a clear understanding of site soils and wetland geomorphology is needed.
In some locations, well intended excavations can penetrate a pervious substratum and prevent successful hydrologic restoration.

Slide 137



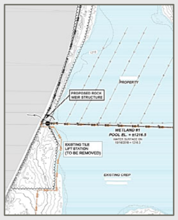
Slide 138

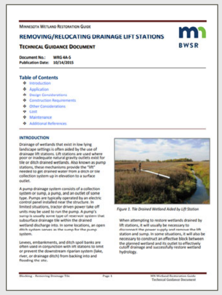


It is very important to consider how excavations and the placement of excavated material will get paid for.

Slide 139

Design and Construction – Lift Pumps





Occasionally, you will be faced with a pending wetland restoration that has its drainage benefited by a lift pump.

Not going to spend much time on this strategy as aside from removing the lift station, sump, and associated infrastructure, many of the construction strategies already discussed will apply in these scenarios as well.

I will suggest reference to another WRG TGD that is devoted solely to these drainage situations.

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Design and Construction – Lift Pumps

Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Remove and Dispose of Existing Drainage Lift Pump, Sump, and Related Infrastructure	Lump Sum	1		

Generally, payment for removal would be best reflected as a lump sump item.

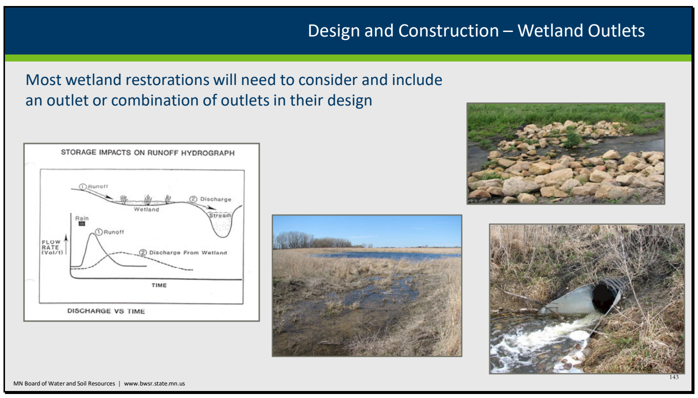
Slide 141

Design and Construction – Wetland Outlets

Slide 142

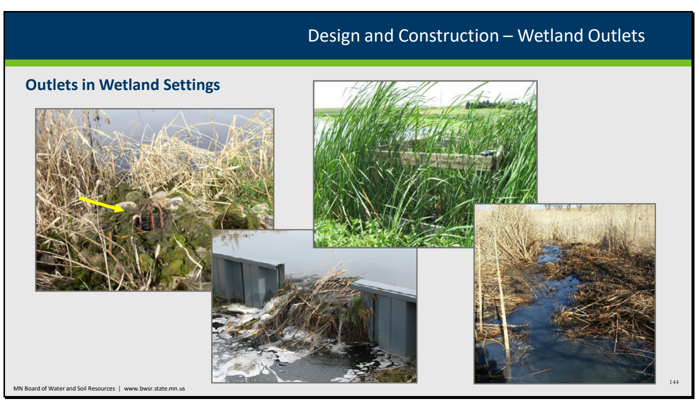
Some restorations that have small contributing drainage areas <u>and</u> have no other inflows, may not need a constructed outlet.

Slide 143



For most sites however, runoff and other hydrologic inputs to the wetland will exceed storage, infiltration, and other losses. In these cases an outlet of some type will be needed to manage expected storm outflows.

Slide 144

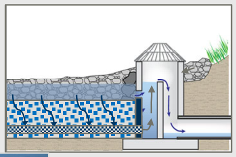


Wetland outlets are often located in remote locations and are often surrounded wildlife and lush vegetation.

Designing and maintaining functional outlets in these wetland settings is probably the most difficult aspect of restoration. Things look great on paper and even after the first few years of implementation. However, over time things can go bad if maintenance is not done on a regular basis.

Slide 145

Outlets in Wetland Settings

Part of our challenge, as designers, is to recognize potential maintenance issues and design the best possible outlet for the given situation. Hopefully, this training will help you recognize potential issues and identify the best possible solution for projects you may be working on or are involved with.

Slide 146

Purpose

- To regulate and manage wetland water levels
- To manage and control wetland discharges
- To prevent uncontrolled flooding or excess water level variations
- To protect and/or minimize flooding problems for downstream areas
- To safely convey wetland discharges into a downstream area or drainage system

Wetland outlets can serve several different purposes.
Control water levels
Control discharges
They need to prevent flooding upstream of our restoration and not create flooding problems downstream
All while safely conveying the discharges to a suitable downstream location

Slide 147

Purpose (con't)

- To provide increased flood detention storage
- To provide water quality treatment benefits
- To provide a physical barrier preventing undesired or nuisance wetland species from entering the wetland system

If we can provide flood storage and detention, which means slowing the release of waters, we gain water quality benefits.
But another thing to consider is keeping nuisance species from entering the system.

Slide 148

Veg Spillway = trapezoidal channel

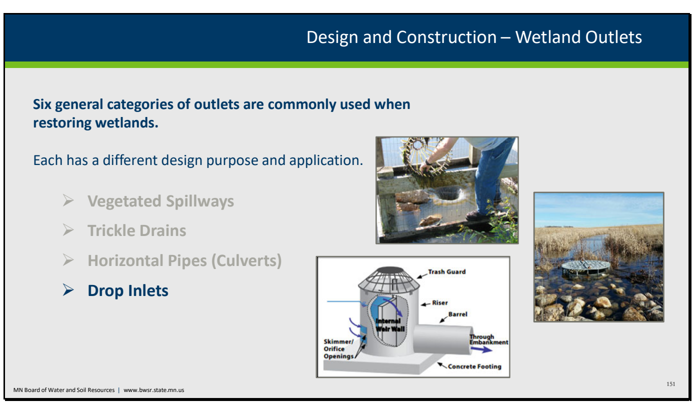
Slide 149

Minimal pipe or tile outlet, just to remove base flows and gradually draw down pools. These do not handle anything close to the 10 year design storm runoff.

