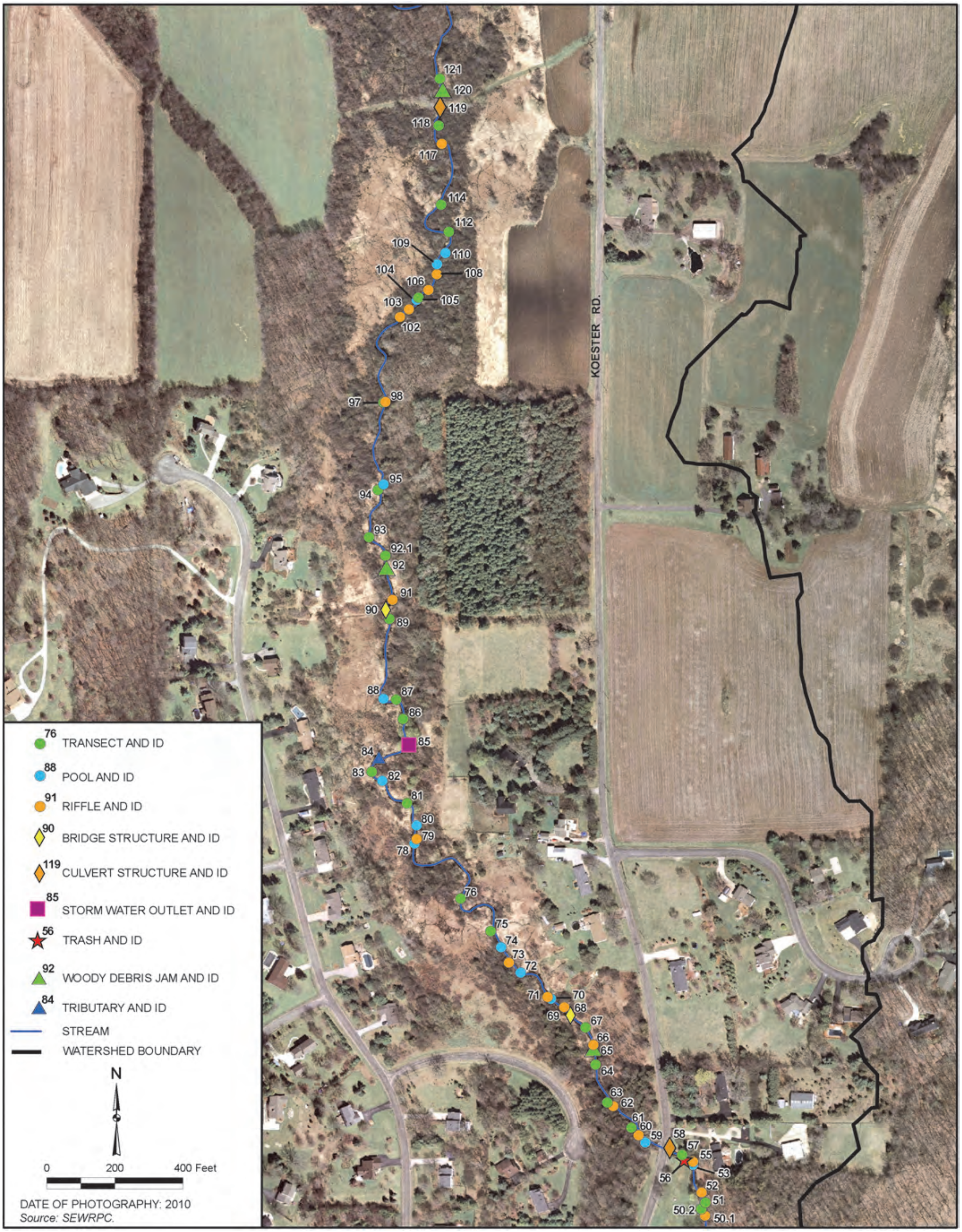
Map F-3

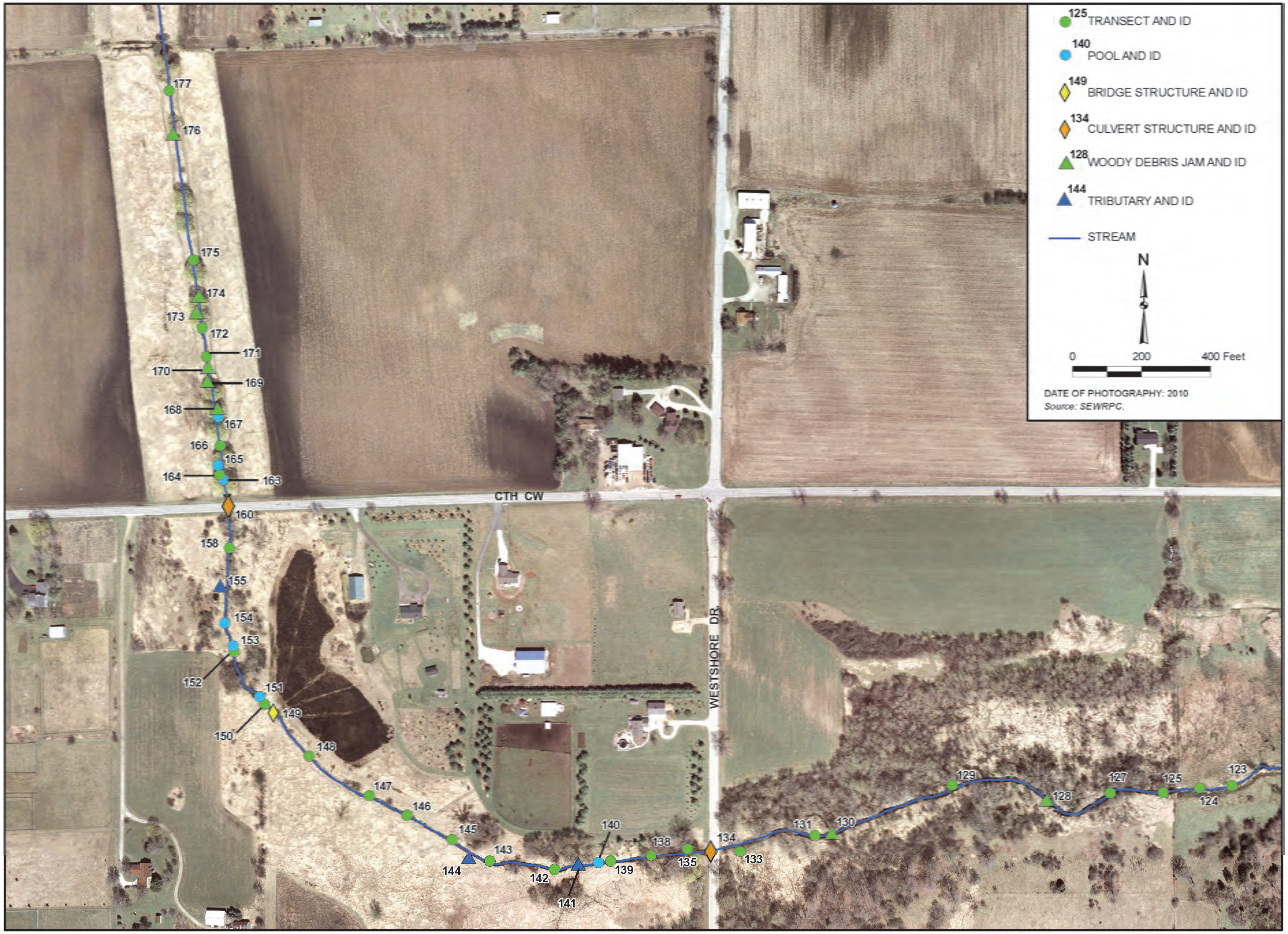
MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014



