2-Stage Drainage Ditch - The Nature Conservancy

October 1, 2007 through September 30, 2010

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The Nature Conservancy

Summary

The Issue

In Minnesota more than 25,000 miles of drainage ditches line agricultural fields. Many of these existing ditches were once headwater streams that were subsequently straightened. Unfortunately, the construction and conversion of these waterways to ditch systems has impacted the ecological health of Minnesota's rivers and has proven challenging for landowners to maintain.

Conventional ditches are wide and deep with steep sides that easily erode (Figure 1), impacting the stability of the ditch and contributing to excessive levels of nitrogen and phosphorus in streams and flooding, all of which can damage water quality and aquatic habitat. Once ditches are constructed or channelized, streams attempt to return to their natural course by meandering, resulting in even greater potential for erosion and deposition within the channel (Hansen, et. Al, 2006).

Conventional Ditches

- Require frequent and costly maintenance
- Contribute to excess nutrients and sediment in downstream rivers
- Lower the IBI (index of biological integrity)
- Provide limited ecological services for the local biotic community

The Solution: Two-Stage Drainage Ditch

In an effort to restore and protect water quality and ensure that agriculture-the largest income generator in the region-remains economically viable, The Nature Conservancy and its partners launched a first-of-its kind initiative in southeast Minnesota to test the benefits of installing a two-stage drainage ditch. Developed using methodology and software advanced by scientists Dan Mecklenburg and Andy Ward, the two-stage ditch features vegetated "benches" on each side of the ditch. The benches mimic the floodplains that occur naturally along streams. Additionally, the benches make the sides of the ditch more stable and the vegetation helps absorb water during high flow periods and filter nutrients from the water.

<u>Hypothesis</u>:

Ecological Benefits

- Increased nutrient removal
- Reduced turbidity
- More wildlife habitat

Potential Economic Benefits

- Improved bank stability and less erosion
- Increased water storage capacity
- Flood reduction
- Lower maintenance costs

Southeast Minnesota 2-Stage Ditch Conservation Innovation Grant

The USDA Natural Resources Conservation Service awarded The Nature Conservancy a Conservation Innovation Grant (CIG) in September, 2007. The University of Minnesota, Minnesota Pollution Control Agency coordinated and conducted water quality and quantity monitoring for the 2-stage ditch. The Conservancy provided cash and in-kind match toward the project along with grant and contract management.

Deliverables:

A During the period of award, the grantee is required to attend at least one meeting hosted by NRCS. The meeting will provide a forum for technical feedback among grantees and NRCS

   a. TNC project manager attended the 2010 SWCS Annual Conference and presented poster of the project in the CIG Showcase. This project was awarded first place for excellence.

B. A full length 2-stage ditch totaling nearly 7,000 linear feet in Minnesota, which will document the effectiveness of drainage design at reducing common impairments such as nutrients, sediment, altered hydrology and the lack of aquatic/riparian habitat.

   b. After further review the initial ditch intended to be converted to a 2-stage was not compatible. Approval was given by NRCS staff to move the project to a nearby ditch. 5,640 feet of 2-stage ditch was constructed along with multiple drainage water treatment practices. Pre-construction data was collected. There is ongoing monitoring for physical properties of the ditch along with physical, chemical and biological properties of water quality.

C. Provide an evaluation report to NRCS, State agencies, and other interested parties.

   c. This report will serve as an evaluation report and distributed to NRCS, state agencies and other interested parties. Updates to this report will be distributed once further data analysis for the project is completed.

D. Demonstration and information will be communicated at field days and through publications in the agriculture sector.

   d. Project partners hosted field days during and after construction of the project. Project process and results were communicated at 7 speaking events and via 4 print media outlets and a continuous feature on TNC's website.

<u>Project Modification</u>:

The original CIG proposal was intended to construct a 2-stage ditch within an existing Judicial Ditch upstream (north) of the City of Austin, MN. Each affected landowner was supportive of the 2-stage ditch design and spoke in favor of the project to the ditch authority. However, in the course of the site investigation process and design, a malfunctioning culvert was discovered and was holding water within the ditch. Construction of the 2-stage ditch would repair this culvert and increase flows to the City of Austin. Engineering studies and a hydraulic model showed no change to peak flow to the City of Austin. The indication that the project would result in increased flooding caused concern among Department of Natural Resources Division of Waters regulators and subsequently the drainage authority. This misunderstanding became an obstacle for the project. It was determined by project partners to avoid constructing the 2-stage ditch within a Judicial Ditch. At that point partners searched for a private ditch in need of repair that would be suitable for a 2-stage ditch design. This caused nearly a 2 year delay in the project and significant staff time by The Nature Conservancy. A new ditch needed to be surveyed and designed. Even more time consuming was reaching signed agreements with a new set of landowners.

Discussion

Constructing the 2-stage ditch on a private ditch system avoids the drainage authority process and the political implications that come with it. Proposing to construct an alternative ditch design on a Judicial Ditch proved to be a mistake. Partners had hoped that engaging a ditch authority with control over hundreds of miles of ditches would allow for the expansion of this alternative design and increase the knowledge of drainage authorities. The experience of this project highlights the difficulty in changing the mindset of local drainage authorities and their role in improving environmental performance of the public drainage system.

In order to expand this alternative drainage design to the thousands of miles of publicly administered ditches throughout Minnesota project partners must share the results with drainage engineers. Information will be shared with county commissioners, watershed districts and drainage engineers for years to come.

Reasons for a 2-Stage Ditch: The lands and waters throughout the Upper Mississippi River Basin sustain a robust agriculture economy and local communities. This productive landscape has come at a cost to some of the area's natural resources. Tributaries throughout the basin have been listed on the Clean Water Act Section 303(d) list as impaired for fecal coli form and turbidity. Another, often overlooked, threat to the area’s waters is altered hydrology. Several human actions have altered the hydrology of the basin's streams, including the removal of perennial vegetation, dams, subsurface and surface drainage systems. Altered hydrology in these streams can often contribute to increases in other impairments like sedimentation and aquatic habitat destruction along with limiting a streams ability to cycle nutrients.

Restoring hydrology in these drained watersheds is essential to maintaining aquatic biodiversity, not just in the headwater streams often directly affected by agricultural drainage, but larger river systems downstream where these drained waters concentrate in a short period of time contributing to floods that damage property, crops, aquatic habitat and the lives of residents. It is hoped that this project will help reduce flooding by increasing the storage capacity of a local ditch, attenuating and extending the water travel time.

In some areas, surface and subsurface drainage are considered essential to maintain productive agriculture. A 2-stage ditch is intended to be a new way to maintain agriculture ditches to achieve the drainage needed by crop producers and improve aquatic habitat within ditches, regulate hydrology, reduce in-stream sedimentation and increase nutrient cycling that will reduce nitrates entering the Mississippi River and thus the Gulf of Mexico. The design and construction of a 2-stage ditch in southern Mower County is a first step to maintain drainage, while mitigating its contribution of excess nutrients.