Slide 150

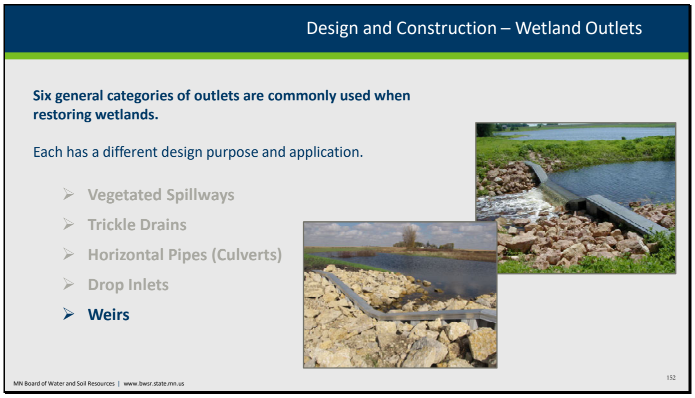
Sized to handle larger flows.

Slide 151



Vertical component and a horizontal pipe/barrel taking the water to some downstream outlet.

Slide 152



Pass much larger flows, generally outlet into ditches.

Slide 153

Weirs in combination with downstream culverts can provide higher discharge rates with the benefits of culvert and crossing.

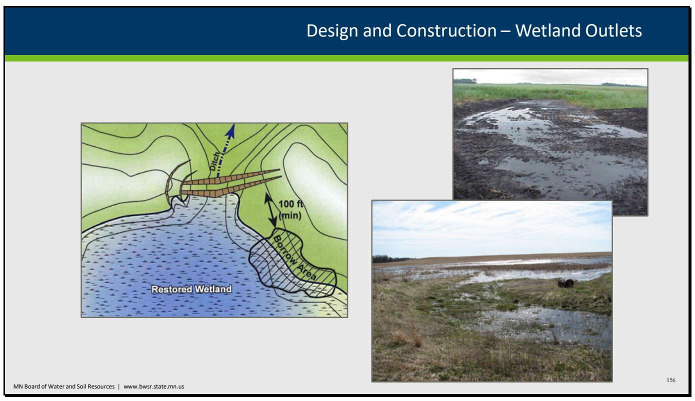
Slide 154

Similar to a vegetated spillway, but able to handle higher flows and velocities, along with some vertical drop.

Slide 155

Just pics of armored spillways

Slide 156

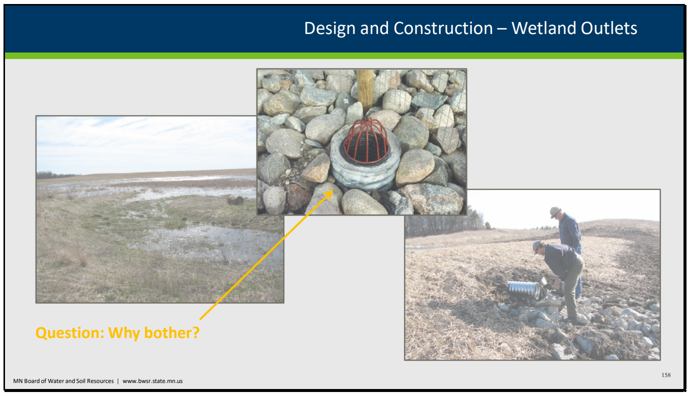


Fortunately, the decision of outlet type and function will often be quite easy as the majority of wetlands that get restored utilize simple vegetated spillways as an outlet.

Slide 157

Or vegetated spillways in combination with a simple pipe or tile inlet structure.

Slide 158

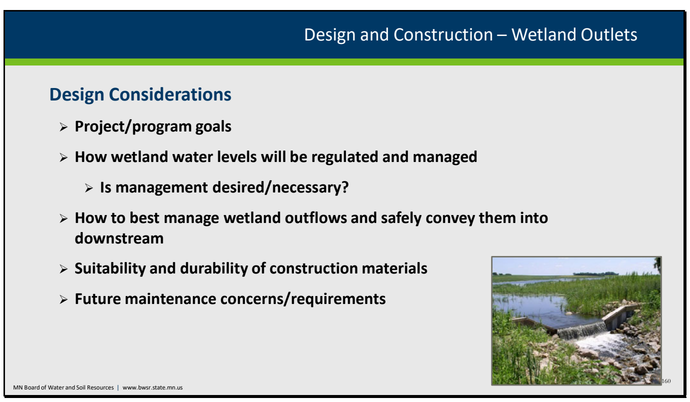


QUESTION: if one of these little tile inlets only passes less than 1 cfs, what's the point of putting them out there?
ANS: The veg spillway will pass the storm flows, but once the pool level recedes to the crest (or edge) of the veg. spillway, you want to bring the water level down just a little lower so the spillway does not remain saturated for days.

Slide 159

For the few other more complex sites, there are a number of styles, configurations, and therefore costs for outlets. Usually working with engineering staff or through experience you can learn how to narrow down the ones best suited for the project.

Slide 160



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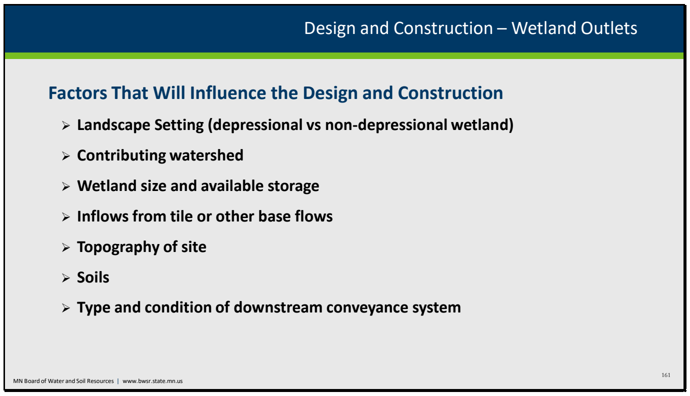
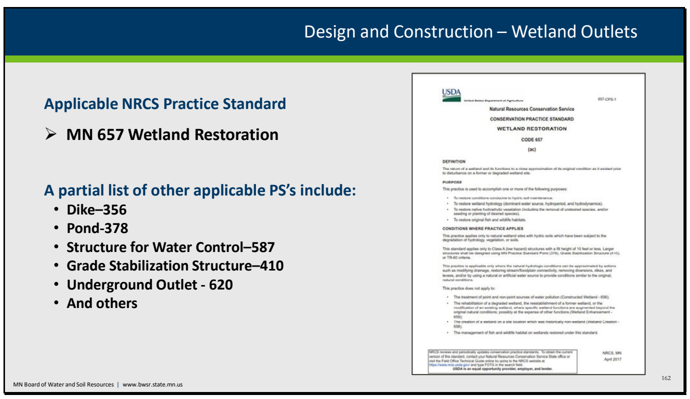