PRELIMINARY DRAFT

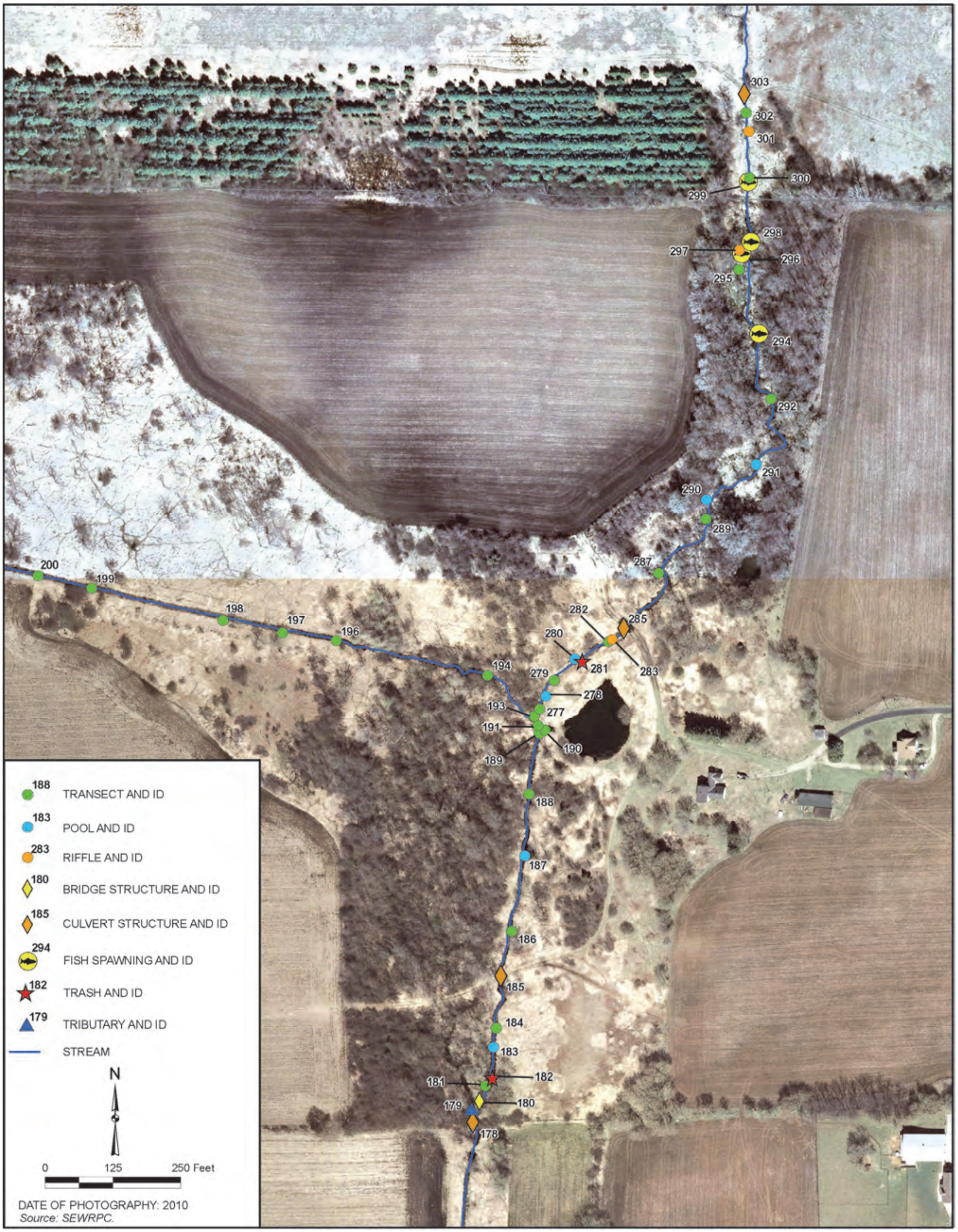
Map F-4

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014



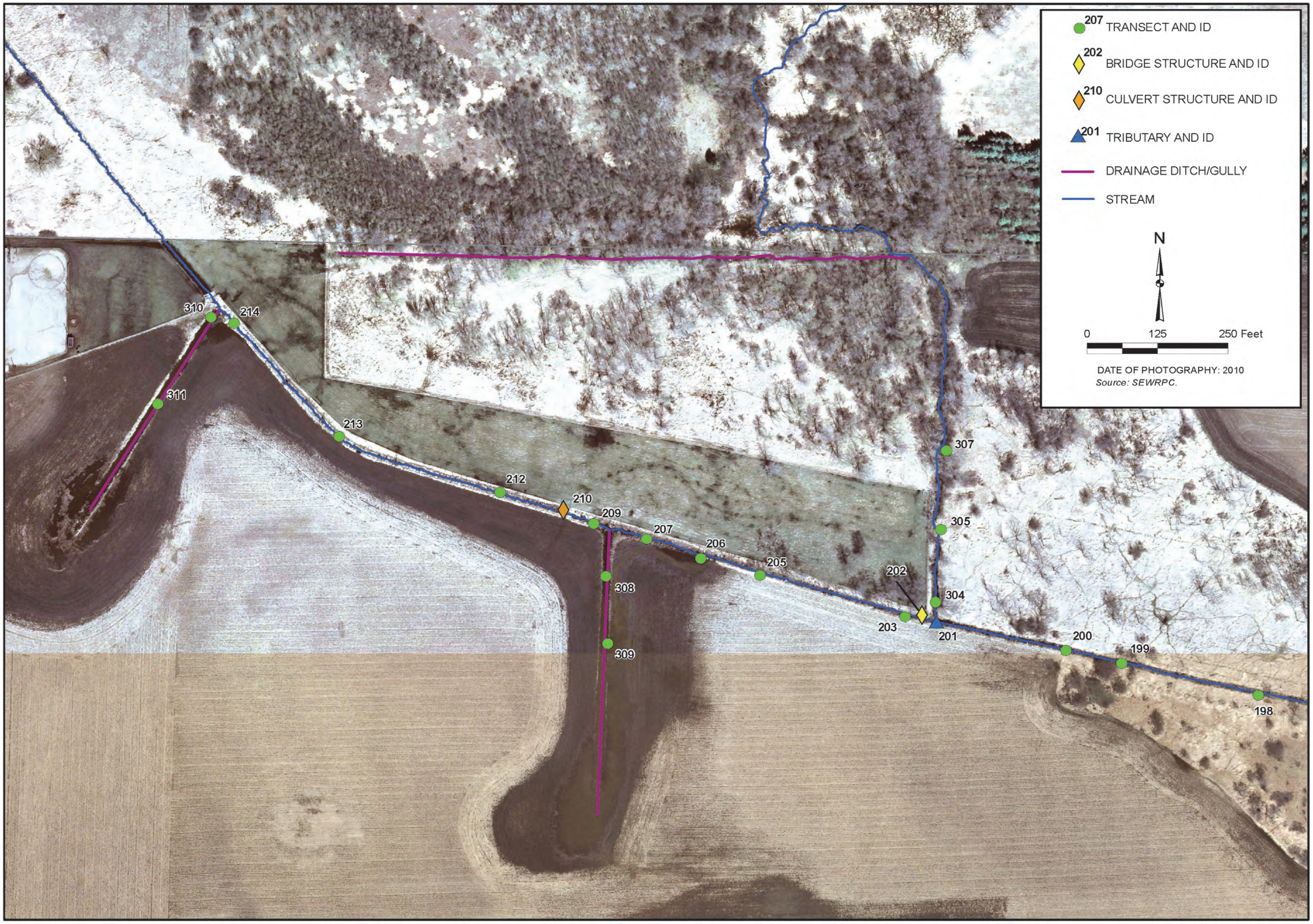
Map F-5

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014



Map F-6

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014



Map F-7

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014

Map F-8

MASON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2014

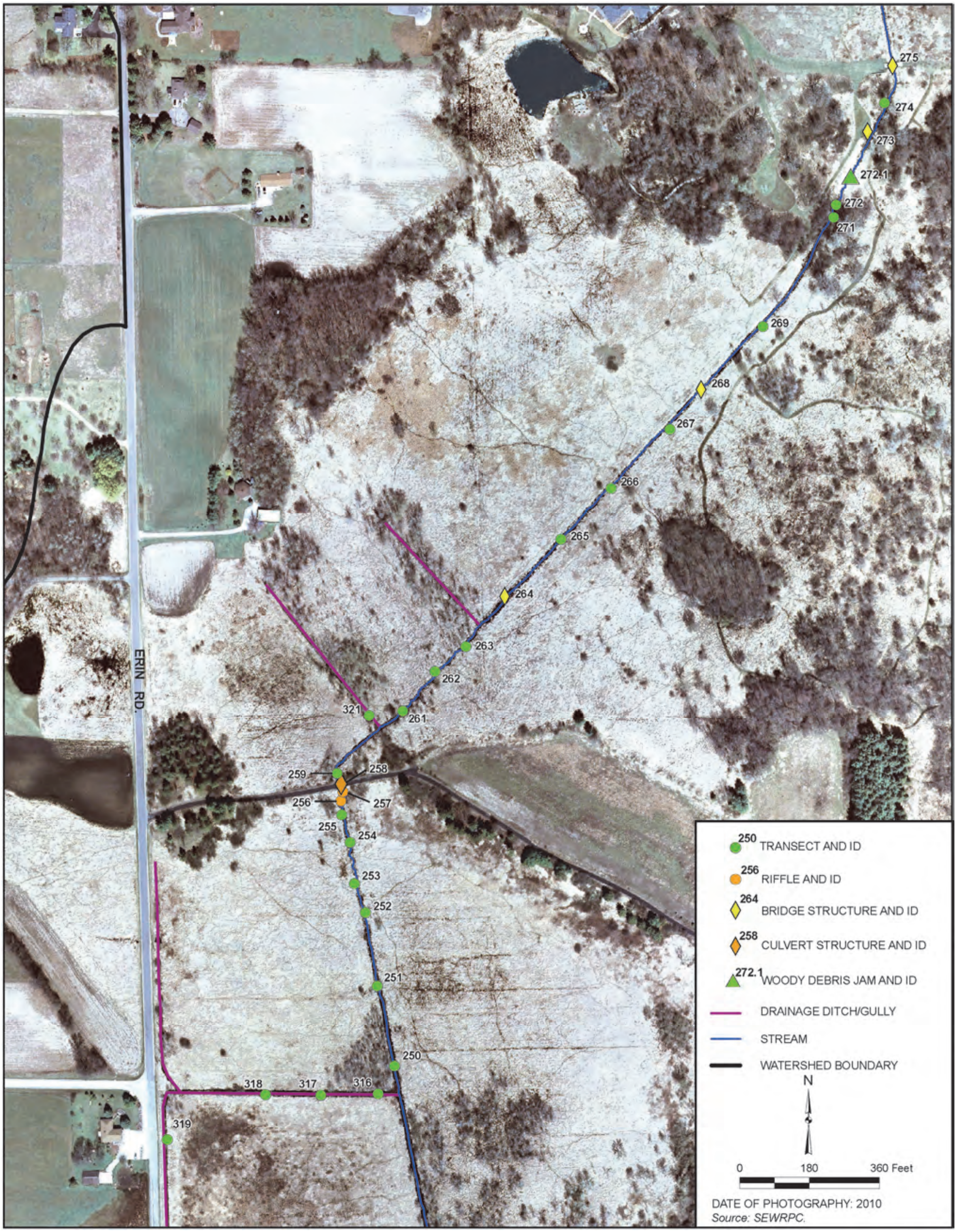


Table F-1

TRANSECT AND POINT FEATURE DATA DESCRIPTIONS COLLECTED AS PART OF THE MASON CREEK STREAM INVENTORY CONDUCTED BY SEWRPC STAFF: 2014 (SEE MAPS F1-F8)

Inventory Assortment	**Description**
Sequence	Each point surveyed, from upstream to downstream, was given a sequence ID number in the final Master Data Table. Sequence numbers are shown in the Appendix F Stream Inventory Maps F-2 through F-8.
Class	Each point surveyed was assorted into a *class*, such as Cross-Section, Drainage Ditch, Drain Tile, Erosion, Geomorphology, Infrastructure, Pond Outlet, Pool, Riffle, Spawning Site, Trash, Tributary, and Woody Debris Jam,
Class_Order	Each class listed above was grouped separately and each point within that specific group was given a Class_Order number.
Feature	Classes such as, geomorphology and infrastructure were associated with different *features* (e.g., "stream crossing" or "stormwater outlet" within the infrastructure class).
Feature2	The feature "stream crossing" was further categorized as either a "bridge" or "culvert."
GIS_ID	Each point surveyed was given a GIS_ID during the infield survey using a GPS device (e.g., "MST22" stands for: Mason Creek structure number 22).
Parameters	***<u>Transect/Cross-Section Features</u>***
WaterWidth	*Wetted (water) stream width* or low flow channel width at the time of the survey at stream cross-sections.
Incised_Ht	*Incised Height* ***was*** collected at stream cross-sections where the stream channel is substantially disconnected from its floodplain. This is a vertical measurement from middle of streambed to the height of the lowest bank.
Incised_Wt	*Incised Width* ***was*** collected at cross-sections where the stream is substantially disconnected from its floodplain. This is a horizontal measurement from top of lowest bank height to the opposite bank.
BF_Width	*Bankfull Width*. The measurement of the channel width that occurs when water just begins to leave the channel and spread onto the floodplain.
LB_Length	*Left Bank Length.* **Horizontal** measurement collected from top of bankfull (left bank) directly out to where it would meet the toe of bank. This was collected at each surveyed cross-section.
LB_Height	*Left Bank Height.* **Vertical** measurement from toe of bank directly straight up to top of bankfull. This was collected at each surveyed cross-section.
LB_SLOPE	*Left Bank Slope.* The left bank ratio of horizontal distance divided by the vertical height of the streambank. This measurement was taken at stream cross-sections.
RB_Length	*Right Bank Length*. **Horizontal** measurement collected from top of bankfull (left bank) directly out to where it would meet the toe of bank. This was collected at each surveyed cross-section.
RBfromBF	*Right Bank Length From Bankfull.* A calculation (bankfull width minus right bank length) that gives the right bank length for each surveyed cross-section.
RB_Height	*Right Bank Height.* Vertical measurement from toe of bank directly straight up to top of bankfull.
RB_SLOPE	*Right Bank Slope.* The right bank ratio of horizontal distance divided by the vertical height of the streambank. This measurement was taken at stream cross-sections.
BF_AVG	*Average Bankfull Depth (ft.).* The average depth measured at the bankfull discharge, or where water would flow out from the banks. Bankfull depths were measured at three to five points evenly spaced across a surveyed cross-section.
BF_MAX	*Maximum Bankfull Depth (ft.).* The maximum depth measured at the bankfull discharge, or where water would flow out from the banks. Bankfull depths were measured at three to five points evenly spaced across a surveyed cross-section.
BF_AREA	*Bankfull Area.* A calculation (bankfull width multiplied by average bankfull depth) that measures the amount of space, or area, that water would have to take up in order to spill out into the floodplain, at each surveyed cross-section.
Water_1	*Water Depth (ft.)* The **first** water depth measured at a stream cross-section. Each cross-section measured three to five water depths that were evenly spaced across the stream (e.g., Water_1, Water_2, Water_3, Water_4, and Water_5).
Water_AVG	*Average Water Depth (ft.).* The average water depth across the stream channel measured at each stream cross-section. Water depths were measured at three to five points evenly spaced across a surveyed cross-section.

Water_MAX	*Maximum Water Depth (ft.).* The maximum water depth across the stream channel measured at stream cross-section. Water depths were measured at three to five points evenly spaced across a surveyed cross-section
Water_AREA	*Water Area.* A calculation (water width multiplied by average water depth) that measures the amount of space, or area, water takes up at each surveyed cross-section.
W_D_ratio	*Water to Depth Ratio.* A calculation of bankfull width divided by average water depth to give the average water to depth ratio.
Sed_Water_1	*Sediment plus Water Depth (ft.)* Sediment depth plus the water depth measured at stream cross-sections. Sediment and water depths were measured at three to five points evenly spaced across a surveyed cross-section
Sed_1	*Sediment Depth (ft.)* The **first** sediment depth measured at a stream cross-section. Each cross-section contained three to five sediment depth measurements evenly spaced across that particular cross-section (e.g., Sed_1, Sed_2, Sed_3, Sed_4, and Sed_5).
Avg_Sed	*Average Sediment Depth (ft.)* The average depth of sediment measured across the stream at surveyed cross-sections.
Max_sed	*Maximum Sediment Depth (ft.)* The maximum depth of sediment measured across the stream at surveyed cross-sections.
LB_Under_Max	*Maximum Left Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measures the deepest undercut point on the left bank of a surveyed cross section.
LB_Under_Avg	*Average Left Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measurement is the average depth of the undercutting on the left bank.
RB_Under_Max	*Maximum Right Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measures the deepest undercut point on the right bank of a surveyed cross section.
RB_Undcer_Avg	*Average Right Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measurement is the average depth of the undercutting on the right bank.
Silt_ct	*Percent Silt.* The percentage of streambed substrates at a surveyed cross-section that are made up of silt.
Sand_ct	*Percent Sand.* The percentage of streambed substrates at a surveyed cross-section that are made up of sand.
Gravel_ct	*Percent Gravel.* The percentage of streambed substrates at a surveyed cross-section that are made up of gravel.
Cobble_ct	*Percent Cobble.* The percentage of streambed substrates at a surveyed cross-section that are made up of cobbles.
Boulder_ct	*Percent Boulder.* The percentage of streambed substrates at a surveyed cross-section that are made up of boulders.
Bedrock_ct	*Percent Bedrock.* The percentage of streambed substrates at a surveyed cross-section that are made up of bedrock.
Clay_ct	*Percent Clay.* The percentage of streambed substrates at a surveyed cross-section that are made up of clay.
Detritus_ct	*Percent Detritus.* The percentage of streambed substrates at a surveyed cross-section that are made up of organic matter, such as leaf-litter.
HABITAT	Type of stream habitat at surveyed stream cross-sections (pool, riffle, or run).
VELOCITY	An observation taken at stream cross-sections of how fast (slow, moderate, fast) the water is flowing in the stream.
SHADING	Portion of the stream at a surveyed stream cross-section that is shaded by overhanging trees, shrubs, or grasses. **0-** unshaded; **1-** partially shaded; **2-** halfway shaded; **3-** mostly shaded.
COVER	*Amount of instream fish cover.* The percent of stream containing some form of fish cover at a surveyed cross-section. **0** indicating none or 0 percent instream cover; **1-** less than 25 percent instream cover; **2-** 25 to 75 percent instream cover; **3-** greater than 75 percent instream cover.
WOOD_DEB	*Woody Debris.* The percent of stream that contains woody debris at a surveyed cross-section. **0** indicating none or 0 percent of stream containing woody debris; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of woody debris.
AQ_PLANTS	*Aquatic Plants.* The percent stream that contains aquatic plants at a surveyed cross-section. . **0** indicating none or 0 percent of aquatic vegetation; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of aquatic plants.

ALGAE	Percent of stream that contains algae at a surveyed stream cross-section. **0** indicating none or 0 percent of stream contains algae; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of algae.
OH_VEG	*Vegetative Cover.* Indicates that overhanging vegetation fish cover was present at the surveyed cross-section.
MACRO	*Aquatic Plant Cover.* Indicates that aquatic plant fish cover was present at the surveyed cross-section.
ALGAE1	*Algae Cover.* Indicates that algae fish cover was present at the surveyed cross-section.
LOGS_WOODY_DEB	*Woody Debris Cover.* Indicates that woody debris fish cover was present at the surveyed cross-section.
ROOTS	*Root Cover.* Indicates that root cover was present at the surveyed cross-section.
BOULD_COBB	*Boulder/Cobble Cover.* Indicates that boulder and/or cobble cover was present at the surveyed cross-section.
WILDLIFE	*Wildlife.* Observed wildlife was noted at each cross-section.
BANK	*Right Bank Angle of Less than 90 Degrees.* Indicates that the right bank was less than 90 degrees at the surveyed cross-section.
BANK_1	*Right Bank Angle of 90 Degrees.* Indicates that the right bank was 90 degrees at the surveyed cross-section.
UNDERCUT	*Undercut Right Bank.* Average measurement of the cut bank depth at which the bank is overhanging the stream.
BANK1	*Left Bank Angle of Less than 90 Degrees.*
BANK1_1	*Left Bank Angle of 90 Degrees.*
UNDERCUT1	*Undercut Left Bank.* Average measurement of the cut bank depth at which the bank is overhanging the stream.
Point Features	
Stream Crossing	*A structure*, either a bridge or culvert crossing, identified along with its measurements during the instream field survey.
Drain Tile	A drain tile identified within the stream system. Measurements taken include diameter and material of drain tile (metal or plastic), left or right bank and whether or not it was actively draining.
Pool	A *substantial pool* or deep point within the water column identified. Water depth and width are measured.
Riffle	Portions of the water column where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep. Measurements include riffle width, depth and length.
Stormwater Outlet	Stormwater drainage systems identified. Includes stormwater pond outlets or drainage ditch culverts. Culvert diameter, location, and culvert material are noted.
Trash	Any tire(s), large pieces of metal, or plastic material identified within the streambed that would need to be removed. Description and location of the trash is noted during the field survey.
Woody Debris Jam	Large pieces or aggregations of smaller pieces of wood (e.g., logs, large tree branches, root tangles) located in, or in contact with, the water surface often resulting in water backup or interfering with stream flow. General description of the woody debris jam is noted, such as size, impoundment of water and any impacts it is creating within the stream system.

Source: SEWRPC.