<u>How it Works</u>:

A two-stage ditch more closely mimics the functions of a natural channel than a trapezoidal ditch. Constructing a base-flow channel within the ditch geometry allows for sediment transport during low-flow periods. The size of the low-flow channel is based on a linear relationship between cross-sectional area and cumulative drainage area (Magner and Brooks, 2005). The remaining ditch bed serves as the bankfull or flood-flow portion of the channel. (Christner, Jr. et al. 2004). Frequent peak-flows (> 2-yr event) will overtop the low-flow channel bench and dissipate energy in an active floodplain located within the ditch geometry. Ditch banks serve as valley walls to contain infrequent peak-flows (25-yr event). Benefits of this design include: less maintenance, nutrient attenuation via buffering vegetation within the ditch geometry, and potentially increased hydraulic residence time.

Figure 1. Sedimentation and slumping banks.

Project Objectives and Results:

1) Design a two-stage ditch.

Prior to design of the 2-stage ditch, project partners conducted site reviews of several candidate ditches and specific ditch reaches to evaluate the suitability of a 2-stage ditch demonstration site. A 5,640 foot section of private ditch near Adams, MN, was selected with consideration to:

- Bank seepage
- Toe slope erosion
- Bank angle
- Vegetation
- Slumping
- Sediment storage and transport in the channel
- Hydrologic pathways and physical processes
- Regional curve of the area
- Cross-sectional data for the ditch reach (Figure 2)
- Profile data for the reach including bed, water elevation, bench and top of ditch (Figure 3)
- Bed material

Site surveys (Figure 4), ditch characteristics and regional hydrology information was used to develop a design by the Board of Water and Soil Resources' (BWSR) Agricultural Engineer with assistance from University of Minnesota Biosystems and Bioproducts Engineering. Please refer to Appendix A for all design sheets. Because the 2-stage ditch is an evaluation project and monitoring is being conducted, additional drainage conservation measures were designed and installed. Within the ditch channel a linear wetland (Figure 4) was designed. This is a narrow channel within the bench of the ditch parallel to the base flow channel. The linear wetland pre-treats tile water for about 30 feet before entering the ditch channel. Each side inlet and tile outlets were also rip rapped to stabilize banks and reduce erosion from these outlet pipes and minimize bank scouring (Figure 6).

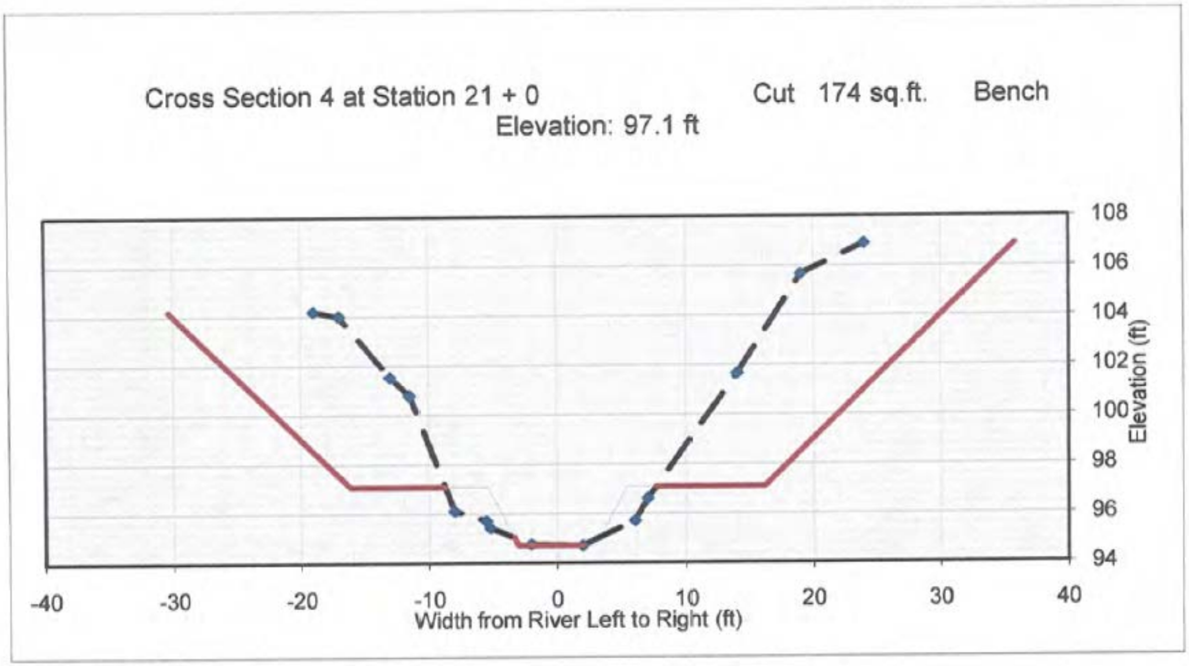

Figure 2. Survey of common existing cross section and 2-stage design.

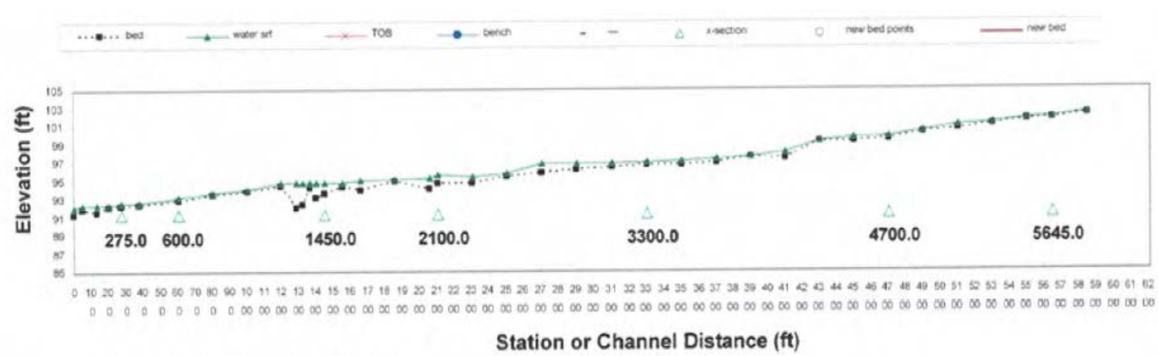

Figure 3. Longitudinal profile.

Figure 4. Identifying tile and side inlets.

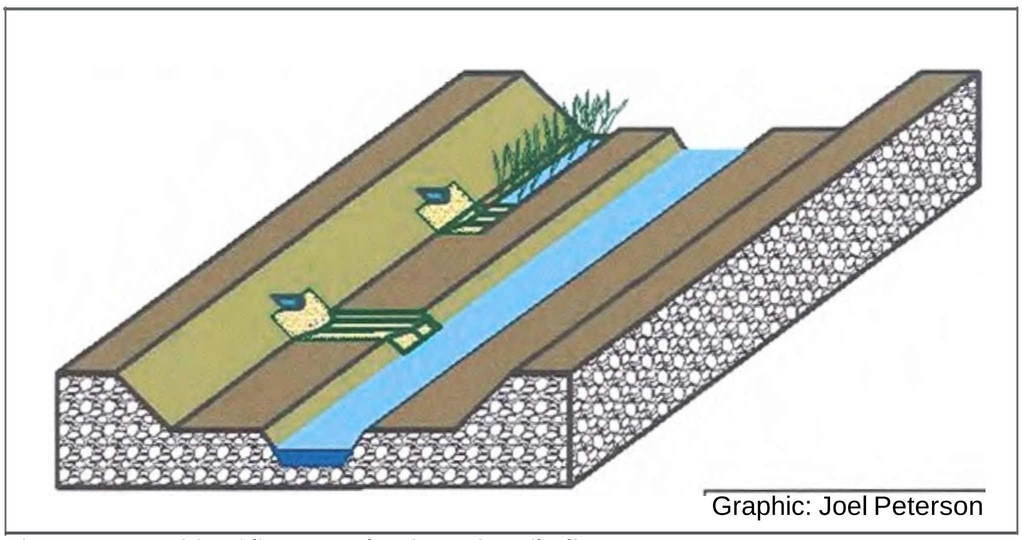

Figure 5. Graphic of linear wetland treating tile line.