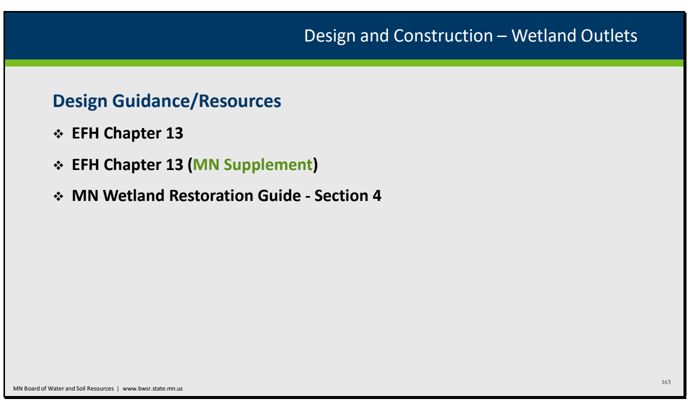
Factors that influence the design will come down to the project constraints of the physical site.
Landscape setting
Characteristics of the watershed

Slide 162



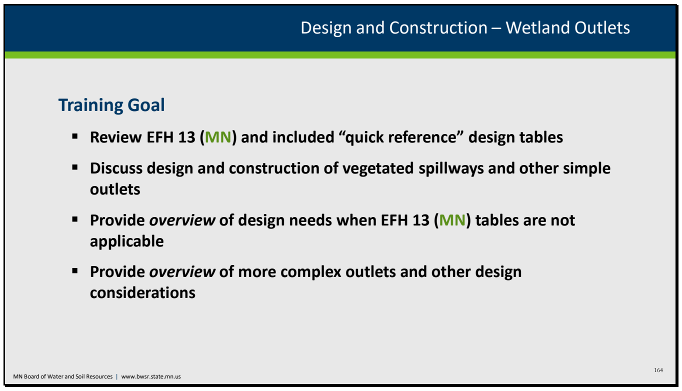
Each of these practices has individual criteria for design storm, freeboard, size, et cetera. Each also has individual Engineering Job Approval Authority limits.
PS 657 is the primary practice standard. Certain sections contain information on scrapes and tile blocks. But then other sections mention other practices that can be used to accomplish the restoration, and point you to those other practice standards for those specific components.

Slide 163

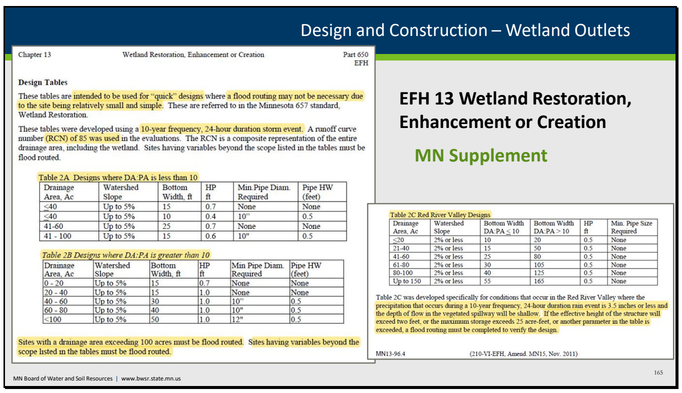


A number of design guidance and technical resource documents exist to help in this effort

Slide 164



Slide 165



Chapter 13 Wetland Restoration, Enhancement or Creation Part 650 EFH

Design Tables

These tables are intended to be used for “quick” designs where a flood routing may not be necessary due to the site being relatively small and simple. These are referred to in the Minnesota 657 standard, Wetland Restoration.

These tables were developed using a 10-year frequency, 24-hour duration storm event. A runoff curve number (RCN) of 85 was used in the evaluations. The RCN is a composite representation of the entire drainage area, including the wetland. Sites having variables beyond the scope listed in the tables must be flood routed.

Table 2A Designs where DA:PA is less than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min.Pipe Diam. Required	Pipe HW (feet)
≤40	Up to 5%	15	0.7	None	None
≤40	Up to 5%	10	0.4	10”	0.5
41-60	Up to 5%	25	0.7	None	None
41 - 100	Up to 5%	15	0.6	10"	0.5

Table 2B Designs where DA:PA is greater than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min Pipe Diam. Required	Pipe HW (feet)
0 - 20	Up to 5%	15	0.7	None	None
20 - 40	Up to 5%	15	1.0	None	None
40 - 60	Up to 5%	30	1.0	10”	0.5
60 - 80	Up to 5%	40	1.0	10"	0.5
<100	Up to 5%	50	1.0	12"	0.5

Sites with a drainage area exceeding 100 acres must be flood routed. Sites having variables beyond the scope listed in the tables must be flood routed.

Table 2C Red River Valley Designs

Drainage Area, Ac	Watershed Slope	Bottom Width DA:PA ≤ 10	Bottom Width DA:PA > 10	HP ft	Min. Pipe Size Required
≤20	2% or less	10	20	0.5	None
21-40	2% or less	15	50	0.5	None
41-60	2% or less	25	80	0.5	None
61-80	2% or less	30	105	0.5	None
80-100	2% or less	40	125	0.5	None
Up to 150	2% or less	55	165	0.5	None

Table 2C was developed specifically for conditions that occur in the Red River Valley where the precipitation that occurs during a 10-year frequency, 24-hour duration rain event is 3.5 inches or less and the depth of flow in the vegetated spillway will be shallow. If the effective height of the structure will exceed two feet, or the maximum storage exceeds 25 acre-feet, or another parameter in the table is exceeded, a flood routing must be completed to verify the design.

MN13-96.4 (210-VI-EFH, Amend. MN15, Nov. 2011)

To avoid having to flood route or perform other hydrologic/hydraulic calculations for relatively small and simple wetland restorations, the MN Supplement to EFH 13 includes design tables to help determine minimum sizing of wetland outlets. We don’t have to read through the whole thing, but the highlighted portions spell out the assumptions. Found on the MN NRCS website.