Appendix G

DITCH CHECK/CHECK DAM AND DITCH TURNOUT MANAGEMENT PRACTICES FOR SOIL STABILIZATION AND SEDIMENT CONTROL IN DRAINAGE DITCHES:

- **DESCRIPTION,**
- **APPLICATION,**
- **CONSTRUCTION REQUIREMENTS,**
- **DESIGN CONSIDERATIONS, AND**
- **MAINTENANCE**

Source: State of California, Department of Transportation, Check Dams, Section 4, Storm Water Quality Handbooks, Project Planning and Design Guide, Construction Site Best Management Practices (BMPs) Manual, Storm Water Pollution Prevention Plan (SWPPP) and Water Pollution Control Program (WPCP) Preparation Manual, March 2003, http://www.dot.ca.gov/hq/construc/stormwater/SC-04.pdf

Part of the Conservation Practices for Homeowners Factsheet Series, available at: Maine DEP (800.452.1942); http://www.maine.gov/dep/blwq/docwatershed/materials.htm, Portland Water District (207.774.5961); http://www.pwd.org/news/publications.php, https://www.pwd.org/sites/default/files/turnouts.pdf

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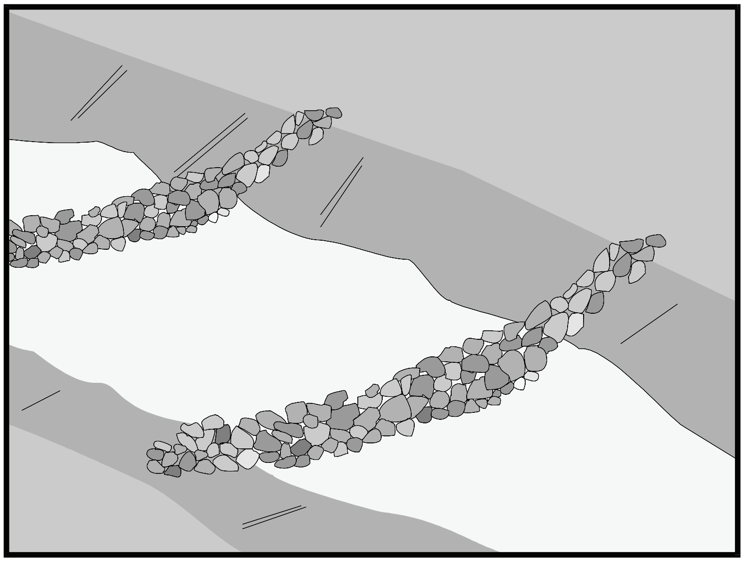
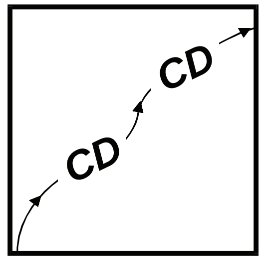
Check Dams

SC-4





Standard Symbol

BMP Objectives

- ● Soil Stabilization
- ● Sediment Control
- ○ Tracking Control
- ○ Wind Erosion Control
- ○ Non-Storm Water Management
- ○ Materials and Waste Management

Definition and Purpose

Check dams reduce scour and channel erosion by reducing flow velocity and encouraging sediment settlement. A check dam is a small device constructed of rock, gravel bags, sandbags, fiber rolls, or other proprietary product placed across a natural or man-made channel or drainage ditch.

Appropriate Applications

- Check dams may be installed:
  - In small open channels that drain 4 ha (10 ac) or less.
  - In steep channels where storm water runoff velocities exceed 1.5 m/s (4.9 ft/sec).
  - During the establishment of grass linings in drainage ditches or channels.
  - In temporary ditches where the short length of service does not warrant establishment of erosion-resistant linings.
- This BMP may be implemented on a project-by-project basis with other BMPs when determined necessary and feasible by the Resident Engineer (RE).

Limitations

- Not to be used in live streams.
- Not appropriate in channels that drain areas greater than 4 ha (10 ac).
- Not to be placed in channels that are already grass lined unless erosion is expected, as installation may damage vegetation.
- Require extensive maintenance following high velocity flows.
- Promotes sediment trapping, which can be re-suspended during subsequent storms or removal of the check dam.

- Not to be constructed from straw bales or silt fence.

Standards and Specifications

- Check dams shall be placed at a distance and height to allow small pools to form behind them. Install the first check dam approximately 5 meters (16 ft) from the outfall device and at regular intervals based on slope gradient and soil type.
- For multiple check dam installation, backwater from downstream check dam shall reach the toe of the upstream dam.
- High flows (typically a 2-year storm or larger) shall safely flow over the check dam without an increase in upstream flooding or damage to the check dam.
- Where grass is used to line ditches, check dams shall be removed when grass has matured sufficiently to protect the ditch or swale.
- Rock shall be placed individually by hand or by mechanical methods (no dumping of rock) to achieve complete ditch or swale coverage.
- Fiber rolls may be used as check dams if approved by the RE or the Construction NPDES Coordinator. Refer to SC-5 "Fiber Rolls."
- Gravel bags may be used as check dams with the following specifications:

Materials

– ***Bag Material:*** Bags shall be either polypropylene, polyethylene or polyamide woven fabric, minimum unit weight 135 g/m2 (four ounces per square yard), mullen burst strength exceeding 2,070 kPa (300 psi) in conformance with the requirements in ASTM designation D3786, and ultraviolet stability exceeding 70% in conformance with the requirements in ASTM designation D4355.

– ***Bag Size:*** Each gravel-filled bag shall have a length of 450 mm (18 in), width of 300 mm (12 in), thickness of 75 mm (3 in), and mass of approximately 15 kg (33 lb). Bag dimensions are nominal, and may vary based on locally available materials. Alternative bag sizes shall be submitted to the RE for approval prior to deployment.

– ***Fill Material:*** Fill material shall be between 10 mm and 20 mm (0.4 and 0.8 inch) in diameter, and shall be clean and free from clay balls, organic matter, and other deleterious materials. The opening of gravel-filled bags shall be secured such that gravel does not escape. Gravel-filled bags shall be between 13 kg and 22 kg (28 and 48 lb) in mass. Fill material is subject to approval by the RE.

Installation

– Install along a level contour.

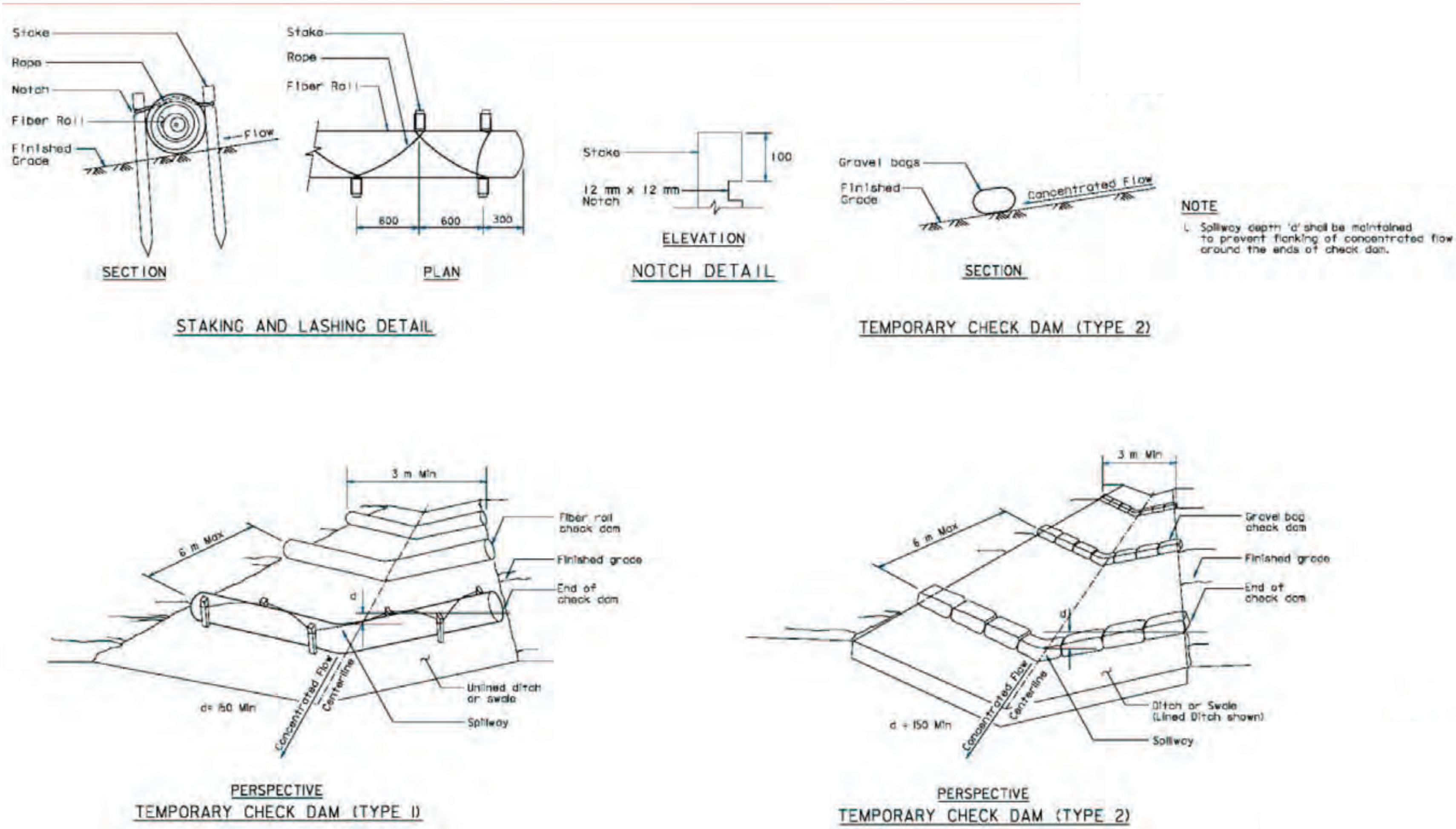
– Tightly abut bags and stack gravel bags using a pyramid approach.

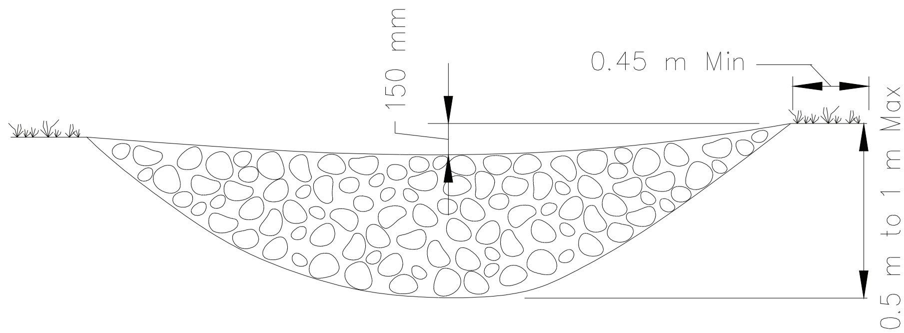
Gravel bags shall not be stacked any higher than 1 meter (3.2 ft).

– Upper rows of gravel bags shall overlap joints in lower rows.

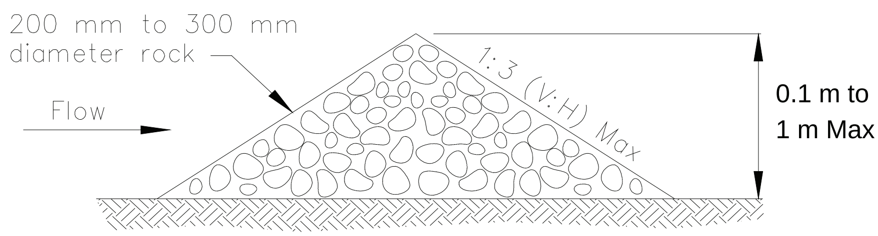
Maintenance and Inspection

- Inspect check dams after each significant rainfall event. Repair damage as needed or as required by the RE.
- Remove sediment when depth reaches one-third of the check dam height.
- Remove accumulated sediment prior to permanent seeding or soil stabilization.
- Remove check dam and accumulated sediment when check dams are no longer needed or when required by the RE.
- Removed sediment shall be incorporated in the project at locations designated by the RE or disposed of outside the highway right-of-way in conformance with the Standard Specifications.


Stake
Rope
Notch
Fiber Roll
Finished Grade
Flow
SECTION
Stake
Rope
Fiber Roll
600
600
300
PLAN
STAKING AND LASHING DETAIL
Stake
12 mm x 12 mm Notch
100
ELEVATION
NOTCH DETAIL
Gravel bags
Finished Grade
Concentrated Flow
SECTION
TEMPORARY CHECK DAM (TYPE 2)
NOTE
1. Spillway depth 'd' shall be maintained to prevent flanking of concentrated flow around the ends of check dam.
3 m Min
6 m Max
Fiber roll check dam
Finished grade
End of check dam
d
Unlined ditch or swale
Spillway
d= 150 Min
Concentrated Flow
Centerline
PERSPECTIVE
TEMPORARY CHECK DAM (TYPE 1)
3 m Min
6 m Max
Gravel bag check dam
Finished grade
End of check dam
d
Ditch or Swale (Lined Ditch shown)
Spillway
d + 150 Min
Concentrated Flow
Centerline
PERSPECTIVE
TEMPORARY CHECK DAM (TYPE 2)



ELEVATION



TYPICAL ROCK CHECK DAM SECTION

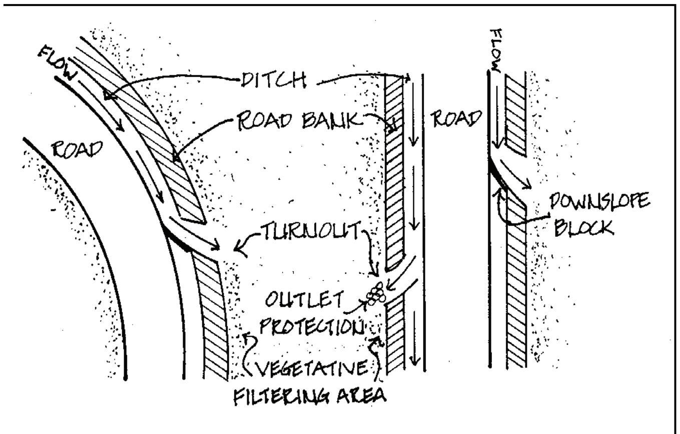
ROCK CHECK DAM
NOT TO SCALE

Purpose: Any camp road, even properly constructed ones, alter natural drainage patterns. On camp roads, the biggest concern is to get water off the road surface as quickly as possible. When surface water is not drained off the road, it can lead to washouts, muddy conditions, and potholes.

Turnouts return stormwater runoff as sheet flow to natural drainage areas. Often turnouts are simply extensions of ditches that redirect water into the woods and disperse runoff before it can cause erosion. Turnouts reduce the speed of runoff, allowing soil particles to settle out instead of being transported to a stream, river, or lake. Water and nutrients can then be filtered and absorbed by the surrounding vegetation.

Installation: Turnouts are used to direct water away from the road into a vegetated buffer area, and can be constructed on paved or gravel roads with or without ditches. Turnouts can be the width of a backhoe bucket, a bulldozer blade, or a handheld shovel. Turnouts should intersect the ditch at the same depth, and gently slope down and away from the road.

As it is easier to disperse smaller volumes of water at a time, turnouts should be constructed as often as possible. Ideally, turnouts should be placed every 50 feet. Utilize the natural contours of the land and install turnouts frequently enough to prevent large volumes of runoff from accumulating along the side of the road. Turnouts should be placed closer on steeper slopes. However, check with abutting property owners to ensure this water will not adversely impact their property.



DETAIL - TURNOUTS

Turnouts should be stabilized so as not to create additional soil erosion. The turnout can be seeded and stabilized with hay mulch or erosion control blankets. Alternately, on steeper slopes or areas receiving greater flow, 3”-6” angular stone rip-rap placed over non-woven getotextile fabric can be used to line the structure.