Figure 6. Side inlet modifications.
Tile inlet prior to 2-stage construction — Side inlet post 2-stage construction

A modified side inlet (Figure 7) was also installed to hold water on the edge of the field before entering the ditch, forcing water through a rock lens (Figure 8) that slows runoff and filters phosphorous laden sediment.

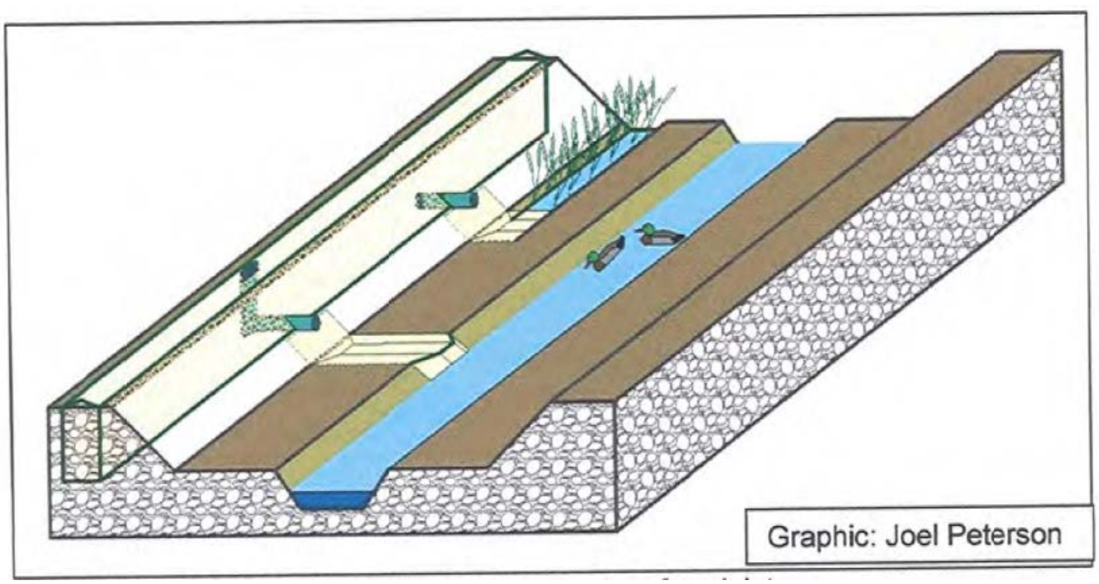

Figure 7. Modified side inlet with rock lens and surface inlet.

Figure 8. Top of modified side inlet showing rock lens.

Another common situation with drainage ditch instability is bank slumping (Figure 9) due to seepage forces on the ditch bank. U of M and BWSR engineers designed a seepage trench (Figure 10) set back from the ditch bank to accumulate seepage water and direct it via tile line to a stable portion of the ditch bank.

Figure 9. Portions of pre-construction ditch with slumping.

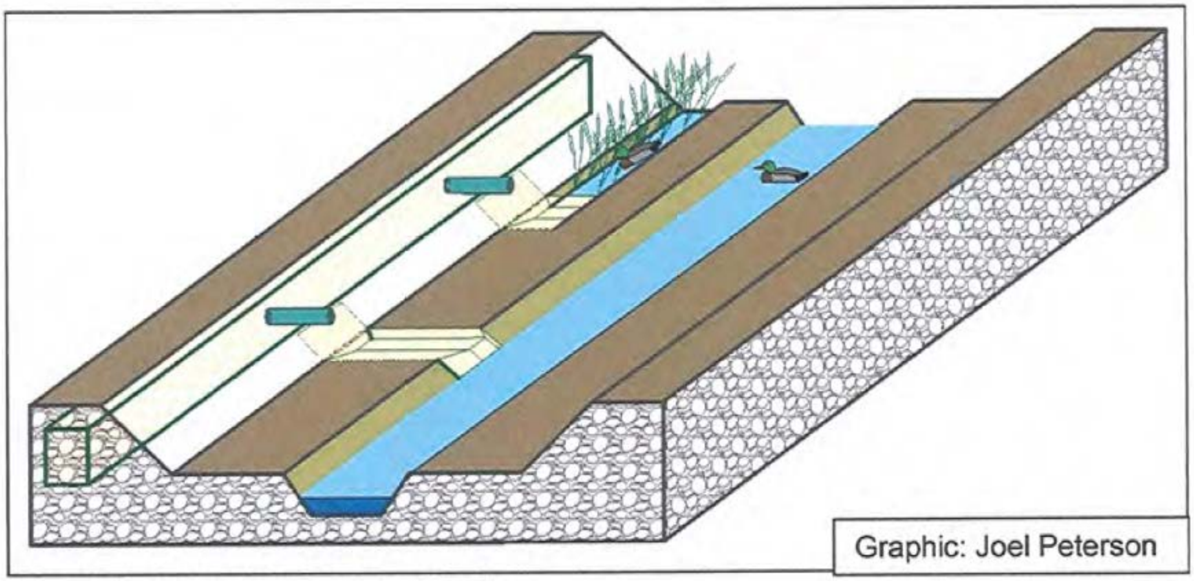

Figure 10. Diagram of seepage trench.

2) Construct a two--stage ditch.

Construction of the 2-stage ditch began on October 1, 2009, with onsite guidance from U of M, TNC and Mower SWCD project members. Construction of the 2-stage ditch and additional drainage conservation practices continued through November 2, 2009 (Figure 11 and 12). Erosion control practices were maintained daily to minimize sediment loss (Figure 13). A native ditch mix (Table 1) consisting of 11 grasses and 8 forbs was established during construction as erosion control blanket was placed. A cover crop of rye, oats and winter wheat was also seeded at this time.

Table 1. Native seed mix.

Species Common Name	Scientific Name	Seeding Rate (PLS Lbs/Acre)
Grasses:		
Oats	Avena sativa	25
Fringed Brome	Bromus ciliatus	1
Canada Wild Rye	Elymus canadensis	2.5
Slender Wheat Grass	Elymus trachycaulus	2.5
Virginia Wild Rye	Elymus virginicus	2
Fowl Bluegrass	Poa Palustris	2
Switchgrass	Panicum virgatum	3
Big Bluestem	Andropogon geraidii	2
Indiangrass	Sorghastrum nutans	1
Western Wheat Grass	Elytrigia smithii	1
Little Bluestem	Schizachyrium scoparium	2
Forbs:		
Purple Prairie Clover	Dalea purpureum	0.09
Showy Tic-trefoil	Desmodium canadense	0.09
Early Sunflower	Heliopsis helianthoides	0.08
Wild Bergamot	Monarda fistulosa	0.07
Black-eyed susan	Rudbeckia hirta	0.1
Blue Vervain	Verbena hastata	0.07
Swamp Milkweed	Ascelpias incamata	0.07
Golden Alexanders	Zizia aurea	0.15

Figure 11. Upstream end during initial construction.