Slide 166

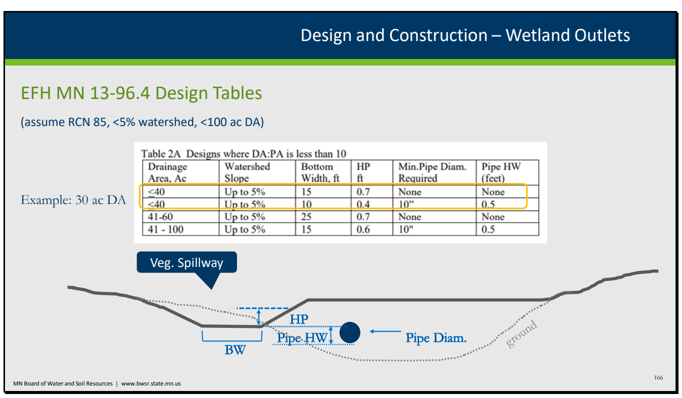
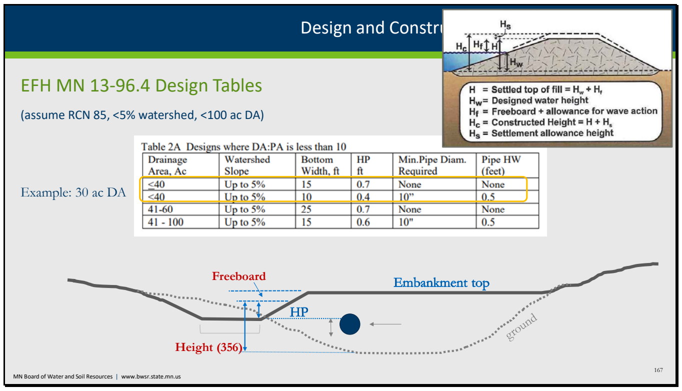


Table 2A Designs where DA:PA is less than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min.Pipe Diam. Required	Pipe HW (feet)
<40	Up to 5%	15	0.7	None	None
<40	Up to 5%	10	0.4	10”	0.5
41-60	Up to 5%	25	0.7	None	None
41 - 100	Up to 5%	15	0.6	10"	0.5

Basically, the tables are based on a watershed with an RCN 85 or less, <5% avg watershed slope, and the tables only go up to 100 ac DA.
You can use these to size your vegetated spillway, pipe (if needed), and embankment elevations.
Side slopes, top width, settlement: from PS 356

Slide 167

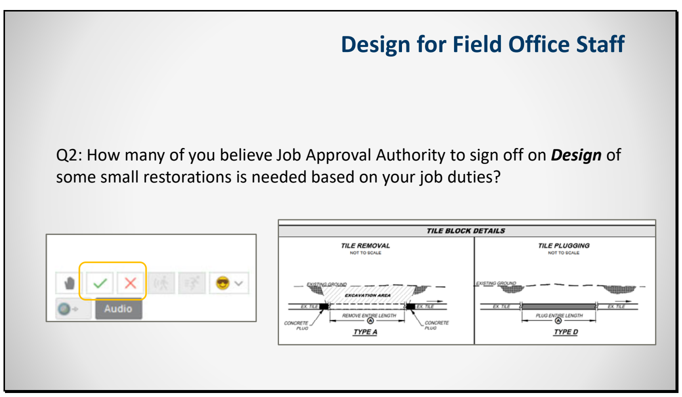


Freeboard needs to being added to HP to get embankment elevation. Freeboard varies depending on PS used. Generally going to be 12” or greater. For PS 356, Freeboard is a function of H and embankment soils.

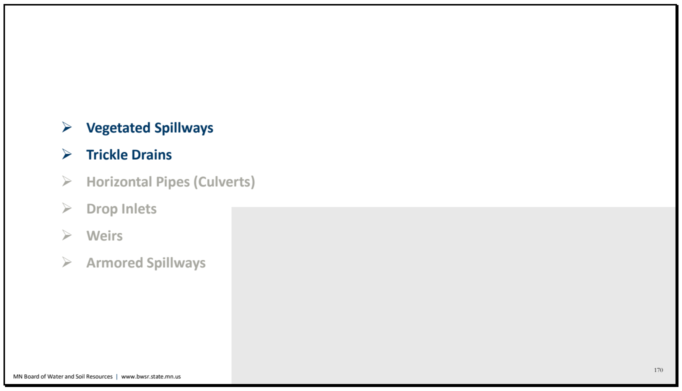
Slide 168

Not just 657, but in general.

Slide 169

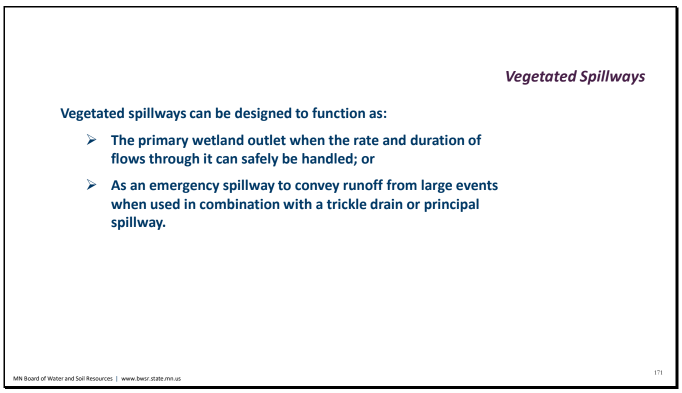


Slide
170

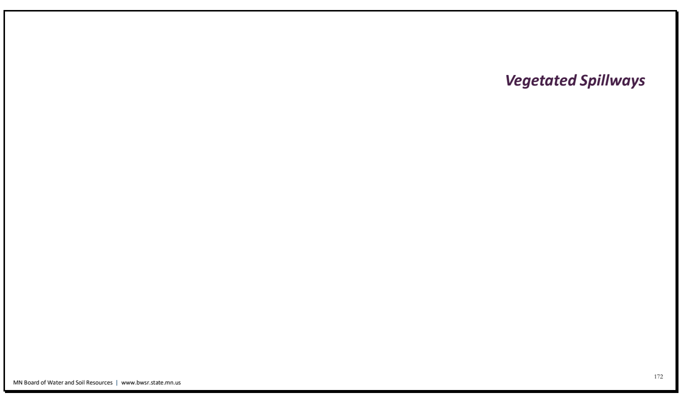


The use of vegetated spillways and trickle drains as outlet components are a key part of the design tables. Because of that, we are going to take some time to discuss design and construction considerations of these two types of outlets.

Slide
171



Slide
172



Excavated spillways consist of the three elements. 1. The inlet channel 2. The level portion or control section 3. And the exit channel.
Each element has a special function.
The flow enters the spillway through the inlet channel. The depth of flow Hp located upstream from the level portion or control section is controlled by the characteristics of all 3 parts of the spillway.

The level portion should be located near the intersection of the extended centerline of the dam with the centerline of the spillway and have a length of at least 25 feet

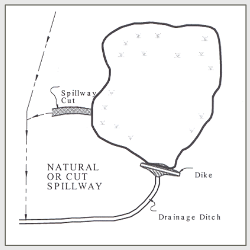
The exit channel must have a slope that is adequate to discharge the peak flow within the channel. The slope, however, must be no greater than that which will result in maximum permissible velocities for the soil type or the planned grass cover. The exit channel should be straight and should confine the outflow to a point where scour will not occur.