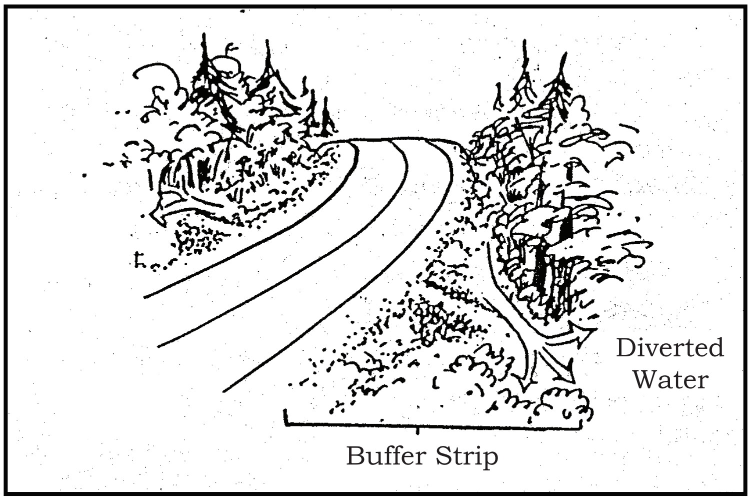
The turnout should have a flared end section that is level and lined with rock to spread out the flow. This level-lip spreader or rock dam converts the concentrated, channeled flow into slower, sheet flow just before it discharges into the vegetated area.

Most importantly, do NOT outlet turnouts into existing stream channels or drainage ways!

Materials: No special tools or equipment are required to construct turnouts. A backhoe, FrontRunner, or even a shovel can be used to build a turnout.

As with ditches, turnouts must be stabilized to keep from causing further erosion problems as they discharge stormwater away from the road. Turnouts with less than a 5% slope can be seeded with a conservation mix and mulched with hay or an erosion control blanket until the seed germinates. On steeper slopes, secure non-woven geotextile fabric on the soil and cover with 3”-6” stone rip-rap.

Care needs to be taken on the outlet of the structure. It is vital that the channeled water be spread out and slowed so it does not erode the neighboring land. Turnouts should have a flared end section that is level and lined with rock to spread out the flow. Use 4”-6” crushed, angular stone for the outlet.



Maintenance: Because the turnout may have a secondary function as a small sediment trap, maintenance is critical to ensure excessive sedimentation from storm events does not fill the structure and render it nonfunctional.

Check turnouts during and after large storm events for erosion or accumulation of debris. Any turnout will fill with sediment over time, and it is critical to remove this material for the structure to function properly. Confirm that water flows evenly into the vegetation, and does not form an erosive channel. Shift stone, as needed, to stop any channelized flow.

Have a post-storm plan in place for checking for damage and determining maintenance needs.

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Appendix H

DITCH PLUG MANAGEMENT PRACTICE FOR BLOCKING AND FILLING SURFACE DRAINAGE DITCHES:

- **DESCRIPTION,**
- **APPLICATION,**
- **CONSTRUCTION REQUIREMENTS,**
- **DESIGN CONSIDERATIONS, AND**
- **MAINTENANCE**

Source: Minnesota Wetland Restoration Guide, Blocking and Filling Surface Drainage Ditches, Technical Guidance Document WRG 4A-1, October 2015, http://bwsr.state.mn.us/restoration/resources/documents/appendix-4a-1.pdf

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BLOCKING AND FILLING SURFACE DRAINAGE DITCHES

TECHNICAL GUIDANCE DOCUMENT

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

Table of Contents

INTRODUCTION

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

Figure 1. Construction of an Earthen Plug Across Drainage Ditch

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

APPLICATION

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

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

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

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

Figure 2. Shallow Ditch Being Filled

DESIGN CONSIDERATIONS

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

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

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

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

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

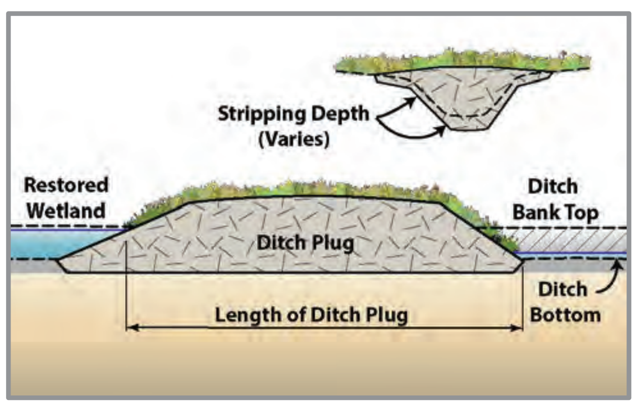

Figure 3. Ditch Plug Design Details

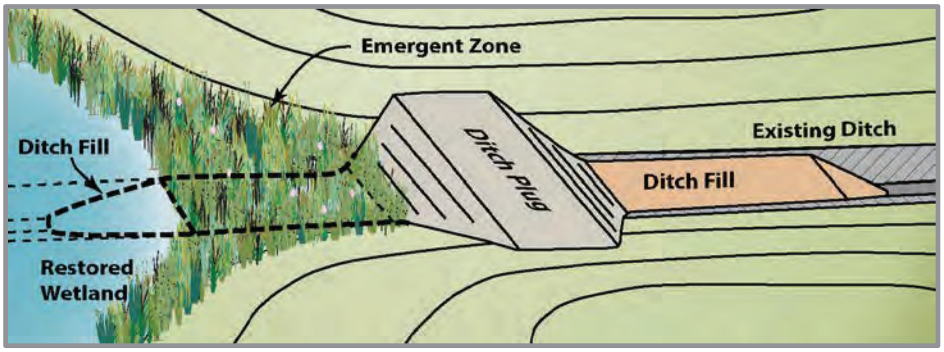

Figure 4. Ditch Plug Complimented with Adjacent Ditch Fills

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

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

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

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

Depressional Wetlands

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

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

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

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

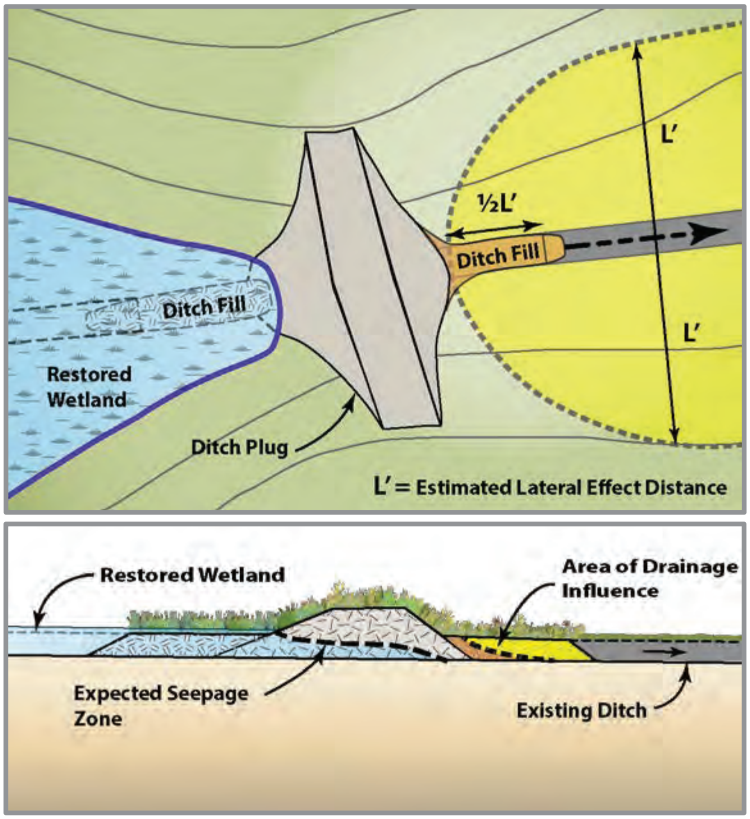

Figure 5. Ideal Location and Design Layout for a Ditch Plug in a Depressional Wetland Settings

Sloped Wetlands

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

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

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

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

Non-Depressional Wetland Flats

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

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

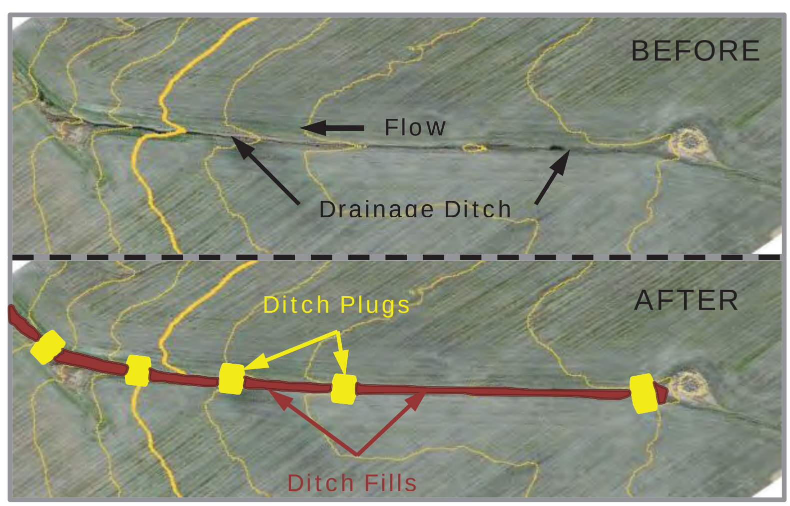

Figure 6. Ditch Plug/Fill Design for Sloped Wetland Setting – 2 Foot Contours

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

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

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

PROJECT BOUNDARIES/PROPERTY LINES

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

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

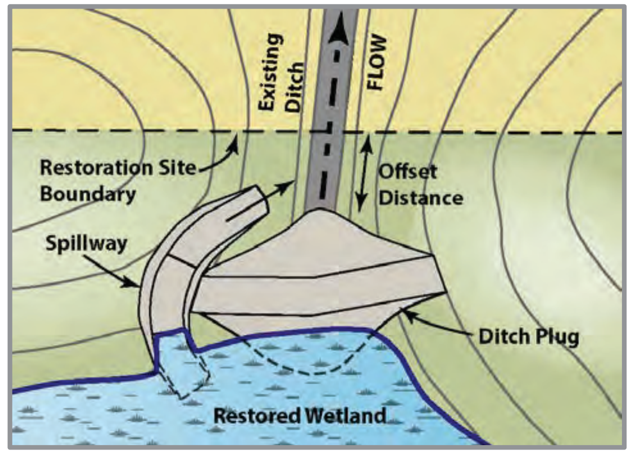

Figure 8. Ditch Plug Offset from Property Line

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

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

CONSTRUCTION REQUIREMENTS

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

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

DITCH PLUGS

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

Figure 9. Ditch Area being Stripped Prior to Plug Construction

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

Figure 11. Compaction of Constructed Ditch Plug

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

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

Figure 10. Ditch Plug under Construction

Figure 12. Finished Ditch Plug with Crown in Middle

DITCH FILLING AND RECONTOURING

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

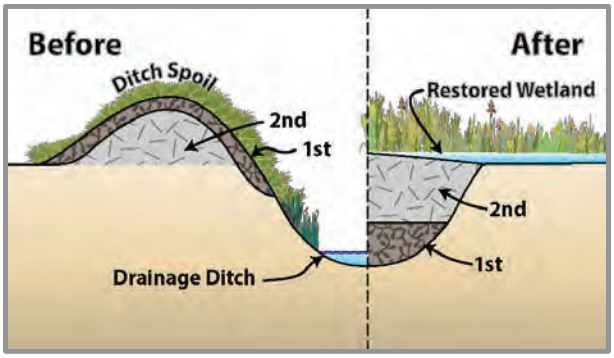

Figure 13. Construction Sequence to Address Invasive or Undesired Vegetation on Ditch Bank

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

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

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

OTHER CONSIDERATIONS

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

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

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

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

- Consideration is needed to address stabilizing areas of the restoration site that are disturbed during construction. All disturbed areas should be seeded with consideration for additional stabilization on slopes and in other areas where concentrated flow may occur. This can include the use of straw mulch, erosion control blankets, hydro mulching, etc.

COST

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

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

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

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

MAINTENANCE

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

ADDITIONAL REFERENCES

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

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

Appendix I

CHANNEL FORMING DISCHARGES:

- **DESCRIPTION**
- **KEY FEATURES AFFECTING CHANNEL SHAPE,**
- **HOW TO DETERMINE BANKFULL DISHCHARGE,**
- **DATA NEEDS, AND**
- **HOW TO MEASURE**

Source: Andy Ward, Jessica L. D'Ambrosio, and Jonathan Witter, "Channel-Forming Discharges", The Ohio State University Department of Food, Agricultural, and Biological Engineering and the Ohio NEMO Program, The Ohio State University-Extension, Fact Sheet Agriculture and Natural Resources, Report No. AEX-445-03, 2008.

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THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

AEX-445-03

Channel-Forming Discharges

Andy Ward, Jessica L. D'Ambrosio, and Jonathan Witter
The Ohio State University Department of Food, Agricultural, and Biological Engineering
and the Ohio NEMO Program

What Is Channel-Forming Discharge?

Have you ever wondered why a stream is located where it is, is bigger or smaller than another stream, why it is crooked, or why some streams are wide and shallow while others are narrow and deep? The answers to these questions enable us to understand the origin and evolution of a stream system, which will help us to develop ways to protect, enhance, or sustain these complex and fragile ecosystems. Streams are constantly changing and, like any physical system, trying to create balance between all of the factors acting on them. The balance of constantly changing factors is called *dynamic equilibrium*. Two primary influences on the equilibrium of a stream system are the quantity and movement of both water and sediment. We call the movement of water or sediment *discharge*. The quantity and movement of both water and sediment tend to balance each other within the confines of the stream channel and this is what, ultimately, gives the stream bed and banks their shape or form. We also can call this movement *channel-forming discharge*. The purpose of this fact sheet is to provide an explanation of channel-forming discharges, their importance to stream systems, and how they can be determined.

Factors That Give Stream Channels Shape

A natural stream running through the middle of a valley will have a main channel and a connected *active floodplain*—land closest to the channel that is flooded often (Figure 1). The channel carries water and sediment discharges through the system that is related to a specific, predictable amount of flow called the *bankfull discharge* or *effective discharge.* When the discharge is higher than the channel can hold within its banks, the extra water and sediment spills out over the banks and onto the floodplain. The active floodplain, if connected to the channel, helps to decrease the speed at which water is flowing and helps to maintain dynamic equilibrium so that the bed and banks are not washed away during a big storm event.

Figure 1. A small urban stream with a connected active floodplain containing less than the bankfull discharge; note the distinct shape and size of both stream banks. B: The same stream with a bankfull, or channel-forming discharge, after a rainstorm.

If we understand the balance between water and sediment discharges—or *fluvial processes*—we can begin to predict what happens to the stream when these factors are out of balance (Figure 2). For example, if higher water flow is not able to spill out onto the floodplain, it may be picking up sediment from the bed and banks. This is called *degradation* and can cause erosion and *scour* (Figure 2A, C). On the other hand, if water containing a lot of sediment is flowing very slowly because of a dam installed downstream, the heavier sediment particles will drop out of the water flow and deposit on the bed and banks. This is called *aggradation,* which is a build up of material (Figure 2B, D).