Figure 12. Excavated 2-Stage ditch showing vegetation in base flow channel.

Figure 13. Placement of Erosion Control Blanket.

Due to various project delays the project was constructed after the growing season in 2009. It was a dormant seeding, but erosion control blanket was placed over the entire length of the ditch to minimize erosion. Because vegetation was not established some erosion took place on the upland bank and within the ditch channel where the blanket tore. The base flow channel remained relatively intact because existing vegetation was left undisturbed throughout most of the project length. Figures 14 through 20 show the 2-stage ditch from construction, vegetation establishment, flood event and post flood event.

Figure 14. Upstream end during construction.

Figure 15. 2-stage ditch in spring of 2010.

Figure 16. Upstream end 10 months following construction.

Figure 17. Upstream end during September 2010 flood event.

Figure18. Upstream end 1 week post September 2010 flood.

Figure 19. Stabilizing 2-stage ditch bench.

Figure 20. Stabilized 2-stage ditch bench June 2010.

Fixes

During the spring of 2010, following snow melt runoff, a status check of the ditch revealed several areas of malfunction:

- A bank failure occurred near the upstream end of the ditch (Figure 21).
  - It was determined the bank slumping was the result of an ice dam that gouged the ditch. Due to the late season construction and limited vegetation established, the banks were in a vulnerable position.
    - Bank was rebuilt and stabilized to original design (Figure 22).
- Significant erosion had also taken place on the field side of side inlets.
  - This was the result of inadequate rip rap and poor seed establishment.
    - More rip rap was placed and reseeded with erosion control blanket (Figure 23).
- Scour erosion had occurred at the outlet locations of side inlets and tile lines.
  - Outlet pipes were too short and insufficient rip rap was placed in some locations.
    - Outlet pipes were extended away from bank and additional rip rap was installed.
- Linear wetland was damaged causing direct tile outlet to main ditch channel.
  - Vegetation was not established to stabilize linear wetland berm.
    - Linear wetland was retrenched and stabilized.
- There was no crossing within the new 2-stage ditch.
  - A Missouri crossing was installed where a previous crossing existed (Figure 24).

Figure 21. Bank failure on 2-stage ditch spring 2010.

Figure 22. Repair of 2-stage ditch bank failure August 2010.

Figure 23. Rock inlet fixed with additional seeding and rip rap.

Figure 24. Missouri Crossing 2-Stage Ditch.

Result of Design, Construction and Fixes

Despite nearly a full month of rain during construction of the 2-stage ditch and construction occurring during the month of October at the end of the growing season, the ditch proved to be quite stable with the exception of the required fixes listed above. The cover crop and some native vegetation became established during the spring of 2010, with significant patches of giant ragweed. Installation of erosion control blanket over the cover crop and native seed was costly, but likely prevented additional erosion damage and instability in the constructed ditch. During the summer of 2010, most vegetation was established. The base flow channel was narrowed, with established vegetation and the bed material was mostly gravel, a sign of good habitat and stream function.

Ideally, the project would have been constructed in mid-summer during a period of low precipitation with enough time for vegetation to be established. Project partners were fortunate to work with a cooperative contractor that understood the project and required little on-site management.

3). Conduct monitoring and evaluate the conservation and economic value of this practice.

Watershed Description:
3,500 acres in size (Figure 25)
2.25 miles of open ditch treated
95% Cropland with corn, soybean and hay rotation with tile drainage

<u>Assessments</u>

Stability:
Bank and channel stability will be assessed using a combination of Rosgen's stability index and Simon channel evolution stage models as well as measurements of bank parameters bulk density, shear stress and moisture content (Figure 26).

- o Visual inspection (Figure 27)
- o Rosgen's and Simon's methods

Biological Monitoring:
Standard methods were used to obtain IBI scores for the drainage ditch and appropriate reference reaches prior to and after the construction of alternative designs. Fish and macroinvertebrate monitoring took place pre and post construction by Minnesota Pollution Control Agency staff. This data will be analyzed in the winter of 2010/2011. This is a good indication of habitat within the treatment reach (Figure 28).

Water Quality Monitoring:
Mass balances of nitrogen, phosphorus, and sediment will be used to evaluate the difference among design options (Figure 29) of (1) a two-stage ditch, (2) a recent clean-out ditch (Figure 30), and (3) a nearby undisturbed ditch (Figure 31). Extensive sampling of water quality parameters and flow rate will be used to perform the mass balances. Data for the nearby recent clean-out ditch and undisturbed ditch will be obtained from the monitoring sites operated by the Minnesota Department of Agriculture.

- Intensive nitrogen monitoring
  - o One week – cool and warm
  - o Detailed inflow (Figure 32) and outflow (Figure 33) measurements
  - o Use nitrate probe
- Automatic sampling probes
  - o Turbidity
  - o pH,
  - o Temperature

    - Dissolved Oxygen

- Monthly water samples
- Bi-weekly nitrate samples

Long-term Effectiveness Monitoring:

- nutrient attenuation
- sediment transport
- bank stability
- seepage forces
- biotic response

The monitoring and evaluation conducted during this project will inform researchers and other professionals on the effects of two-stage ditch design (Figure 34). If the results of this design indicate positive environmental effects, the information gathered will assist agencies and individuals implement a new approach to surface drainage systems. The project may demonstrate a new practice that will reduce nitrate inputs to our water and reduce the threat of flooding to downstream properties. The biological and habitat monitoring done during this project will increase our understanding of the habitat potential of improved drainage systems. Data will be analyzed by project partners on an annual basis. Project partners will communicate this analysis and facilitate a discussion of the potential of this design.