Slide 173

Design and Construction – Wetland Outlets

Vegetated Spillways

- **Use of vegetated spillways in natural low areas without shaping is desirable since existing soils and established vegetation are (usually) not disturbed.**
- **Alternatively, locating them in areas away from planned embankments is also desirable.**

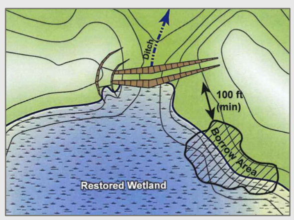


Slide 174

Design and Construction – Wetland Outlets

Vegetated Spillways

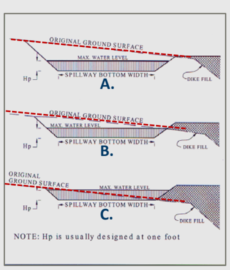
- **When necessary, construct around one or both ends of planned embankments.**
- **Not recommended to be placed over constructed embankment fills**



Slide 175

Design and Construction – Wetland Outlets

Vegetated Spillways



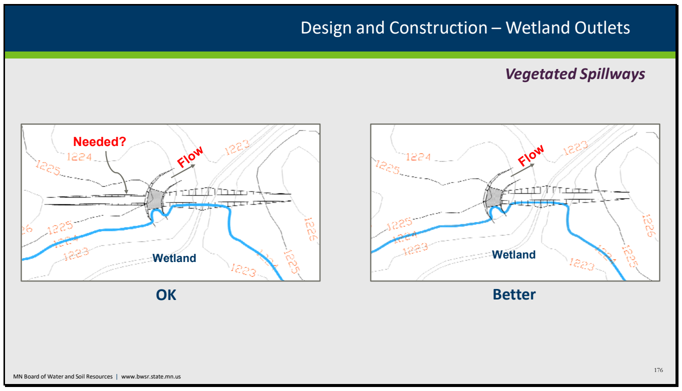
A Only

A and B

A, B and C

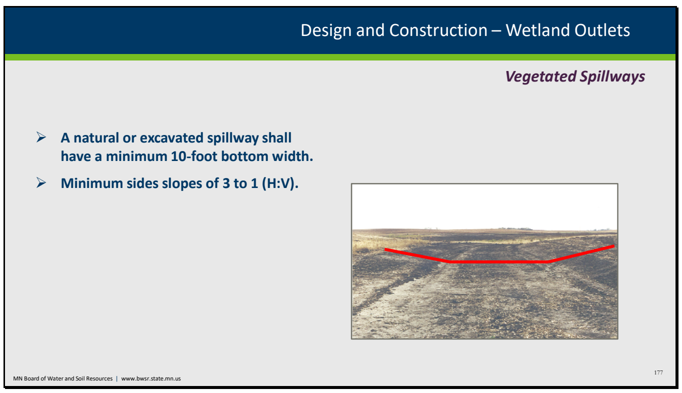
Three alternative spillway cuts against an earthen embankment (dike) are shown. Put a mark in the box that best represents the scenario or scenarios considered as being permissible.

Slide 176



First slide is OK but add unnecessary costs to construction

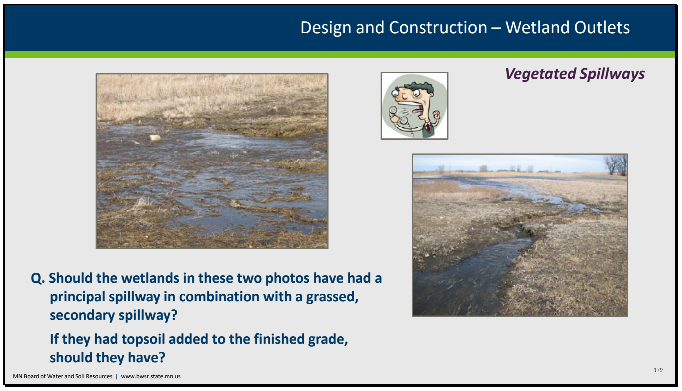
Slide 177



Slide 178

If spillway cut extends into nonorganic soil, over excavate to allow 4 to 6 inches of topsoil to be added as a suitable substrate for seeding.

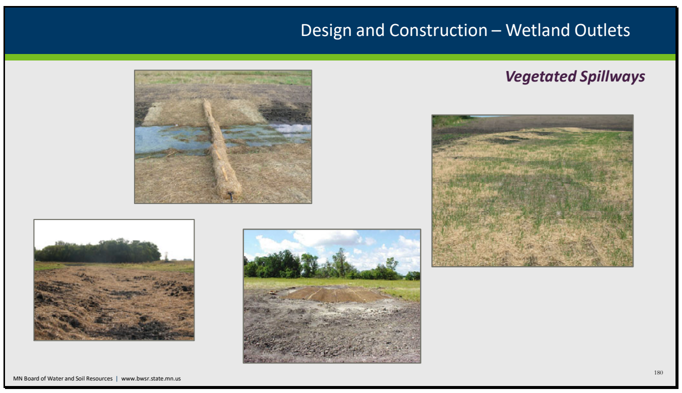
Slide 179



Vegetated spillways are most susceptible to scour and failure in spring and first few years after construction, prior to establishment of sod forming grasses.

Maybe, hard to determine as these both appear to a refection of spring runoff/snowmelt with prior fall construction.

Slide 180

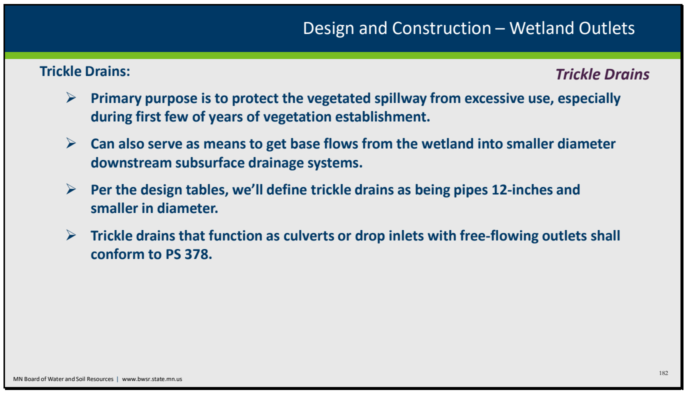


Where needed, provide necessary erosion and sediment control BMP’s to protect spillway during vegetation establishment period.

Slide 181

One thing we have learned over time is that veg spillways that stay wet or receive frequent discharges can cattail growth which, due to its thick stems and dense growth, has an extremely high retardance. This will reduce design discharge rates and can permanently raise the elevation of the restored wetland’s NWL.