The *bankfull discharge* is often related to the amount of water flowing in a stream that fills the main channel and begins to spill onto the active floodplain[1, 2]. Bankfull discharge is a range of flows (volume per unit time) that is most important in forming a channel, floodplains (benches), and banks. When we talk about *bankfull discharge,* we also talk about the collection and/or analysis of data relating to the channel shape and size, or *dimension*[3, 4].

The term *effective discharge* is the amount of water (again, volume per unit time) that transports the most sediment over the long term[2]. When we talk about effective discharge we also talk about the collection and/or analysis of data related to the type and amount of sediment in that flow of water. This moving sediment is called the *suspended* and/or *bedload sediment*[5]. Often, the terms *bankfull* and *effective discharge* are considered to be synonymous. For example, Leopold[6] stated that bankfull discharge is "considered to be the channel-forming or effective discharge". Powell and others[7] found that, for large rivers in Ohio, the bankfull and effective discharge were often similar.

The term *bankfull* causes some confusion in some artificial, or constructed, channels such as agricultural ditches because the size of the ditch is unrelated to *fluvial processes*, or the size that nature would form naturally. In streams that are *entrenched* or *incised*, or too deep (this is common in urban and many rural settings), the bankfull stage is lower than the top of the bank and is identified as a bench, change in bank material and vegetation, the top of point bars, or a scour line. By taking measurements of the stream, we can predict the size and shape of the stream, or its *bankfull geometry*, when it is in equilibrium.

The force that flowing water exerts on the bed and banks of a stream channel is called *shear stress*. Shear stress is typically used to describe scouring or degrading of the bed and banks. Except on bends, it is related to the depth of flow of the water and the slope of the channel bed. The deeper the water, or the steeper the slope of the bed, the greater the force. For every place in a stream there will be some combination of water depth and bed slope that will cause the bed or banks to scour. A simple but approximate way of estimating when scour will occur is to use Andy's

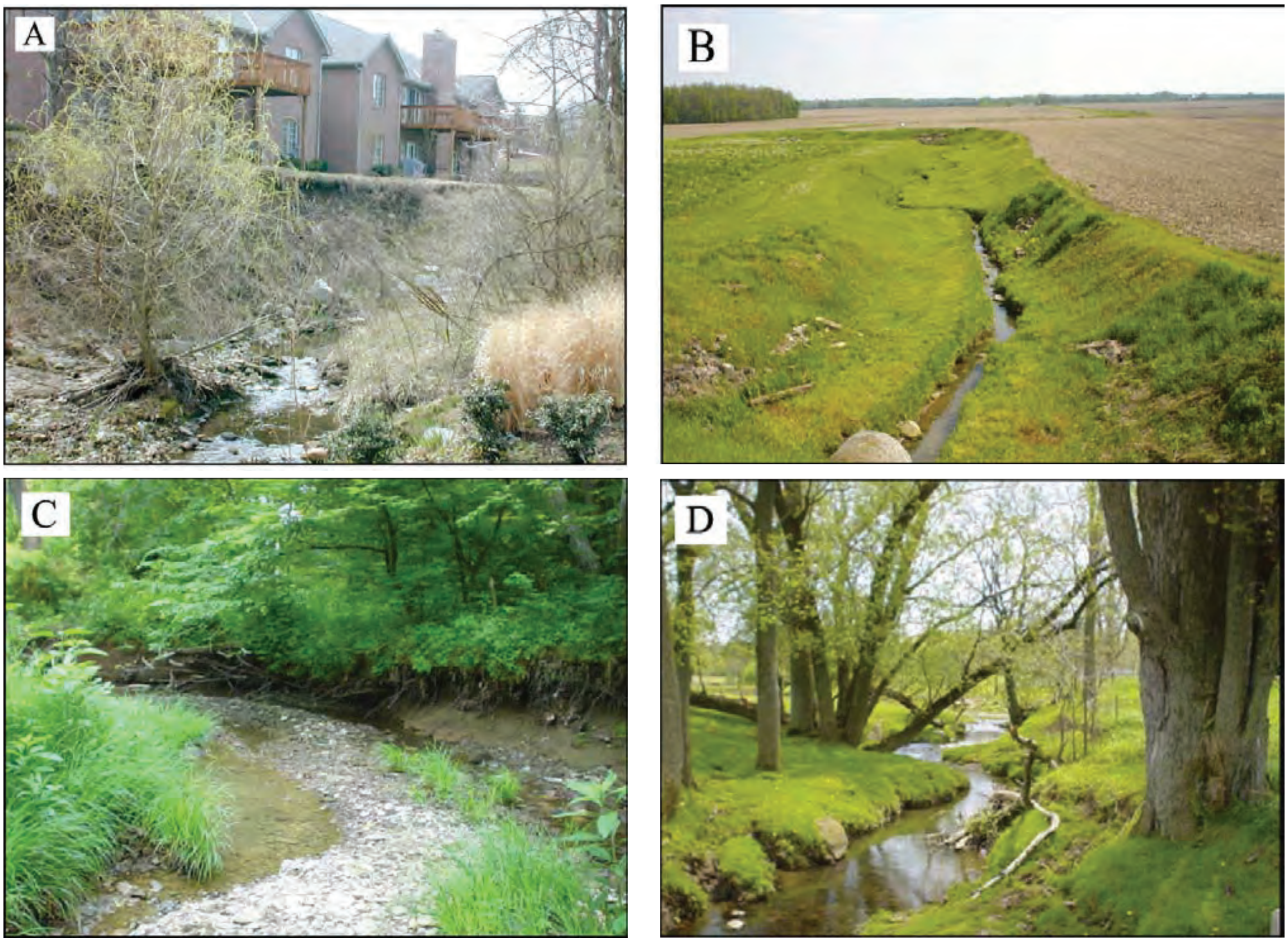

Figure 2. A: A deeply incised stream that is out of equilibrium due to urbanization. B: An agricultural ditch was built too wide and has naturally started forming a new floodplain and is changing its form to regain equilibrium. C: Aggradation of sediment, called a flat point bar, on the left is occurring to regain equilibrium; the point bar will continue to build up until it is at the same level as the connected active floodplain on the left side of the picture. D: An incised rural stream that has become unattached from its active floodplain, the pasture on either side of the trees.

Rule, which states, "if the depth of flow is 1 foot and the bed slope is 1% then the average size bed material that will start to move will be 1 inch." If you use those particular units, multiplying depth and slope will give you the approximate sediment diameter. For example, if the depth of flow in the channel is 4 feet and the bed slope is 0.5% then the average size bed material (called the d_{50}) that will move with the flow of water will be 2 inches (4 *multiplied by* 0.5).

For many streams that are in equilibrium we will find, by using Andy's Rule, that the average bed material size is related to the average bankfull depth and the bed slope. The method is not exact and in some cases the shear stress is better related to other factors. If there is no relationship between bankfull depth, bed slope, and bed material size, it might be an indication that the stream is not in equilibrium. In a straight section of a stream (called a *reach*) average shear stresses on the banks are about 80% of those on the bed. On the outside of a bend, the shear stresses on the banks might be several times larger than those on the bed. This is the main reason why banks erode and streams shift their position.

What Data Do I Need To Determine Channel-Forming Discharges?

Obtaining highly detailed stream data, also called *surveying,* can be a time consuming and difficult activity, particularly in large rivers. Fortunately, useful guidelines for smaller, shallower streams—also called *wadeable*—are available[8]. For each *reach*, data are collected over a stream length equal to at least 20 times the channel width so that the survey includes at least two bends in the channel. Channel width and depth measurements depend on an ability to correctly measure the location of the *bankfull elevation*. Signs of *bankfull elevation* in a stream can be found at the back of point bars, significant breaks in slope, benches, changes in vegetation, or at the top of the bank. Determining the bankfull elevation is not an easy thing to do and requires a lot of practice and good observation skills (Figure 3).

One channel width and depth measurements are taken at the *bankfull elevation,* data can be plotted on a graph (using a basic spreadsheet program like Microsoft Excel) and related to watershed size—or *drainage area*—for the channel. The relationship is indicated with a trend line, and an equation for predicting each component is generated. When many of these measurements from different locations are plotted on the same graph for the same watershed over a range of drainage areas, these relationships are called *regional curves* (Figure 4). To illustrate this idea we will use data for the Scioto River near Higby, Ohio, which has a drainage area at this location of 5,131 square miles. The measured bankfull width is 567 feet, the measured mean bankfull depth is 12.1 feet, and the bankfull cross-sectional area (width multiplied by depth) is 6,880 square feet. Using the regional curve for the Scioto River shown in Figure 4, the predicted (calculated using the equations on the graph) bankfull width is 475 feet, the predicted mean bankfull depth is 14.1 feet, and the bankfull cross-sectional area is 6,710 square feet. It is not uncommon for estimates obtained from a regional curve and measured values to vary by 50% or more, so regional curves should be used with caution.

Determining the Bankfull Discharge

Discharge in a channel can be calculated by knowing just a few pieces of information. This is illustrated in the following sequence of equations. Discharge is calculated by knowing the cross-sectional area of the stream and the average velocity of the flowing water:

$$q = va$$

This is also called the *equation of continuity*, where q is the discharge (ft^3/sec), a is the cross-sectional area of the stream (ft^2) and v is the average velocity of flowing water (ft/sec). Bankfull velocities for low gradient channels (<2% bed slope) will usually be between 2 and 5 ft/s. At the Higby gage the bankfull velocity is about 4 ft/s. To determine the average velocity, v, you must know the slope, S, of the bed (ft/ft), the hydraulic radius, R, of the channel (ft) and something called a Manning's roughness coefficient, n. This velocity calculation is called *Manning's equation*:

$$v = \frac{1.5}{n} R^{2/3} S^{1/2}$$

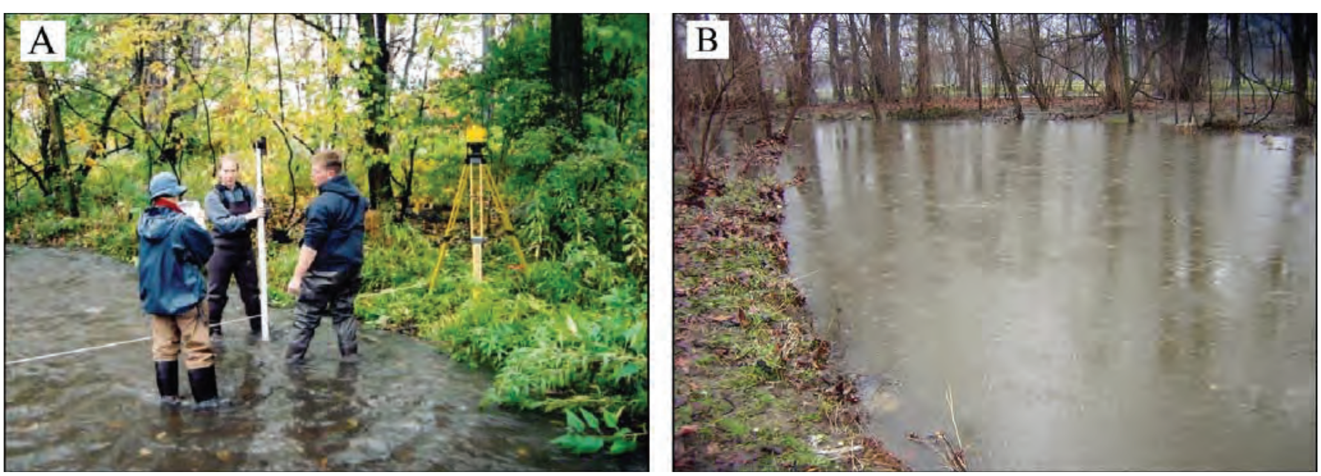

Figure 3. A: Measuring bankfull features in an urban stream. B: Bankfull flow in the same stream with water depths and currents that make taking measurements unsafe.

Manning's *n* is an indicator of how much resistance to flow a channel bed has and can be found in a hydrology textbook estimated from other equations[9,10]. Most channels in Ohio will have a Manning's *n* value of 0.025 to 0.05. To calculate the hydraulic radius of the channel, *R*, you need to know *P*, the wetted perimeter (ft) of the channel cross-section (see Figure 5):

$$R = \frac{a}{P}$$

Determining the Effective Discharge

Effective discharge is related to the sediment transport rate (Figure 6). Low discharges—or smaller flow rates—associated with small storm events transport a small amount of sediment, and high discharges—or larger flow rates—associated with large storm events transport a very high amount of sediment (Figure 6A). However, the largest storm events producing the largest discharge flow rates do not happen very often so the total sediment load carried over many years is very small (Figure 6B). Small storm events producing smaller discharge flow rates happen very often so the total amount of sediment carried is large (Figure 6B). When the frequency of a discharge event is multiplied by the rate at which sediment is transported for that frequency, we obtain Figure 6C, which is a measure of the total sediment load carried for that particular discharge. Therefore, in Figure 6C, the *effective discharge* rate, which carries the most sediment over time, is around 17,000 cubic feet per second (cfs) and is carrying 100,000 tons of sediment per year.

This approach for determining the amount of sediment moving through a system—also called *geomorphic work*—is known as the Wolman-Miller model[11]. The reason the data do not all fall on the trend line in Figure 6A is because there are seasonal and annual changes in land use that affect a stream system. For example, a large storm producing a lot of

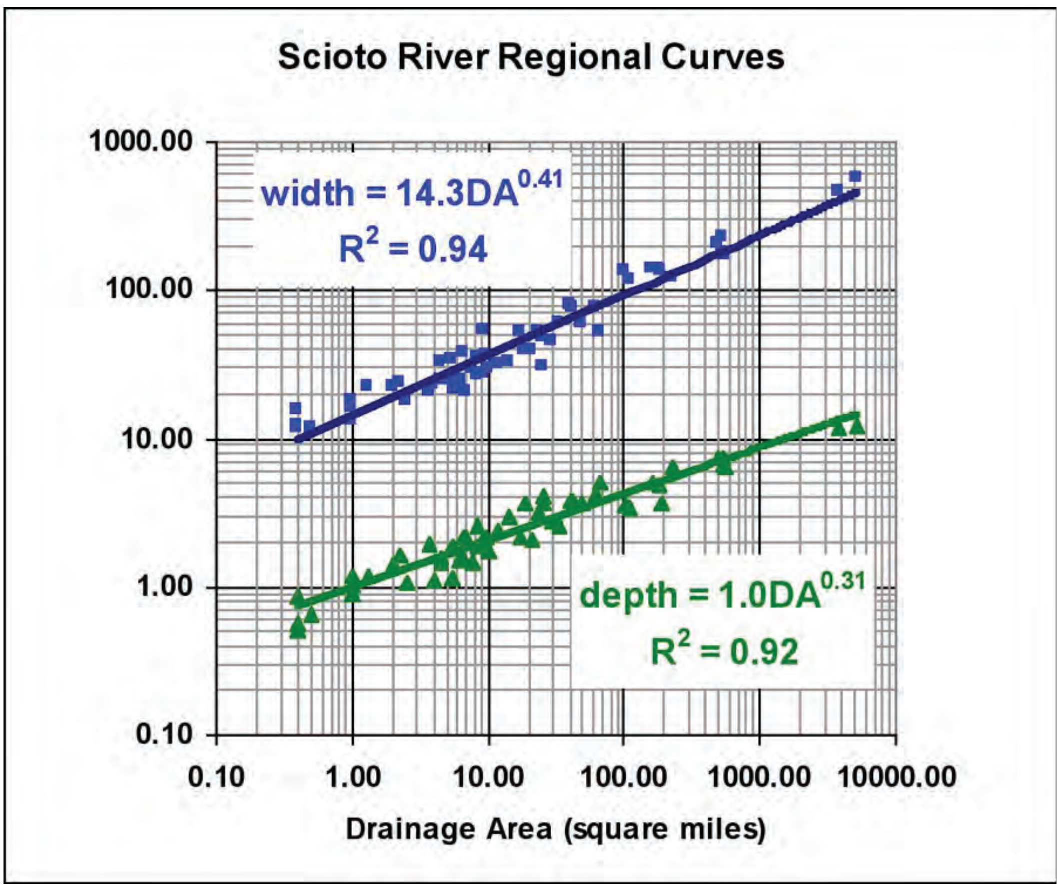

Figure 4. Regional curve for the Scioto River watershed near Higby, Ohio.

runoff during frozen conditions might contain little sediment while a much smaller storm producing runoff might contain high sediment loads from a recently plowed field or land disturbed by a development project.