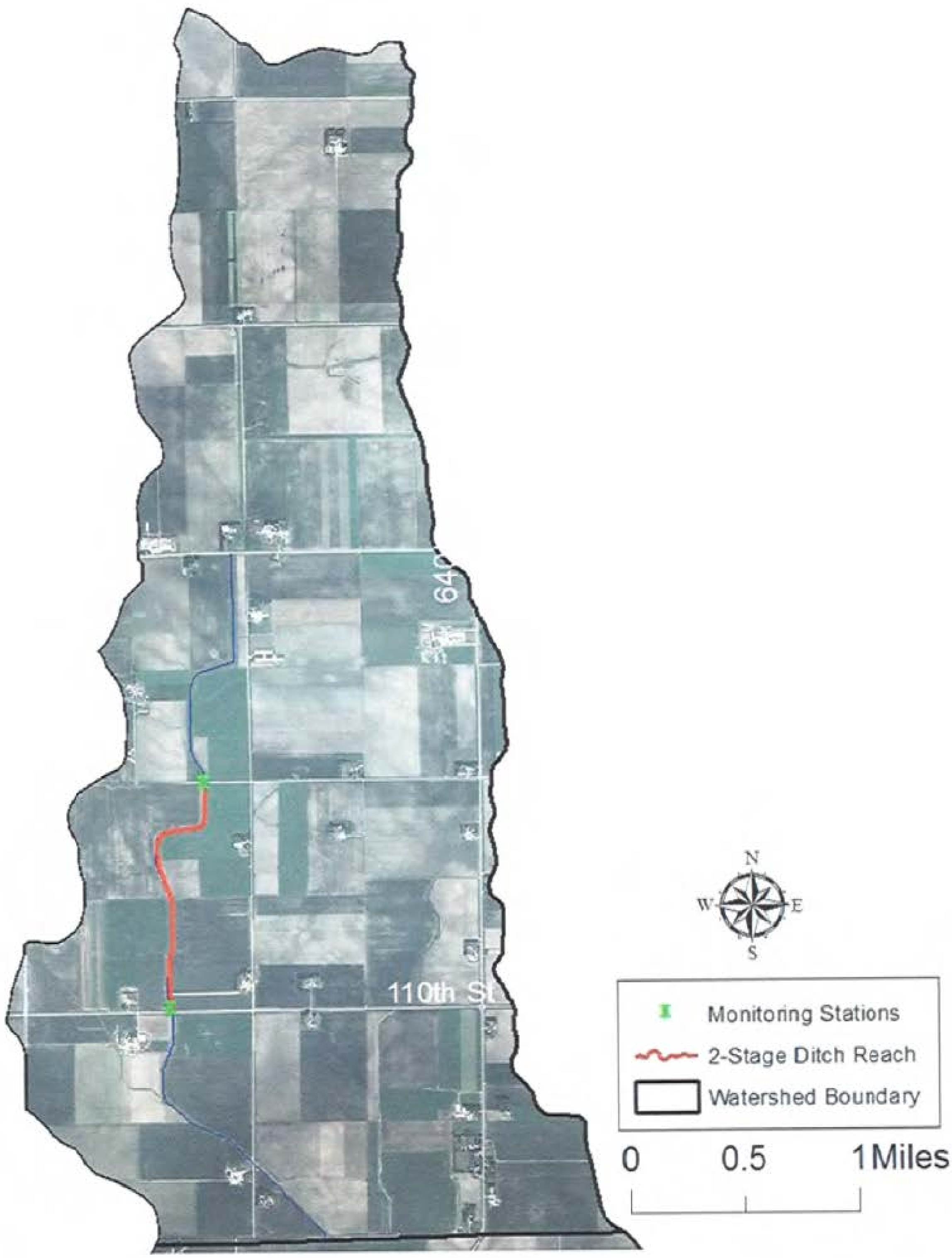

Figure 25. Watershed map of 2-Stage ditch.

Figure 26. Installation of monitoring wells to measure seepage forces.

Figure 27. Narrowed base flow channel.

Figure 28. Cobble ditch bed a sign of good aquatic habitat.

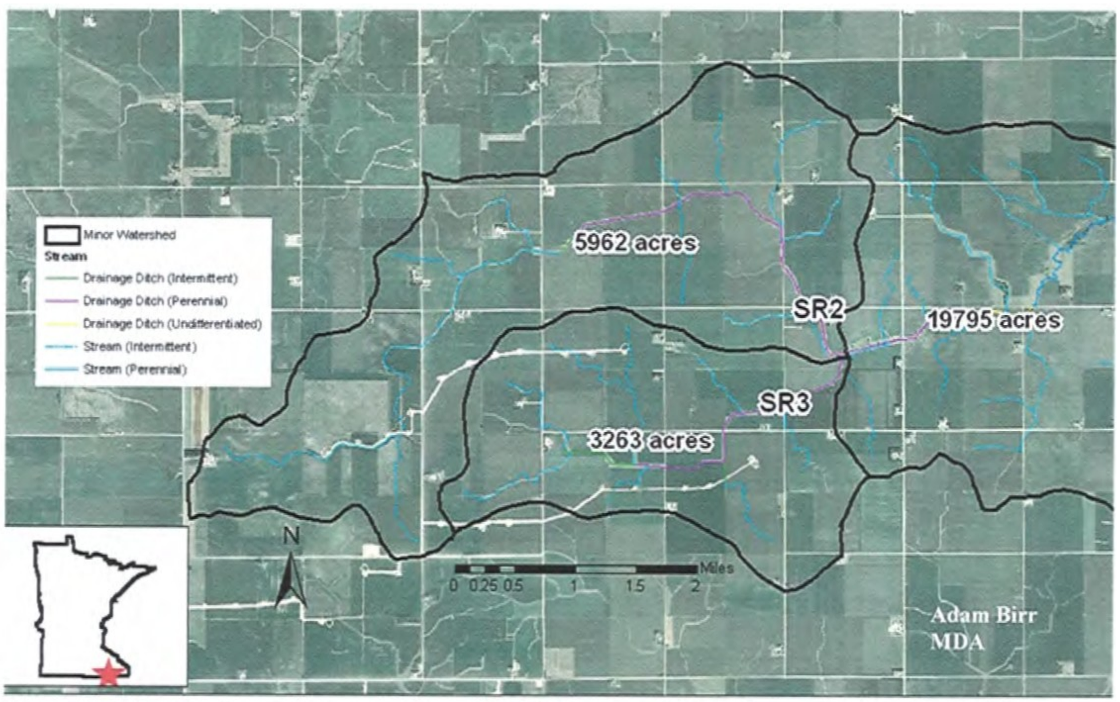

Figure 29. Watershed map of reference ditches.

Figure 30. Photo of reference ditch.

Figure 31. Photo of reference ditch.

Figure 32. Monitoring station at upstream end of ditch.

Figure 33. Monitoring station at downstream end.

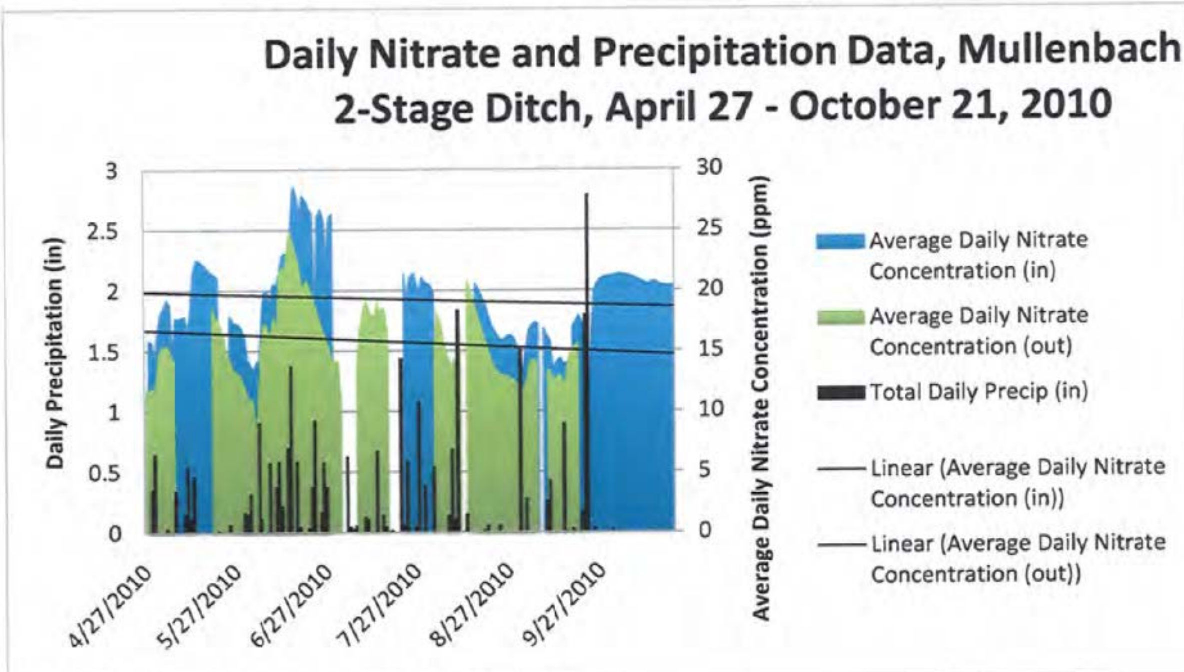

Figure 34. Daily nitrate and precipitation data.