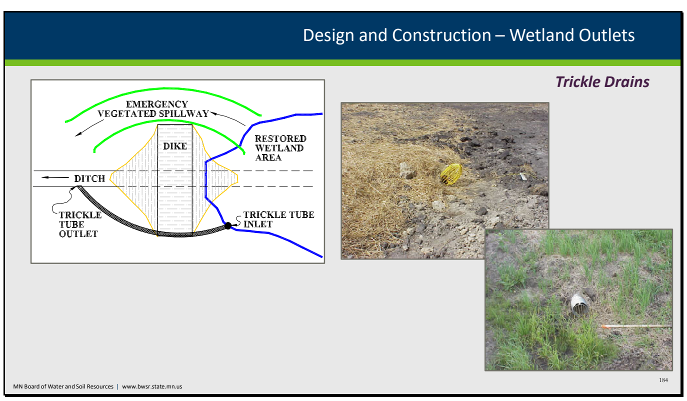
Slide 182



Slide 183

Can be either be a horizontal pipe (culvert) or a vertical drop inlet
Inlets and outlets should be durable (avoid exposed plastics) – protect them with end sections, sleeves, concrete, riprap, etc.

Slide 184



Or something in between.

This trickle drain layout has been around a long time and used successfully in situations where an open outlet on the DS side of a plug or embankment can be constructed.

By avoiding the constructed plug or embankment, single wall CPE can be used as the conduit material. This layout also increases the length of pipe used which helps to flatten its grade and, with appropriate backfill and compaction procedures, can help reduce the risk of piping along the outer face of the conduit.

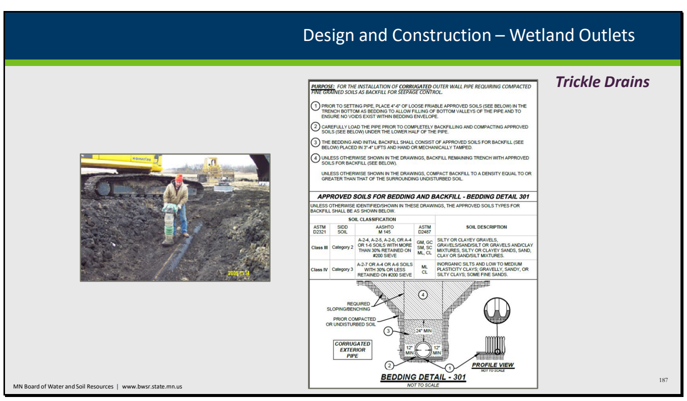
Slide 185

Ensure water-tight joints (sectional pipe)
Tie HDPE joints if thru embankments or other fills to ensure joint remains secure as embankment and its foundation settles

Slide 186

Trickle drains that function as culverts or drop inlets with free-flowing outlets should incorporate a filter diaphragm or ant-seep collar to help control external pipe seepage.

Slide 187



Must use appropriate pipe bedding, backfill and compaction procedures.

Slide 188

Use appropriate trash guards at pipe inlet to prevent plugging by trash or debris

Slide 189

Or other aquatic species – in this case bullheads (not part of a restored wetland but had to show this)

Slide 190

The main knock against any type of trickle drain or for that matter most inlet devices associated with wetland outlets is they are prone to plugging and require frequent maintenance to keep cleaned. This can lead to much frustration by project landowners and in some cases, neighboring landowners.

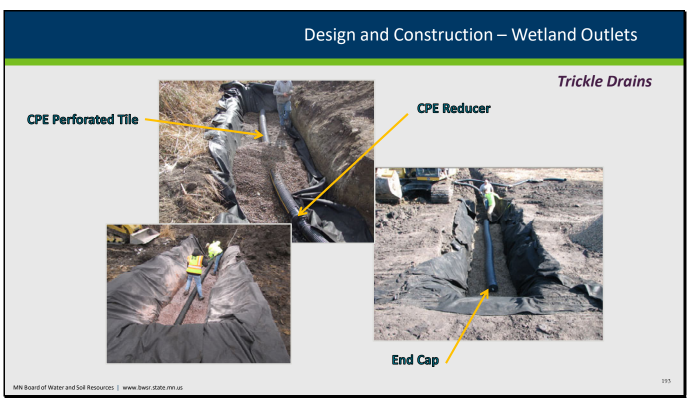
Slide 191

So what can be done about this?
These types of fence skimmers can work OK but need to installed correctly.

Slide 192

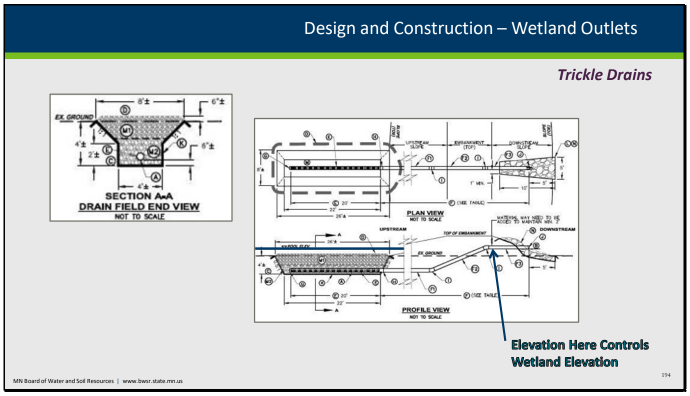
And maintained. They are not fool proof and over time have proven to be somewhat unreliable.
So what are our options?

Slide 193



An outlet device we have been experimenting with that had some success, in the right settings, is gravel inlet system that feeds a section of perforated tile. This set up has no open intake that can get plugged.

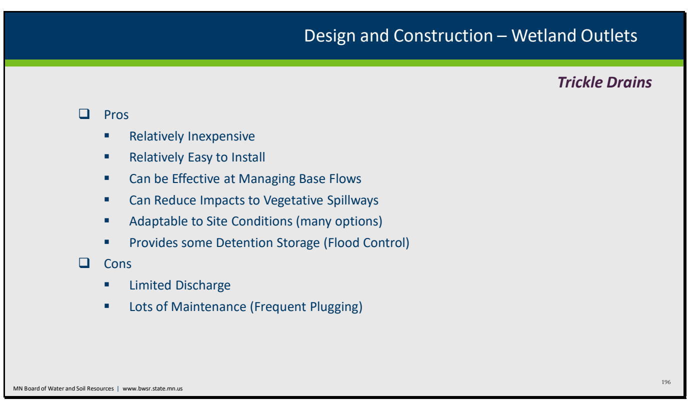
Slide 194



Here a schematic of one configuration for this. There are several options in how to do this.