How Often Do We Get Channel-Forming Discharges?

It is difficult to determine exactly how many times each year a channel-forming discharge will occur on a particular stream reach because we usually do not have detailed enough data to make those predictions. Based on an analysis of annual discharge data for humid and semi-humid regions, the channel-forming discharge generally may occur or be exceeded several times a year. The return period is the likelihood a storm event will occur or be exceeded. For example, the 10-year recurrence interval storm event has a 10% chance of occurring in any given year. In Ohio's streams, *bankfull discharge* may be associated with a return period that is less than the 1-year recurrence interval event[7]. However there are many streams where it is in the 1 to 2 year range, and some streams where the recurrence interval approaches 5 years. Information on the recurrence interval of channel-forming discharges should only be used as one piece of evidence in determining the bankfull characteristics of a channel.

Figure 7 shows recurrence interval information for discharges on the Scioto River near Higby, Ohio. Using the data in Figure 7, for an *effective discharge* of 17,000 cfs the regression lines predict RIs of 0.45 and 0.92 years. For an *effective discharge* of 26,000 cfs the two lines provide RIs of 1.1 and 1.3 years. Because of the limitations of data available or methods developed to analyze them, we advise caution in interpreting discharge and recurrence interval data. To illustrate this using the data for the Scioto River near Higby, Ohio, there are on average more than 24 days a year with discharges exceeding 17,000 cfs. Yet, in 1954 there were no daily discharges larger than 17,000 cfs while in 1996 there were 10 events, lasting a total of 73 days, which exceeded 17,000 cfs. As a general guideline, it should be expected that, for most streams and rivers in Ohio, flows exceeding the channel forming discharge would occur at least a few times annually.

What About Discharges That Are Not Channel-Forming?

A question that we might ask is, why do smaller or larger discharges than the *effective discharge* not form channels, banks, benches, and bars that are different than those associated with the stream channel? The answer to this question is not simple. There probably

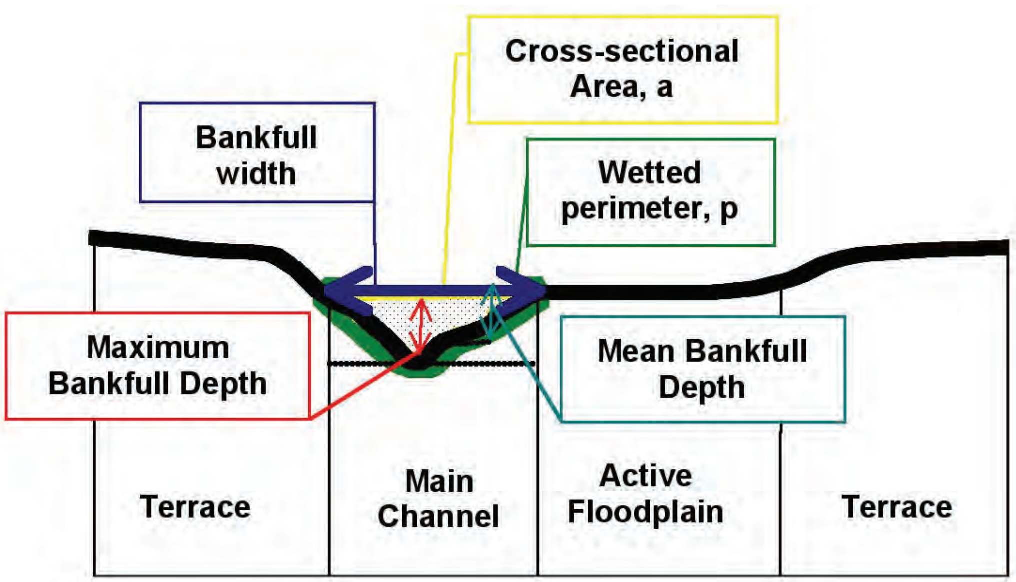

Figure 5. Cross-section of a channel with an active floodplain and terraces.

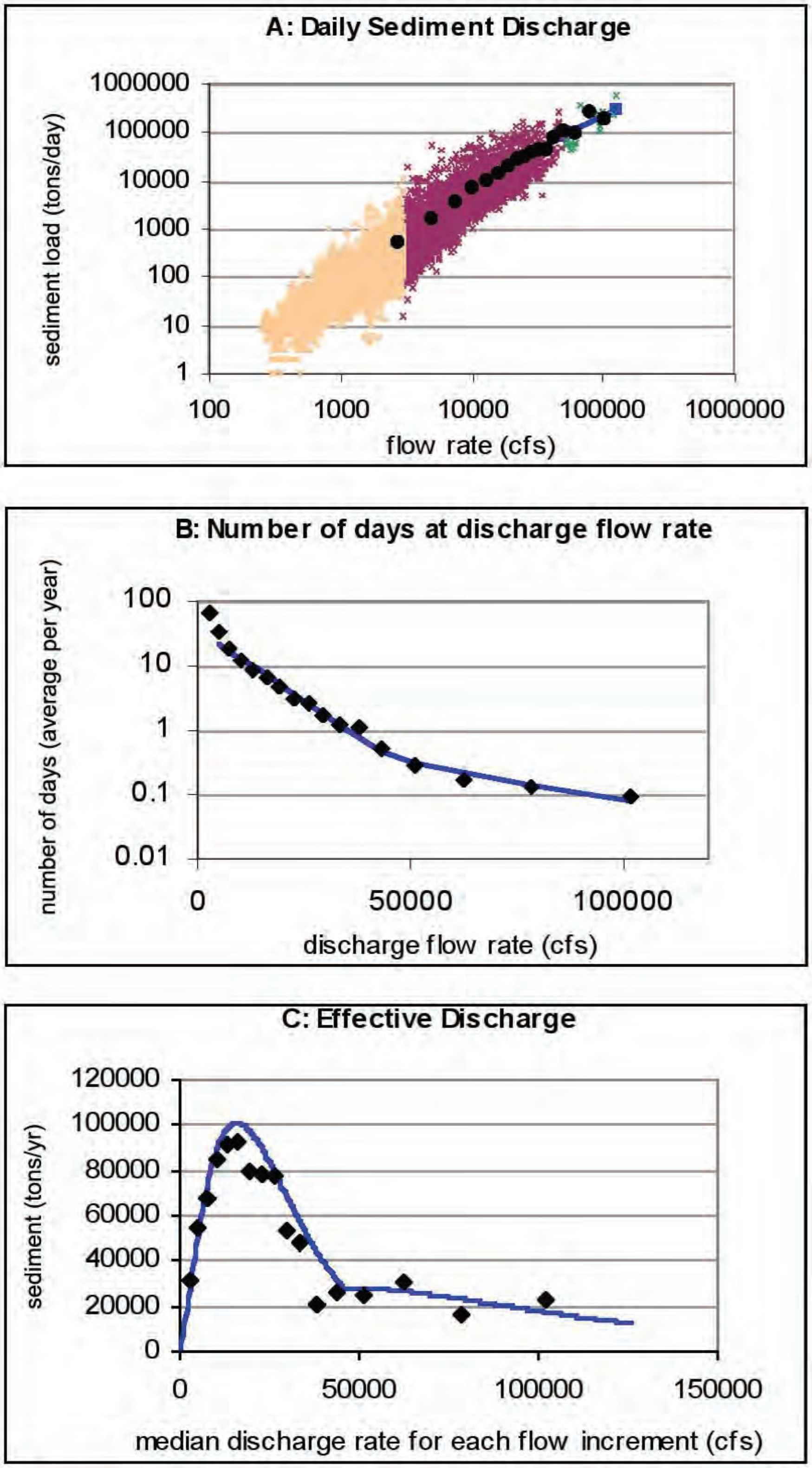

Figure 6. Illustration for Scioto River, Ohio, explaining that effective discharge carries the largest total seidment load. A: Plot of measured discharge and sediment data. B: Frequency of different median discharge rates. C: Plot of sediment load versus median discharge—the peak sediment load occurs at the effective discharge value.

is a wide range of discharges that have the potential to shape a river channel. For example, we have found in Northwest Ohio discharges associated with high subsurface drainage flows form a low bench in most agricultural drainage ditches. Why are similar features not formed in natural rivers or other ditches? First, very low discharges are ineffective in moving sediment and can only transport very fine material such as clay. If fine clays are not available, there will be little or no sediment transport. Second, the ability of these low discharges to scour the bed and banks of a channel also is very low. Third, if beds, banks, and benches are to be formed as primary features of the system, then there must be a way to effectively stabilize the deposited sediments so they do not eventually wash downstream. In the case of many agricultural ditches, vegetation provides stabilization and it grows very quickly on these features.

In a natural channel we might think of discharges lower than the effective discharge either: (1) being too small to scour and/or transporting sufficient sediment to create permanent features; or (2) occurring too frequently to allow the deposited materials to stabilize. Perhaps harder to understand and visualize is why discharges larger than the *effective discharge* do not scour and wash away the banks, benches, and bars. In places along a river system, extreme storm events might cause bank instability problems, but on average, most channel and floodplain features that are in dynamic equilibrium have relatively stable banks and beds. Once balanced, they do not *aggrade* (build up due to sediment deposits) or *degrade* (downcut due to scour) because discharges larger than the effective discharge spread out across the floodplain, have low velocities when they flow across these features, and in the main channel have similar forces on the bed and banks to those produced by the *effective discharge*.

Why Is My Channel the Shape It Is?

We have seen that the size of a channel is related to the forces on the bed and banks, the size of the bed and bank material, the discharge that carries the most sediment over a long period of time, the bed slope, and the depth of flow associated with the channel-forming discharge. So, why are channels not the same shape?

In a pasture, where there are clay soils that are stabilized by dense grass roots, we might find a narrow but deep channel. In a woodland, where there are clay/loam soils and large sparse tree roots that anchor the soil, we might find a wide and shallow channel. The constant degrading and aggrading of stream beds and banks leads to bends forming in the channel and the channel, if not constrained by valley walls, to moving

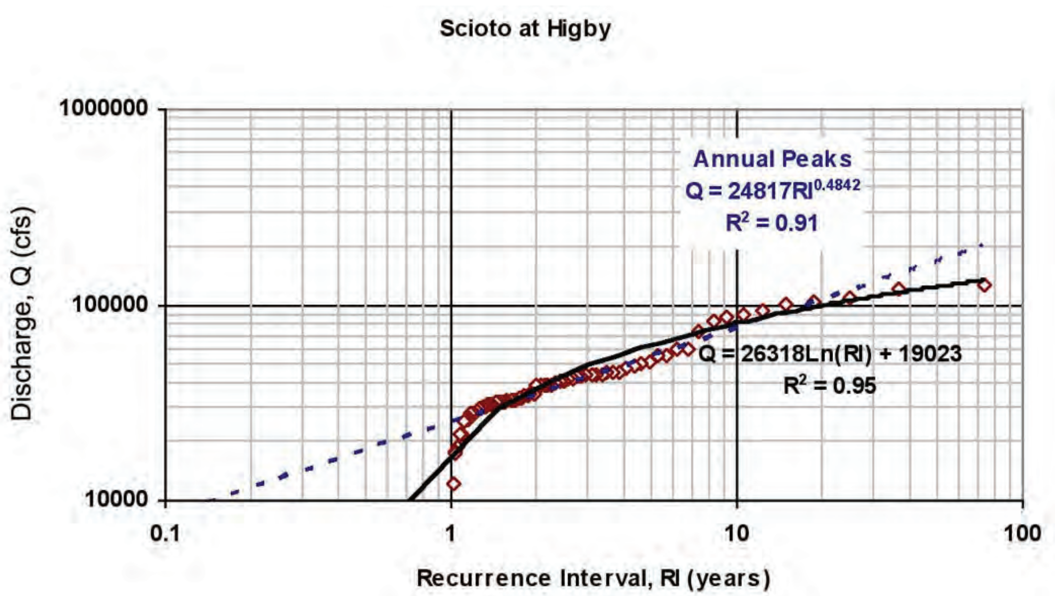

Figure 7. Discharge versus recurrence interval relationships at the Higby, Ohio USGS stream gage.

through a valley over time. This is mainly related to the resistance of the beds and banks to scour and the stability of the banks. Some materials will scour more easily than others. For example, if a channel bed has degraded to bedrock (this can be thought of as its foundation) it will have trouble getting deeper. To maintain dynamic equilibrium, the banks will scour and the channel will widen. In other cases, vegetation on the banks will help to stabilize the bank materials and it might be easier for the bed to scour than the banks. If we understand the balance between water and sediment discharges—or *fluvial processes*—we can begin to predict what happens to the stream when these factors are out of balance.