<u>Discussion</u>

Since construction of the 2-stage ditch was delayed, the data collection post construction was also delayed. Unfortunately, there is insufficient data at this time to report the full environmental benefits of this 2-stage ditch. However, preliminary data does show a reduction in nitrates as indicated in Figure 34. Monitoring will continue on this ditch thanks to financial support from Minnesota Pollution Control Agency and the reference reaches funded by Minnesota Department of Agriculture for several years to come. While difficult to do, it is important for long-term funding to be secured for projects like this to truly evaluate effectiveness over the life of the project. We will continue to seek funding and technical resources to evaluate the effectiveness of the 2-stage ditch design as it relates to: nitrates, turbidity, peak flow, phosphorous, aquatic habitat and aquatic life.

University of Minnesota researchers purchased 2 Hach automatic nitrate probes for the project and placed them at the upstream and downstream monitoring locations. After calibration and comparison to analyzed grab samples the probes proved to be a useful tool to gather real time nitrate data without having to rely on grab samples or a costly automatic sampler.

Long-term bank stability monitoring is essential to evaluate the economic benefit of this practice. Routine ditch maintenance methods are less costly than a 2-stage approach. A basic "dipping" whereby just sediment and deposits are removed from the ditch bed for the same reach of ditch would have cost approximately $10,000-$12,000. A "dipping" with some bank grading and repair would have cost $12,000-$15,000. These estimated figures do not account for erosion control or replacement and improvement of tile and side inlets. Channel excavation for the 2-stage ditch cost $49,665. The increased cost is due to much more of the bank is being excavated to establish the bench. For the 2-stage ditch to be an economically viable ditch maintenance technique it would have to last 3 times longer than a conventional ditch for maintenance. Because this was a research and demonstration project additional costs were incurred for improvements to tile and side inlets. Because partners are sensitive to the issue of erosion and wanted to minimize erosion on site, erosion control costs were more than originally budgeted.

4) Disseminate results to producers, conservation professionals, local drainage authorities, ag-dralnage professionals and the general public.

The project intends to increase the understanding of this innovative approach to agriculture drainage. The project will also show that some natural fUnctions of our streams can be restored in cropland dominated landscapes. An essential function of the project is to advance a conversation of how existing drainage systems are managed. The construction of this 2-stage ditch has provided a tangible example of an alternative to the way surface ditches have been constructed and maintained for over 100 years.

Field Days:

During construction, project partners hosted about 25 participants to a presentation on the project and gave a tour of the site (Figure 35). Participants were able to see the various conservation practices installed while asking questions of the landowner, researchers, contractor and project partners.

Participants included:

- Soil and Water Conservation District Supervisors
- Pollution Control Agency reps
- County Drainage Engineers
- Private Drainage Firms
- Ditch Contractors
- Minnesota Dept. of Agriculture
- Agricultural Producers
- Board of Water and Soil Resources
- University of Minnesota Researchers

Figure 35. Tour participants getting wagon ride from ditch landowner.

Additional tours were given to Conservancy conservation partners from other states, including Iowa NRCS, RC&D, DNR and county conservation board staff. TNC watershed staff from Iowa, Indiana and Minnesota has also toured the site.

The Nature Conservancy also hosted tours of the 2-stage ditch to our corporate agriculture partners. The Conservancy works with our corporate partners to advance conservation practices with suppliers to corporate partners. Participants included multiple divisions within: Cargill, General Mills Incorporated and Harmel.

Presentations:

Power point presentations have been prepared for multiple audiences. Presentations have been given to:

- Basin Alliance for Lower Mississippi in Minnesota
- Cannon River Watershed Partnership
- Minnesota Agriculture and Water Summit
- Minnesota Association of Watershed Districts
- General Mills Incorporated Staff
- Minnesota Ag Water Resources Coalition (comprised of 13 agriculture groups in MN)

A poster was prepared for the 2-stage ditch project and presented at the 2010 Soil and Water Conservation Society Annual Conference in St. Louis, MO. The Minnesota 2-Stage ditch was a warded First Place Award for Excellence in the CIG Showcase Poster Presentation.

Appendix B Image of Poster.

Earned Media

The 2-stage ditch project was featured in a story by Minnesota Public Radio in January, 2010, http://minnesota.publicradio.org/display/web/2010/01/15/ditch-design/

AgriNews and Rochester Post Bulletin in January, 2010, http://www.agrinews.com/research/project/studies/new/ditch/design/storv-1771.html

The 2-stage ditch also appeared in spring 2010 article of Outdoor News, a Minnesota publication.

This 2-stage ditch and similar work in Indiana was featured in an October 2010, issue of Corn and Soybean Digest. http://cornandsoybeandiqest.com/conservation/bank-it-two-staqe-drainaqe-ditches-reduce-erosion-nutrient-runoff-and-maintenance

Information on the ditch can also be found on The Nature Conservancy's website, http://www.nature.org/whereweworklnorthamerica/states/minnesota/press/press4307.html

Transferability

There were many lessons learned during the course of this project as there often are during the course of innovative projects. Several of the lessons and results are transferable. The assessment and design methodology used on the 2-stage ditch could be transferred to other portions of the state. This is made possible by the regional hydrology work completed by the Minnesota Pollution Control Agency and the University of Minnesota. The seepage trench, linear wetland and rock side inlet designs have great potential to be used in other conventional and 2-stage ditch designs. As a result of the rock side inlet design on this project the practice will be evaluated further in a side by side study with a conventional side inlet on a nearby site. As a result of this 2-stage ditch, more will be installed in other portions of Minnesota based on the methodology and lessons learned on this project. A meeting between project partners and NRCS engineering staff occurred on 12/13/10 to review project outcomes and discuss next steps including additional pilot projects.

Conclusion

It is too soon in the life of the 2-stage ditch to fully assess the nutrient attenuation benefits of the practice. However, initial visual observation of the ditch does indicate habitat improvement and aquatic life improvement. The response to the 2-stage ditch has been positive and served to spark a discussion about expanding the use of the practice in Minnesota as a means of improving water quality and aquatic life.