Slide 195

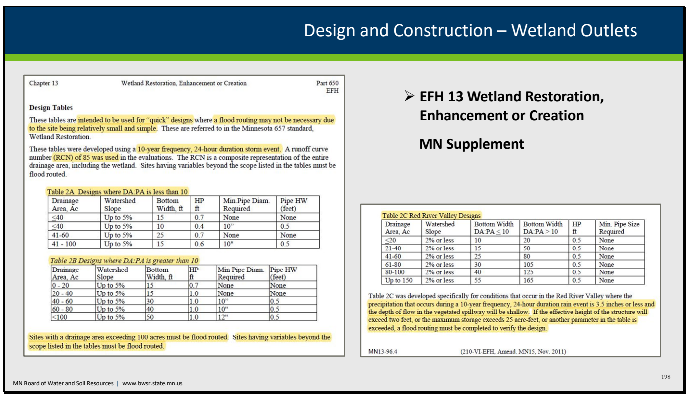
Slide 196



Slide 197

Unfortunately, there are many fairly large and complex projects for which the design and construction of outlets becomes rather important with increased design and construction complexity.

Slide 198



Chapter 13 Wetland Restoration, Enhancement or Creation Part 650 EFH

Design Tables

These tables are intended to be used for "quick" designs where a flood routing may not be necessary due to the site being relatively small and simple. These are referred to in the Minnesota 657 standard, Wetland Restoration.

These tables were developed using a 10-year frequency, 24-hour duration storm event. A runoff curve number (RCN) of 85 was used in the evaluations. The RCN is a composite representation of the entire drainage area, including the wetland. Sites having variables beyond the scope listed in the tables must be flood routed.

Table 2A Designs where DA:PA is less than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min.Pipe Diam. Required	Pipe HW (feet)
≤40	Up to 5%	15	0.7	None	None
≤40	Up to 5%	10	0.4	10"	0.5
41-60	Up to 5%	25	0.7	None	None
41 - 100	Up to 5%	15	0.6	10"	0.5

Table 2B Designs where DA:PA is greater than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min Pipe Diam. Required	Pipe HW (feet)
0 - 20	Up to 5%	15	0.7	None	None
20 - 40	Up to 5%	15	1.0	None	None
40 - 60	Up to 5%	30	1.0	10"	0.5
60 - 80	Up to 5%	40	1.0	10"	0.5
<100	Up to 5%	50	1.0	12"	0.5

Sites with a drainage area exceeding 100 acres must be flood routed. Sites having variables beyond the scope listed in the tables must be flood routed.

Table 2C Red River Valley Designs

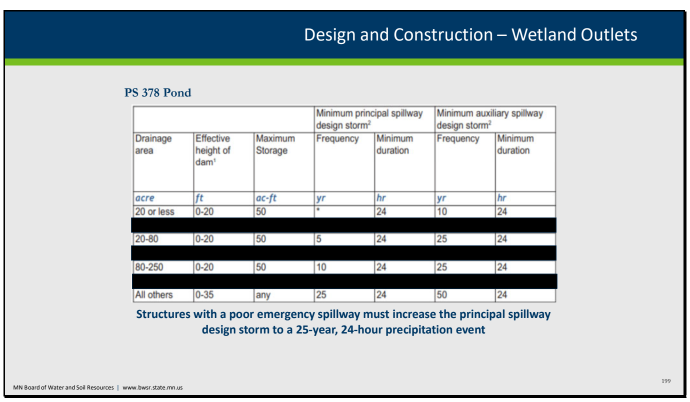
Drainage Area, Ac	Watershed Slope	Bottom Width DA:PA ≤ 10	Bottom Width DA:PA > 10	HP ft	Min. Pipe Size Required
≤20	2% or less	10	20	0.5	None
21-40	2% or less	15	50	0.5	None
41-60	2% or less	25	80	0.5	None
61-80	2% or less	30	105	0.5	None
80-100	2% or less	40	125	0.5	None
Up to 150	2% or less	55	165	0.5	None

Table 2C was developed specifically for conditions that occur in the Red River Valley where the precipitation that occurs during a 10-year frequency, 24-hour duration rain event is 3.5 inches or less and the depth of flow in the vegetated spillway will be shallow. If the effective height of the structure will exceed two feet, or the maximum storage exceeds 25 acre-feet, or another parameter in the table is exceeded, a flood routing must be completed to verify the design.

MN13-96.4 (210-VI-EFH, Amend. MN15, Nov. 2011)

So what happens if a site is not able to be designed using the EFH 13 design tables? Say the drainage area is too large or average watershed slopes are too steep.

Slide 199

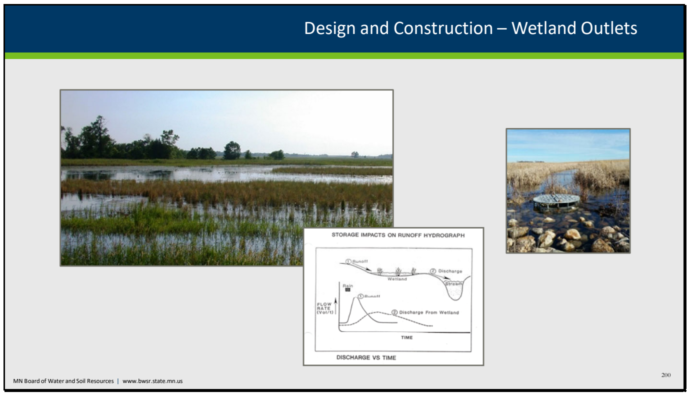


			Minimum principal spillway design storm[2]		Minimum auxiliary spillway design storm[2]	
Drainage area	Effective height of dam[1]	Maximum Storage	Frequency	Minimum duration	Frequency	Minimum duration
acre	*ft*	*ac-ft*	*yr*	*hr*	*yr*	*hr*
20 or less	0-20	50	*	24	10	24
[redacted]						
20-80	0-20	50	5	24	25	24
[redacted]						
80-250	0-20	50	10	24	25	24
[redacted]						
All others	0-35	any	25	24	50	24

Table 4 of the Pond Practice Standard provides some direction in terms of requirements for design analysis.

Is it really that straightforward though? Of course not.