Acknowledgments

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Appendix J

STREAM CROSSING DESCRIPTION, LOCATION, CONDITION, FISH PASSAGE, AND NAVIGATION RATING ASSESSMENT WITHIN THE MASON CREEK WATERSHED: 2014

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Table J-1

STRUCTURE DESCRIPTION, LOCATION, CONDITION, AND FISH PASSAGE RATING ASSESSMENT WITHIN THE MAINSTEM AND HEADWATERS OF MASON CREEK: 2014

Stream Reach	Structure Number	Crossing Name	Description	River Mile	Culvert/Bridge Length (feet)	Ditch Erosion	General Condition	Limiting Water Depth (feet)	Embedded Depth (feet)	Fish Passage Rating	Recommended Actions
Lower Mason Creek	1	Private Driveway	Metal and concrete span bridge	0.04	14.0	Minor	Good	1.6	- -	Passable	None
	2	Private Walking Bridge	Wood span bridge	0.07	- -	- -	- -	- -	- -	Passable	None
	3	Union Pacific Railway	Concrete open bottom arch bridge	0.08	66.0	Stable	Fair	0.4	- -	Passable	None
	4	Peterson Drive	Two cell concrete box culvert, each cell is 6-feet-wide and 5-feet-high	0.25	41.0	Stable	Good	1.0	0.6	Passable	None
	5	Private Walking Bridge	Wood span bridge	0.37	- -	- -	- -	- -	- -	Passable	None
	6	Private Walking Bridge	Wood span bridge	0.40	- -	- -	- -	- -	- -	Passable	None
	7	Private Driveway	One smoot metal ellipse culvert, 4.8-feet-wide and 3.3-feet high; Culvert outlet is perched 0.6 feet above water surface; Sections of culvert coming apart under driveway	0.41	16.0	Stable	Poor; outlet perched above water surface; Scour pond with water depth of 2.7 feet; Culvert sections splitting under driveway	0.4	None	Barrier to Fish Passage	Replace with appropriately sized culvert at stream grade
	8	Private Walking Bridge	Wood span bridge	0.43	- -	- -	- -	- -	- -	Passable	None
	9	Koester Road	Three corrugated metal pipe arch culverts, each approximately 5.5-feet wide and 3.8-feet-high; Excessive amounts of cobble and boulders at upstream side of culverts causing obstruction for many species of fish during baseflow conditions	0.50	51.0	Minor	Poor; rusting through at points	0.3-0.5	None	Barrier to Fish Passage	Remove excess cobble and boulder and place evenly along adjacent banks, leave any stone more than 70% submerged (at baseflow conditions) in place
	10	Private Walking Bridge	Wood span bridge	0.60	- -	- -	- -	- -	- -	Passable	None
	11	Private Walking Bridge	Wood span bridge	0.94	- -	- -	- -	- -	- -	Passable	None
	12	Private Road Crossing	One 4.0-foot-diameter round concrete culvert; Culvert is undersized creating water velocities that prohibit the ability of many species of fish to pass through at baseflow conditions	1.26	19.0	Minor	Fair	0.6	None	Potential Barrier to Fish Passage	Remove or replace with appropriately sized culvert or backwater culvert with instream weir(s) to reduce water velocity and increase depth
Upper Mason Creek	13	Westshore Drive	Two corrugated metal pipe arch culverts approximately 6.6-feet-wide and 4.0-feet-high; Culverts are 30% and 50% plugged with silt	2.12	48.0	Stable	Fair	0.5-0.7	0.4-1.9	Passable	Monitor siltation within culverts
	14	Private Walking Bridge	Wood and metal beam span bridge	2.39	- -	- -	- -	- -	- -	Passable	None

Table J-1 (continued)

Stream Reach	Structure Number	Crossing Name	Description	River Mile	Culvert/Bridge Length (feet)	Ditch Erosion	General Condition	Limiting Water Depth (feet)	Embedded Depth (feet)	Fish Passage Rating	Recommended Actions
Upper Mason Creek (continued)	15	CTH CW	One corrugated metal pipe arch culvert, 15-feet-wide and 3.5-feet-high; Roadside fencing has fallen into stream on downstream side of culvert and is accumulating debris and may impede fish passage if not removed	2.51	50.0	Minor	Fair	0.4	1.0	Potential Barrier to Fish Passage	Remove roadway fencing and debris accumulated from channel at downstream side of culvert
	16	Abandoned Private Culverts	One metal ellipse pipe culvert 4.2-feet-wide and 3.0-feet-high; One 1.5-foot-diameter metal round culvert; Culverts are abandoned and unnecessary and are collecting debris	3.28	10.0	Moderate	Poor, rusted through	- -	- -	Potential Barrier to Fish Passage	Remove both culverts and accumulated debris from channel
	17	Private Walking Bridge	Wood span bridge	3.30	- -	- -	- -	- -	- -	Passable	None
	18	Private Farm Road Crossing	One concrete box culvert 6.2-feet-wide and 2.5-feet-high	3.32	18.0	Minor	Fair	0.6	None	Passable	None
East Branch of Mason Creek	19	Private ford Crossing	Water is flowing over the crossing and there are also three concrete round pipe culverts embedded underneath the road crossing, each approximately 0.7-feet-diamater serving to reduce water depths over the ford.	0.05	- -	- -	- -	0.3	- -	Potential Barrier to Fish Passage	Remove embedded pipes from this crossing and consider regrading and/or installing weirs to increase water depths and decrease water widths
	20	Abandoned Private Culvert	One concrete round culvert 3.0-feet-diameter	0.30	- -	- -	- -	0.4	- -	Passable	None

NOTES: The red indicated high priority and yellow color indicates moderate priority ratings to address fish passage issues in the watershed.

This table is not a complete inventory of stream crossings. Only structures that field crews were able to access are included.

Source: SEWRPC.

Figure J-1

STREAM CROSSING LOCATIONS WITHIN THE MASON CREEK WATERSHED: 2014

1- PRIVATE DRIVEWAY (RM 0.04)

2- PRIVATE WALKING BRIDGE (RM 0.07)

3- UNION PACIFIC RAILWAY (RM 0.08)

4- PETERSEN DRIVE (RM 0.25)

5- PRIVATE WALKING BRIDGE (RM 0.37)

6- PRIVATE WALKING BRIDGE (RM 0.40)

7- PRIVATE DRIVEWAY (RM 0.41)

8- PRIVATE WALKING BRIDGE (RM 0.43)

9- KOESTER ROAD (RM 0.50)

10- PRIVATE WALKING BRIDGE (RM 0.60)

11- PRIVATE WALKING BRIDGE (RM 0.94)

12- PRIVATE CROSSING (RM 1.26)

Figure J-1 (continued)

13- WESTSHORE DRIVE (RM 2.12)

14- PRIVATE WALKING BRIDGE (RM 2.39)

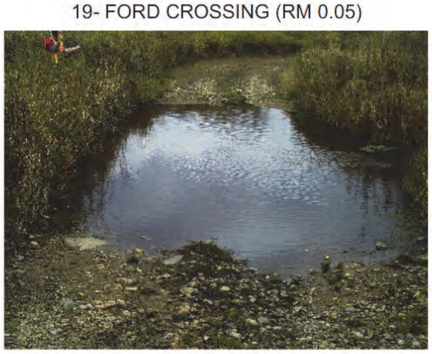
15- CTH CW (RM 2.51)

16- ABANDONED CULVERTS (RM 3.28)

17- PRIVATE WALKING BRIDGE (RM 3.30)

18- PRIVATE CROSSING (RM 3.32)

EAST BRANCH
19- FORD CROSSING (RM 0.05)

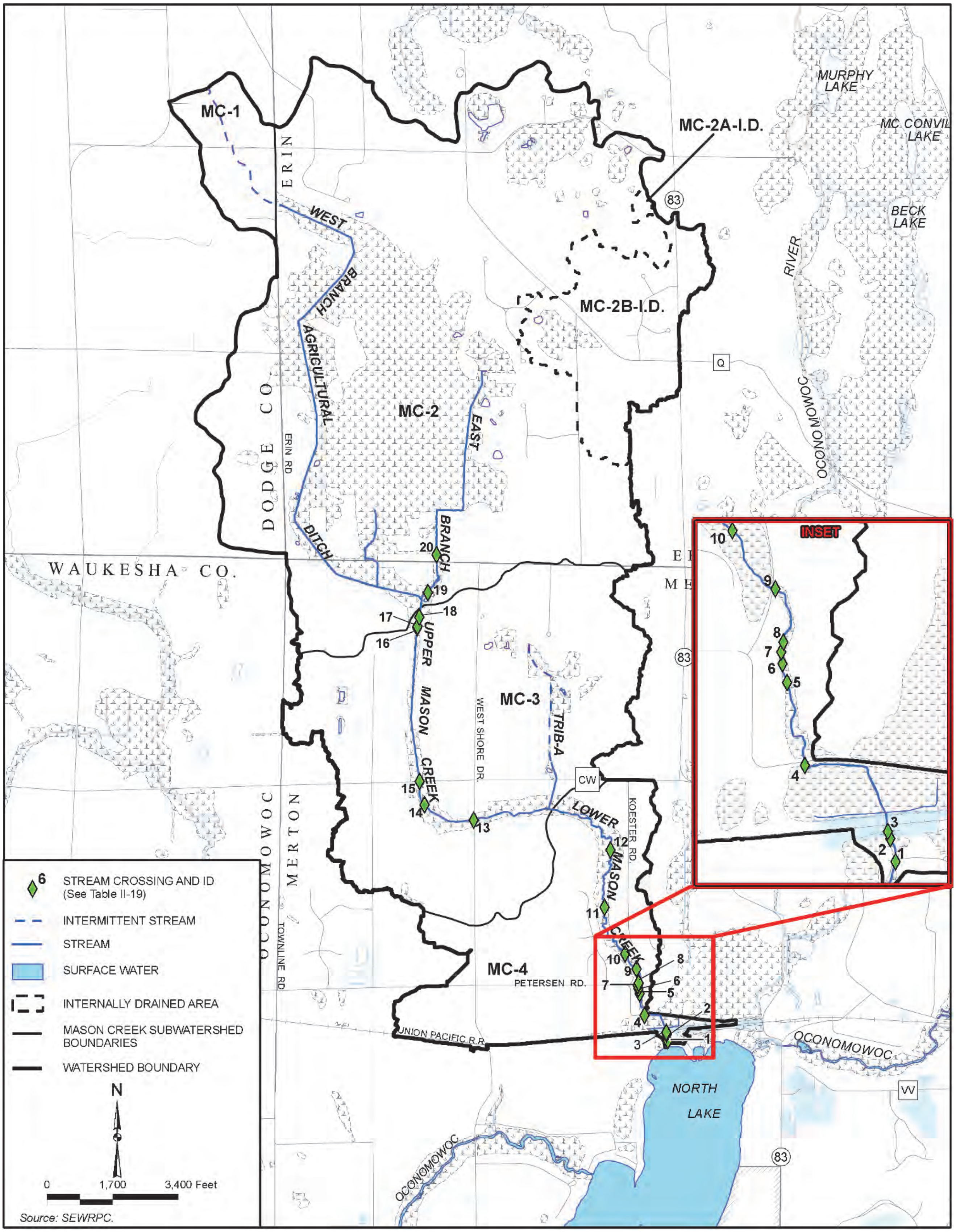


EAST BRANCH
20- PRIVATE CROSSING (RM 0.30)

Source: SEWRPC.

Map J-1

STREAM CROSSINGS WITHIN THE MASON CREEK WATERSHED: 2014



CRITERIA AND GUIDELINES FOR STREAM CROSSINGS TO ALLOW FISH PASSAGE AND MAINTAIN STREAM STABILITY WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

TYPES OF CROSSINGS[1]

- The number of stream crossings should be minimized.

- If a crossing is necessary, structures that maintain to the extent possible the existing streambed and bank conditions are preferable; therefore, bridges spanning streams are preferable to other structures.

- If a culvert is necessary, open bottom structures are preferable to closed bottom structures.

- If a closed bottom culvert is necessary, box culverts, elliptical, or pipe arch culverts are preferable to round pipe culverts, because round pipes generally reduce stream width to a much larger degree than the aforementioned structures, causing long term upstream and downstream passage limitations (see physical considerations below).

- Offsetting Multiple Culverts—If multiple culverts are necessary, it is recommended that the culvert inverts be offset vertically and only one culvert be designed to provide passage during low flow conditions and the additional culverts be used to pass the higher flow events (see figure below). Therefore, the low flow culvert will be the only culvert, in a series of two or more culverts, designed to provide fish passage during low flows and shall meet the physical requirements of passage above.

COMPARISON OF UNDERSIZED AND ADEQUATELY SIZED AND PLACED CULVERTS

Undersized culvert.

Properly sized and placed culverts.

Source: Minnesota Department of Natural Resources.

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[1]*Department of Fish and Game, Division of Ecological Restoration,* Massachusetts Stream Crossings Handbook, *Editors: Amy Singler, Brian Graber, and Carrie Banks, Writing and design: biodrawversity (www.biodrawversity.com), 2nd Edition, June 2012, http://www.mass.gov/eea/docs/dfg/der/pdf/stream-crossings-handbook.pdf*

BIOLOGICAL CONSIDERATIONS[2]

- Contact the area WDNR fisheries manager prior to design and construction to minimize impacts.[3]
- Species of fish present (coldwater, warmwater, threatened, endangered, species of special concern).
- Life stages to potentially be impacted (e.g., egg development within substrates should be avoided).
- Migration timing of affected species/ life stages (e.g., adult spawning times should be avoided).

PHYSICAL CONSIDERATIONS[4]

It is important to note that in order to achieve the minimum physical criteria outlined below, the culvert(s) will need to be oversized as part of the design to ensure adequate long-term fish passage as well as the ability to pass the design period rainfall event.

It is understood that it may not be possible to achieve some of the minimum passage criteria below based upon specific on-site conditions or constraints, however, the closer the designed and completed culvert can meet these criteria the better the long-term passage and overall sustainability of the fishery will be achieved in this region.

Provide Adequate Depth

- Slope—Culvert should be installed with a slope that matches the riffle slope as measured in the thalweg[5] (see Minnesota DNR guidelines[6])
- Water Depth and Velocity—Water depths and velocities should be comparable to those found in the natural channel at a variety of flows. Depths should maintain the determined thalweg depth at any point within the culvert during low flow periods (see Minnesota DNR guidelines).
- Installation Below Grade—The culvert should be installed so that the bottom of the structure is buried to a depth equal to 1/6th the bankfull width of the stream (up to two feet) below the natural grade line elevation of the stream bottom (see Minnesota DNR guidelines). The culvert should then be filled to stream grade with natural substrates. The substrates should consist of a variety of gravel ranging from one to four inches in diameter and either mixed with nonuniformly laid riprap or uniformly placed alternate riprap baffles, large enough to be stable during the culvert design discharge, which will ensure stability of substrates during high flow events.

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[2]*British Colombia Ministry of Forests,* Fish-stream crossing guidebook, *For. Prac. Br., Min. For., http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm, Victoria, B.C. Forest Practices Code of British Columbia guidebook, 2002.*

[3]*UW-Extension and WDNR,* Fish Friendly Culverts*, 2002.*

[4]*Washington Department of Fish and Wildlife, Habitat and Lands Program, Environmental Engineering Division,* Fish Passage Design at Road Culverts: A Design Manual for Fish Passage at Road Crossings*, Washington, March 3, 1999.*

[5]*The thalweg is the lowest point of the streambed.*

[6]*Minnesota DNR, Best Practices for Meeting DNR General Public Waters Work Permit GP 2004-0001, March 2006.*

Provide Adequate Width and Openness

- Crossing Span (see Massachusetts Stream Crossings Handbook):[7]
  - General—Spans channel width (a minimum of 1.2 times the bankfull with of the stream).
  - Optimum—Spans the streambed and banks (at least 1.3 times the bankfull width) with sufficient capacity to provide dry passage for wildlife (see Figure below). Culvert width shall match the bankfull width (minimum) of the existing channel.
- Openness (see Massachusetts Stream Crossings Handbook):[8]
  - General—Openness ratio (cross sectional area/crossing length) of at least 0.82 feet. The crossing should be wide and high relative to its length.
  - Optimum—Openness ratio of at least 1.64 feet and minimum height of six feet. If conditions significantly reduce wildlife passage near a crossing (e.g. steep embankments, high traffic volumes, or other physical barriers), maintain a minimum height of eight feet and openness ratio of 2.46 feet.