Project Partners

- Mower Soil and Water Conservation District
- Rick Morrison
- Bev Nordby
- Bruce Wilson, Professor, Bioproducts and Biosystems Engineering, University of MN
- Brad Hansen, Senior Scientist, Bioproducts and Biosystems Engineering, U of MN
- Geoffrie Kramer, Research Assistant, Bioproducts and Biosystems Engineering, U of MN
- Joe Magner, Research Scientist, Minnesota Pollution Control Agency
- Joel Peterson, Principal Engineer, Minnesota Board of Water and Soil Resources

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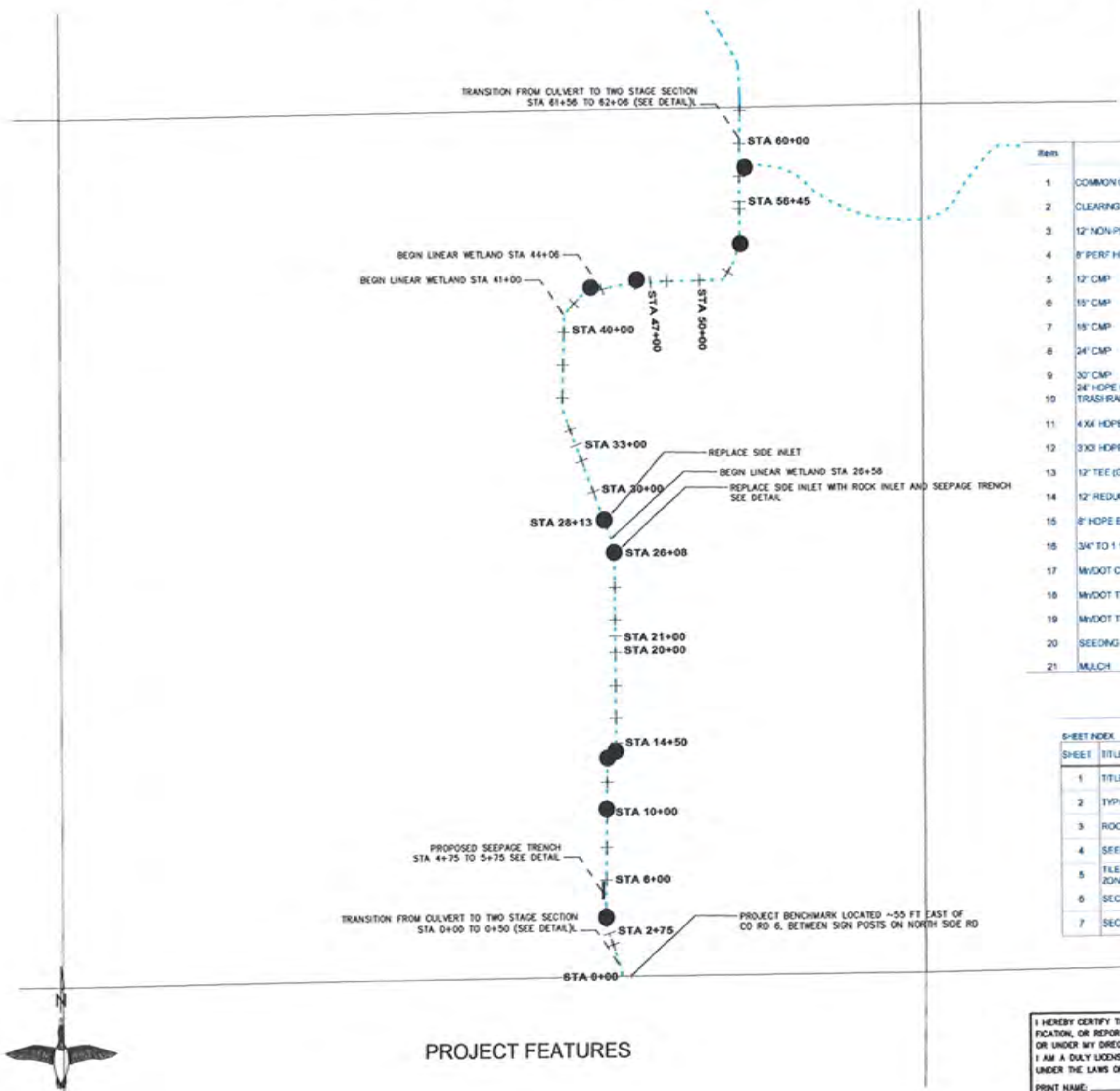
MULLENBACK TWO STAGE DITCH

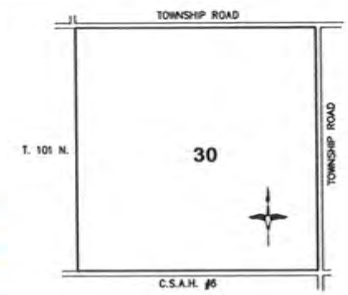


PROJECT FEATURES

Item	Description	Units	Quantity
1	COMMON CHANNEL EXCAVATION (PV)	CY	30,100
2	CLEARING AND GRUBBING	HR	24
3	12" NON-PERF HDPE (GOLDLINE OR EQUAL)	LF	62
4	8" PERF HDPE DRAIN TILE (GOLDLINE OR EQUAL)	LF	120
5	12" CMP	LF	40
6	15" CMP	LF	40
7	18" CMP	LF	80
8	24" CMP	LF	160
9	30" CMP	LF	80
10	24" HDPE CATCHBASIN, 8 LF W/ ENDCAP & TRASHRACK	EA	1
11	4X4 HDPE ANTI-SEEP COLLAR	EA	8
12	3X3 HDPE ANTI-SEEP COLLAR	EA	4
13	12" TEE (GOLDLINE OR EQUAL)	EA	2
14	12" REDUCING TEE (GOLDLINE OR EQUAL)	EA	4
15	8" HDPE ENDCAP (GOLDLINE OR EQUAL)	EA	4
16	3/4" TO 1 1/2" CLEAR WASHED ROCK	TN	90
17	MnDOT CL III RIPRAP	TN	250
18	MnDOT TYPE II GEOTEXTILE	SY	500
19	MnDOT TYPE I GEOTEXTILE	SY	215
20	SEEDING	AC	10
21	MULCH	AC	10

SHEET INDEX

SHEET	TITLE
1	TITLE SHEET
2	TYPICAL TWO STAGE DITCH SECTION
3	ROCK TRENCH SIDE INLET DETAILS
4	SEEPAGE TRENCH AND LINEAR WETLAND DETAILS
5	TILE AND SIDE INLET OUTFALL AND TRANSITION ZONE DETAILS
6	SECTIONS 2+75 - 14+50
7	SECTIONS 47+00 - 56+45



LOCATION MAP
SCALE: 1" = 1320'

TILE OUTLET LOCATIONS		
STATION	TILE SIZE	ACTION
2+23	8"	CUTOFF, CONSTRUCT OUTFALL
4+23	24"	CUTOFF, CONSTRUCT OUTFALL
9+88	6"	CUTOFF, CONSTRUCT OUTFALL
13+40	12"	CUTOFF, CONSTRUCT OUTFALL
15+82	8"	CUTOFF, CONSTRUCT OUTFALL
26+58	10"	CUTOFF, LINEAR WETLAND
28+41	6"	CUTOFF, CONSTRUCT OUTFALL
29+00	8"	CUTOFF, CONSTRUCT OUTFALL
33+00	UNKNOWN	CUTOFF, CONSTRUCT OUTFALL
33+35	12"	CUTOFF, CONSTRUCT OUTFALL
41+00	6"	CUTOFF, LINEAR WETLAND
44+06	8"	CUTOFF, CONSTRUCT OUTFALL
57+16	12"	CUTOFF, LINEAR WETLAND
57+73	12"	CUTOFF, CONSTRUCT OUTFALL