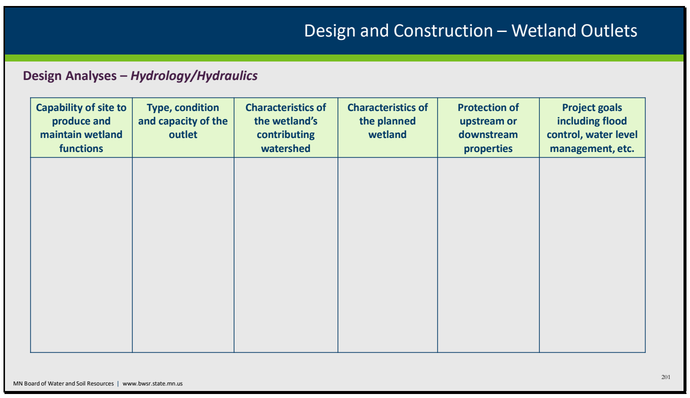
Slide 200



Aside from working in a wetland environment and dealing with associated maintenance issues as part of design, from an analysis perspective there are some advantages when designing a wetland restoration compared to most other conservation practices.

I say that simply because wetlands in general, provide opportunities for increased storage potential which helps with managing larger wetland inflows and volumes as compared to more limiting outlets with respect to capacity.

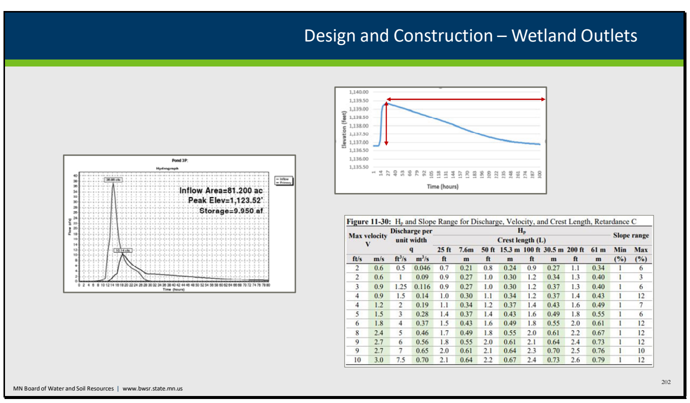
Slide 201



There are a number of items or questions that really should be addressed either before or as part of conducting any type of hydrologic design analyses.

Place a check or other mark in the one column that you think has the biggest impact on the hydrologic and hydraulic analysis.

Slide 202



There are numerous design methods, practice standards, manuals, guidance documents, tools, tables, and modeling programs that can be used to help with the hydrologic and hydraulic analysis. The method chosen will be a function of the site, questions to be answered, and preference of the designer.

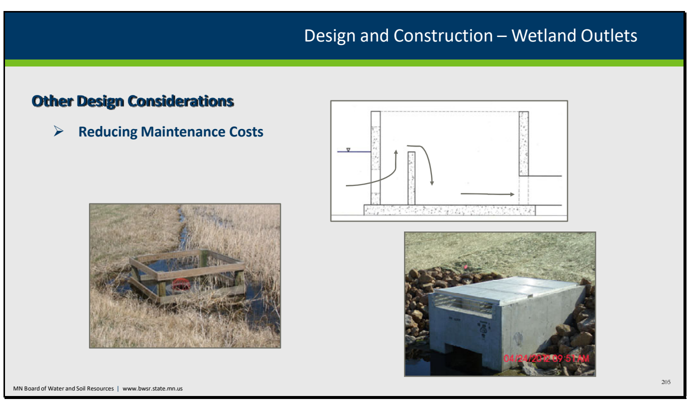
We will not be going into this any further as part of this training but it is important for anyone working with wetland restorations to have some understanding of the analysis requirements and methods used to achieve them.

Slide 203

Slide 204

Use of Various Types of Infiltration Systems as Inlets

Slide 205



Use of Skimmer Devices

Slide 206

Design and Construction – Wetland Outlets

Other Design Considerations

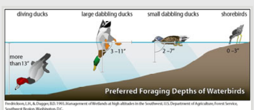
- Managing Wetland Water Levels
- Fish Passage/Barriers

Slide 207

Design and Construction – Wetland Outlets

Benefits of Wetland (Water Level) Management

- Promotes vegetative diversity
- Improves wildlife benefits
- Controls invasive species (rough fish)
- Seasonal flood control



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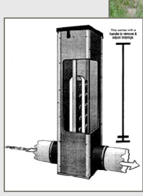
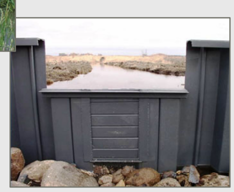
Design and Construction – Wetland Outlets





With draw down devices comes a higher cost to design and construct and maintenance requirements may increase significantly compared to other, simpler outlets.

Slide 209

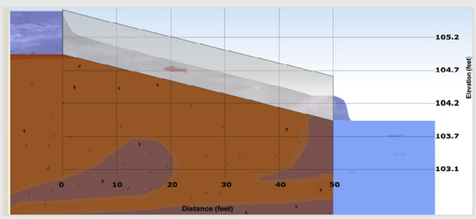
Design and Construction – Wetland Outlets

Benefits of Incorporating Physical Barriers as Part of Oultets

- Controls invasive species (rough fish)
- Promotes vegetative diversity
- Improves wildlife benefits

Slide 210

Design and Construction – Wetland Outlets



High Velocity Tubes

Specially designed sloping culverts that have high velocities and long pipe lengths

Slide 211

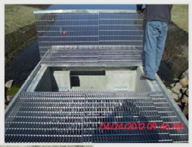
Design and Construction – Wetland Outlets

Fixed Grates
- Vertical
- Horizontal

Slide 212

Design and Construction – Wetland Outlets

Other Types of Grates



Slide 213

Design and Construction – Wetland Outlets

Description of Bid Item	Pay Unit	Estimated Quantity	Unit Price	Sub Total Cost
Excavation - Spillway for Wetland #1	Cubic Yards	25		
F&I Outlet Structure for Wetland #3 *(see bill of materials - sheet xx)*	Lump Sum	1		
F&I 12" 10.8 psi Bell and Spigot HDPE Dual Walled Pipe	Lineal Feet	480		
F&I Geotextile Fabric, MnDOT Type IV	Square Yards	20		
F&I Angular Rock Riprap, MnDOT Class III	Cubic Yards	52		

- ***Many possible configurations here, depending on the type of outlet***

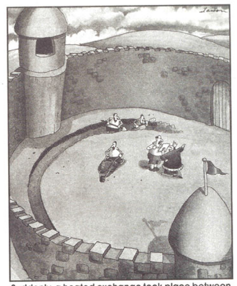
Slide 214

Design and Construction – Wetland Outlets

The joy of working in wetlands

Slide 215

Questions?



Suddenly, a heated exchange took place between the king and the moat contractor.