KEY FEATURES THAT PROMOTE BOTH FISH AND WILDLIFE PASSAGE

Source: Department of Fish and Game, Massachusetts Stream Crossings Handbook, June 2012.

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[7]*Department of Fish and Game, Massachusetts Stream Crossings Handbook, June 2012.*

[8]*Ibid.*

Provide Adequate Resting Areas

- Length—Culverts that exceed more than 75 feet in length need to provide additional resting areas (e.g., installation of baffles or weirs) within the culvert to facilitate passage.[9]

Inlet and Outlet Protection

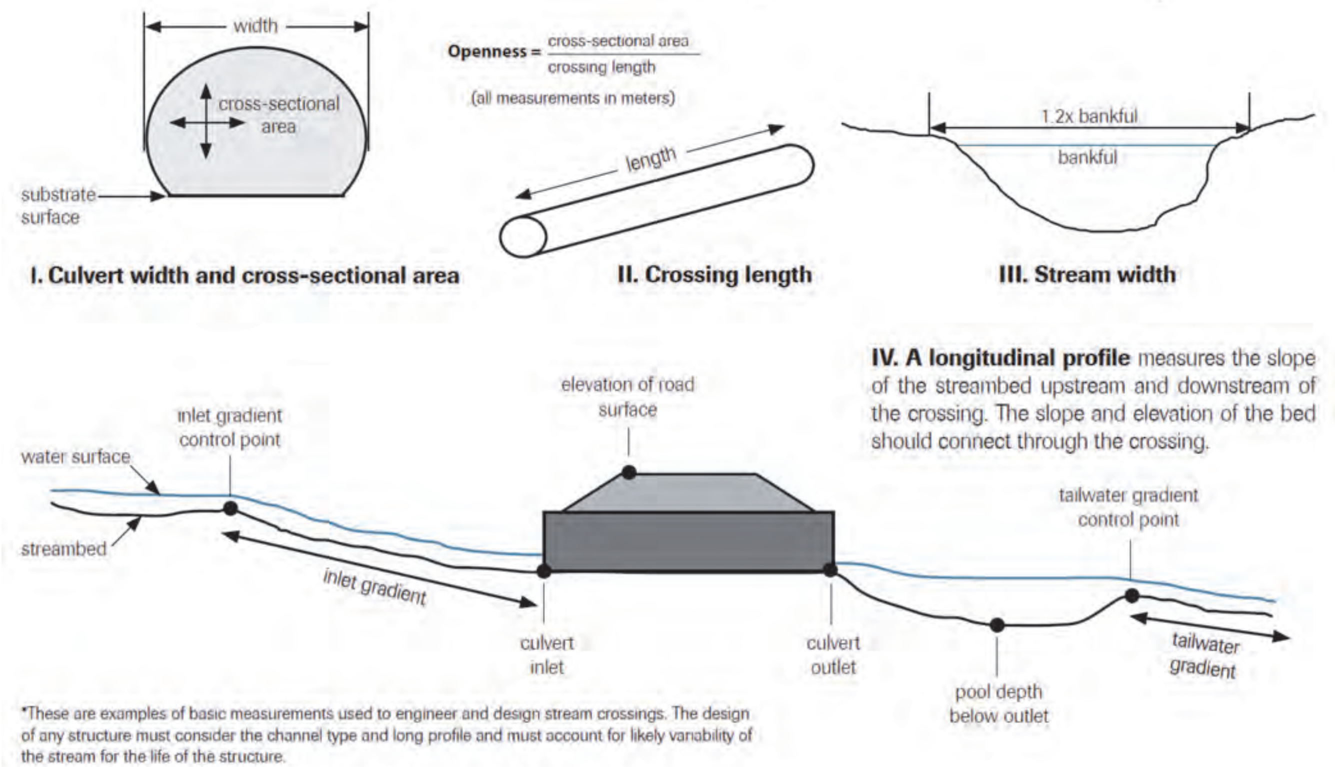
- Align the culvert with the existing stream alignment (e.g., 90 degree bends at the inlet or outlet should be avoided, even though this will increase culvert length, see Minnesota DNR guidelines).

- The low flow culvert should be centered on the thalweg of the channel to ensure adequate depths inside the culvert.

- Provide grade control where there is potential for head-cuts that could degrade the channel.

- It may be necessary to install riprap protection on the outside bank below the outlet to reduce bank erosion during high flow events.

COMMON STREAM CROSSING MEASUREMENTS (SEE ALSO DATA SHEETS BELOW)



Source: Department of Fish and Game, Massachusetts Stream Crossings Handbook, June 2012.

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[9]*Thomas Slawski and Timothy Ehlinger, "Habitat Improvement in Box Culverts: Management in the Dark?," North American Journal of Fisheries Management, Volume 18:676-685, 1998.*

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Appendix K

The St. Croix/Red Cedar River Basin: Farmer-Led Watershed Council Project

Source: Julia Olmstead, UW-Extension Watershed Project Coordinator, The St. Croix/Red Cedar River Basin: Farmer-Led Watershed Council Project, UW-River Falls, 123i RDI Building, River Falls, WI 54022, see website for more information at https://datcp.wi.gov/Documents/FLWCP.pdf

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The St. Croix/Red Cedar River Basin Farmer-Led Watershed Council Project:

Utilizing Performance-Based Farmer-Led Watershed Councils to Reduce Phosphorus Runoff, Improve Water Quality and Enhance Agricultural Productivity

Project objectives: To improve water quality in the Red Cedar and St. Croix River basins through reduced phosphorus and sediment loading; to increase farmer knowledge about, and engagement with, water quality issues, including the adoption of conservation practices; to develop leadership around water quality among farmers in the selected sub-watersheds; and to develop a unique collaborative model of water quality improvement through farmer engagement that can be replicated in watersheds throughout the Upper Mississippi River Basin and nationwide.

Project approach: Phosphorus (P) pollution reductions and the expansion of farm conservation activities will occur by way of an innovative, farmer-directed conservation incentives program. Four Farmer-Led Watershed Councils are up and running in Pierce, Polk, St. Croix and Dunn Counties. Each council receives an annual pool of funding ($17,000 in 2014, provided by the Minneapolis-based McKnight Foundation), with which they can design a conservation incentives program that achieves water-quality goals. The farmers themselves determine the best paths to conservation success within their watershed, and recruit and encourage other farmers to participate. County Land Conservation Department staff and University of Wisconsin-Extension staff work closely with the farmer councils to provide technical assistance, facilitation, resource information and education, as well as monitor the project's outcomes.

Project partners:

Dunn County Land Conservation Division

Pierce County Land and Water Conservation Department

Polk County Land and Water Resources Department

St. Croix County Land and Water Conservation Department

UW-Extension

Wisconsin DNR

Wisconsin Farmers Union

BACKGROUND

The St. Croix and Red Cedar River Basins, situated in west central Wisconsin, each contain several impaired waterways. The two basins include fourteen total maximum daily load (TMDL) projects The land base in these basins is predominantly agricultural. Farming systems that create excess nutrient and sediment run-off are a primary source of pollution. According to the U.S. Geological Survey, agriculture sources contribute more than seventy percent of the nitrogen (N) and phosphorus (P) pollution to the Gulf of Mexico via the Mississippi Basin.[1] Because these basins drain into the Mississippi River, strategies to decrease agriculture's contribution to nutrient and sediment pollution would have a significant impact on improving water quality in the Upper Mississippi River Basin (UMRB) and further downstream.

There have been many attempts to reduce P and other nonpoint source (NPS) pollutants within these basins, with mixed results. Strategies to-date have largely focused on the development of technical tools for assessment and improvements. However, those strategies have missed the

"... agriculture sources contribute more than seventy percent of the nitrogen (N) and phosphorus (P) pollution to the Gulf of Mexico via the Mississippi Basin."

May 2014

human social factors – farmers internalizing the need for better water quality, and making long-term coordinated management decisions based on that internalization – necessary for the widespread diffusion of those tools and sustainable water quality improvements.[2]

The U.S. Environmental Protection Agency recognizes the importance of citizen participation in successful long-term NPS strategies.[3] The lack of progress in meeting NPS reduction goals in the affected basins reinforces the need for innovations to better engage farmers in environmental management. In Iowa, a Farmer-Led Watershed Council model that combines performance-based environmental management with farmer leadership and civic engagement has resulted in significant improvements in the Soil Conditioning Index (SCI) and Phosphorus Index (P index), and has reduced nitrogen use and sediment delivery, all due to participants' management changes.[4] This successful innovation, which has been replicated in several sub-watersheds in northeast Iowa with similar success, serves as the model for our project.

"The lack of progress in meeting NPS reduction goals in the affected basins reinforces the need for innovations to better engage farmers in environmental management."

These Iowa successes have occurred in relatively small watersheds of USGS Hydrological Unit Code (HUC) 12 or similar scale. Farmer councils were developed in each watershed. Iowa State Extension provided technical and financial resources to allow the farmers to determine the best conservation mechanisms for improved water quality. In each watershed, farmers developed a set of performance-based incentives that they encouraged all farmers within the watershed to adopt. The co-development of farmer leadership alongside strong technical support and facilitation has led to wide participation within the watersheds, increased adoption of conservation practices, and long-term commitment to these management strategies by farmers. The projects are all ongoing.

Our project, made up of four pilot sub-watersheds ranging from about 7,000 to 33,000 acres in the St. Croix and Red Cedar River basins, shares the approach with Iowa. Because of existing conservation partnerships developed over years, we have a significant opportunity to observe the effectiveness of this innovation across watersheds, as we are leveraging the technical and financial resources of county, state and non-governmental partners. This is a unique opportunity to improve UMRB water quality and to further develop and promote a model for farmer engagement that can be spread to other watersheds nationwide.

INNOVATIONS

We consider this project innovative for the following reasons:

1. Farmers decide the best paths to water quality and conservation goals, and then conservation partners provide them with the technical resources to get there.

2. The partnership is combining technical conservation practices with civic engagement and farmer-leadership development strategies at a watershed level.

3. The project involves leveraging multi-level and multi-location collaboration, including county conservation departments, university Extension, the WI Department of Natural Resources and non-governmental organizations.

METHODS

The project is based on a model of civic engagement that develops knowledge and creates leadership and action on water quality by farmers. Farmer-Led Watershed Councils now exist in four target sub-watersheds in Pierce, Polk, St. Croix and Dunn Counties. These sub-watersheds were selected because they have both high P-loads as well as a critical number of farmers receptive to leading projects which educate and involve their local farm community in soil conservation and phosphorus runoff reductions.

One of the key innovations of this project is the leading role farmers will play, a strategy based on the successful participatory models of resident-led watershed projects developed by Iowa State Extension and others. The project coordinator (employed by University of Wisconsin-Extension) and the county conservationists will provide technical support, education and facilitation to the farmer councils, as well as a small pool of money, but will not dictate to farmers the best course of action to achieve water quality goals. The councils will decide how best to approach the task of water quality improvement in their watershed. They will have the freedom to select which conservation practices to incentivize, to create monitoring and evaluation plans, and to devise outreach strategies that are tailored to the particulars of their watersheds. In this way, farmers in the councils will become not only conservation leaders within their watersheds, but also strong advocates for the adoption of conservation practices and resources in their farm communities. This type of participatory approach has achieved sustained reductions in P and other water pollutants.

This project combines the considerable strengths of the partners with current watershed management TMDL goals in a groundbreaking collaborative. Conceptually, it draws from research and resources on civic engagement from the University of Minnesota, Iowa State University's sociological work on farmer-led, performance-based watershed projects, and the concept of landscape disproportionality analysis from the University of Wisconsin.[5] Project partners have created a local- and county-led watershed management implementation project partnership within the Red Cedar and St. Croix River (WI portion) Basins. Because of the reach of the many partners involved in this collaboration, it anticipates an increasing adoption of both the participatory model as well as the conservation practices themselves beyond the pilot watersheds and throughout the river basins.

Specifically, our methods are as follows:

Objective 1: Developing farmer-led councils in four pilot watersheds. The project coordinator from UW-Extension and staff from the Land Conservation Department offices in each of the four counties that contain the watersheds are working closely to facilitate and develop the farmer-led councils. Farmer councils have been meeting regularly since February 2013.

Project Personnel

DUNN COUNTY:

Dan Prestebak, Conservationist; Amanda Hanson, Conservation Planner

PIERCE COUNTY:

Rod Webb, Conservationist

POLK COUNTY:

Tim Ritten, Conservationist; Eric Wojchik, Conservation Planner

ST. CROIX COUNTY:

Bob Heise, Conservationist; Kyle Kulow, Conservation Planner

UW-EXTENSION:

Julia Olmstead, Outreach Specialist/ Project Coordinator; Paul Kivlin, Nutrient Management Specialist

Objective 2: Phosphorus-loading inventories in each watershed. To measure our progress, as well as for the farmer council to target the biggest P contributors, county conservation staff and UW-Extension nutrient management specialists will work with farmers to do P indexing on as many fields as possible within the watershed. The P Index assigns a number – 0, 1, 2, 4, 8 or 16 – to each of the conditions which can affect phosphorus losses, where 0 is the lowest P loss potential and 16 is the highest P loss potential. This is completed according to the probability of P loss from the site. Council members will take the lead to encourage non-participating or hesitant farmers to get involved.

Objective 3: Measurable reductions in phosphorus runoff. Several of the incentives we suggest to the farmer councils will result in P pollution reductions, including improved manure management, grass waterways, cover crops and grid sampling for precision agriculture methods. We will be able to track these reductions via annual P index assessments as well as by leveraging already existing edge-of-field water monitoring sites that are located in each watershed. We will also encourage farmers to target conservation activities to the heaviest contributors to P loading within the watersheds.

Objective 4: Increased adoption of conservation practices by farmers within the watershed. The farmer councils will determine which conservation practices are most useful and attractive to farmers within the watershed. They will create an incentives program before the start of the growing season, which will offer small amounts of compensation for farmers to adopt conservation practices. Farmers will be able to choose from a suite of incentive options the council has put together, which can include, but is not limited to: cover crop trials, corn stalk nitrate testing, nutrient management planning, manure spreader calibration, grass waterways, phosphorus indexing, grid sampling and bioreactors. A key component of the project model is the leadership taken by farmers in influencing each other. The council farmers will play a lead role in encouraging other farmers to become involved, using field days, mailings to other farmers, and one-on-one conversations.

Funding:

Staffing time: WI DNR provides funding for the project coordinator's position via UW-Extension, and supports ¼ staff time in each county LCD via a Lakes Grant (this is matched by the county for ½ FTE toward project).

Conservation incentives: The McKnight Foundation (a private, Minneapolis-based foundation) has provided a two-year grant of $100,000 total for the councils.

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Farmer-Led WATERSHED COUNCIL

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