SIDE INLET LOCATIONS - USE CMP		
STATION	EXISTING TILE SIZE/NEW TILE SIZE	ACTION
3+05	30"/30"	REPLACE, CONSTRUCT OUTFALL
4+23	24"/24"	REPLACE, CONSTRUCT OUTFALL
9+20	18"/18"	REPLACE, CONSTRUCT OUTFALL
12+85	24"/24"	REPLACE, CONSTRUCT OUTFALL
26+08	SEE DETAIL	CONSTRUCT ROCK INLET AND SEEPAGE TRENCH
28+13	24"/24"	REPLACE, CONSTRUCT OUTFALL
43+62	14"/15"	REPLACE, CONSTRUCT OUTFALL
45+85	24"/24"	REPLACE, CONSTRUCT OUTFALL
54+41	18"/18"	REPLACE, CONSTRUCT OUTFALL
55+70	10"/12"	REPLACE, CONSTRUCT OUTFALL
56+82	30"/30"	REPLACE, CONSTRUCT OUTFALL

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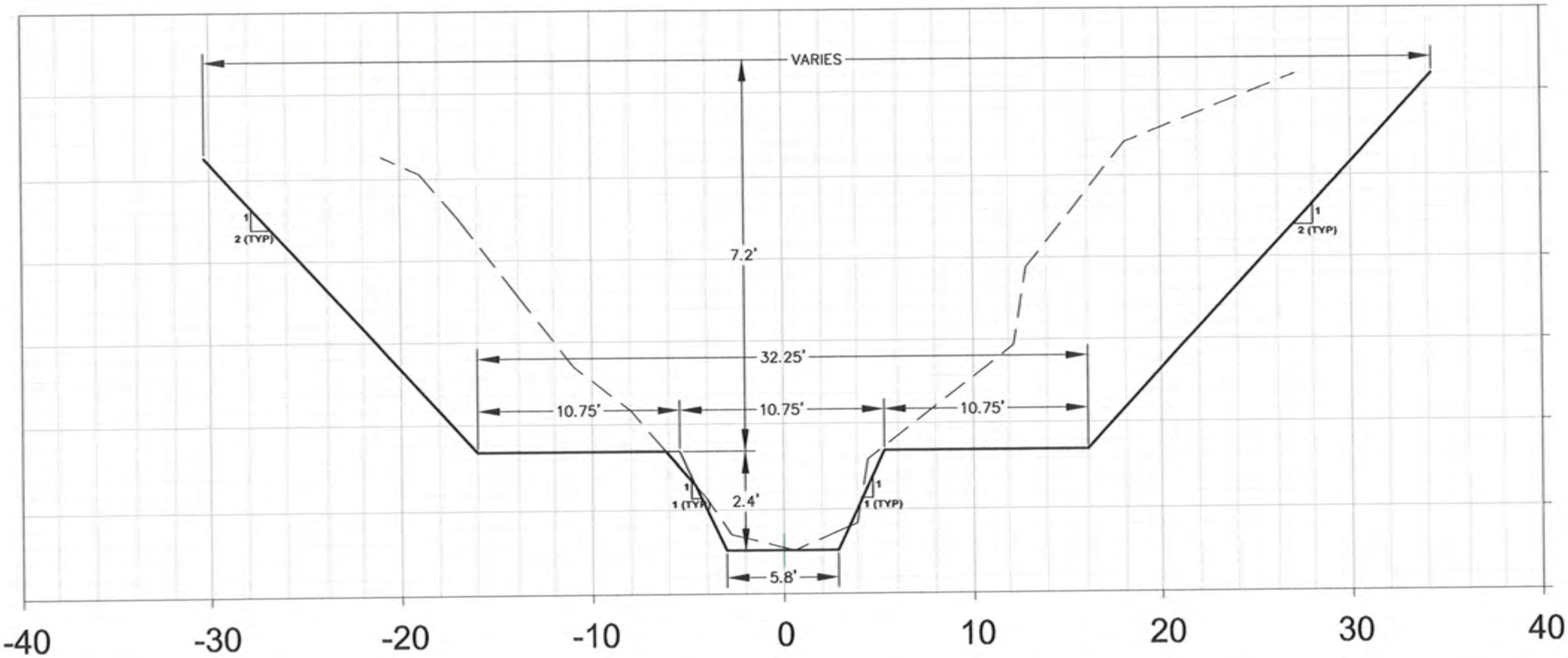
DATE: ______ LICENSE #: ______

ENGINEERING SECTION
Survey N/A | Designed
Drawn JRP | Drawn JRP
Checked | Checked
Horiz Datum | Vert Datum ASSUMED
Sec. 30 | T. 101 N. | R. 16 W. | County MOWER | Twp ADAMS
Job No. 05019 | Easement No. | File | Plan Sheet 1 of 7

MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

Minnesota Board of Water & Soil Resources



TYPICAL CROSS SECTION

NOTES:
SEED AND MULCH ALL DISTURBED AREAS IN ACCORDANCE WITH SPECIFICATIONS

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Drawn JRP | Drawn JRP
Checked | Checked
Hort Datum | Vert Datum ASSUMED

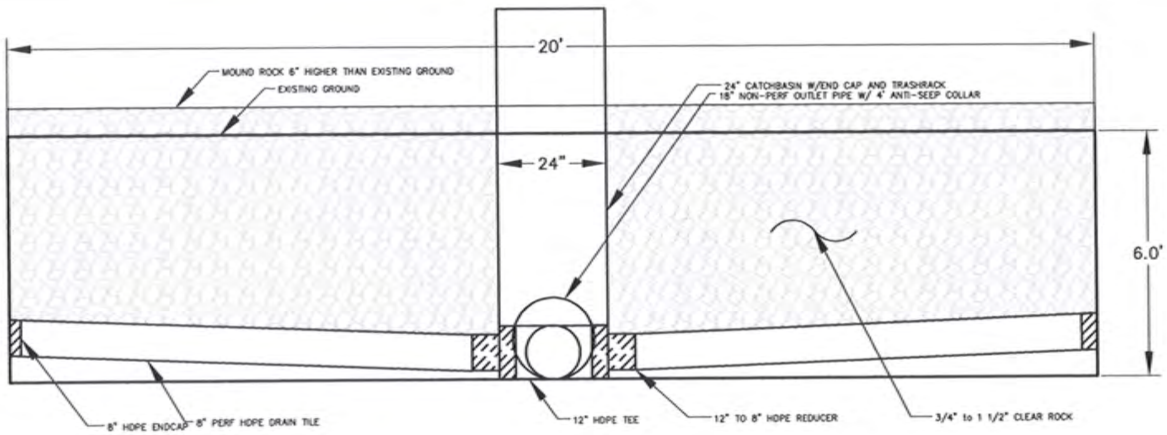
MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

Sec. 30 | T. 101 N. | R. 18 W. | County MOWER | Twp ADAMS

Job No. | Easement No. | File | Plan Sheet 2 of 7

Minnesota Board of Water & Soil Resources

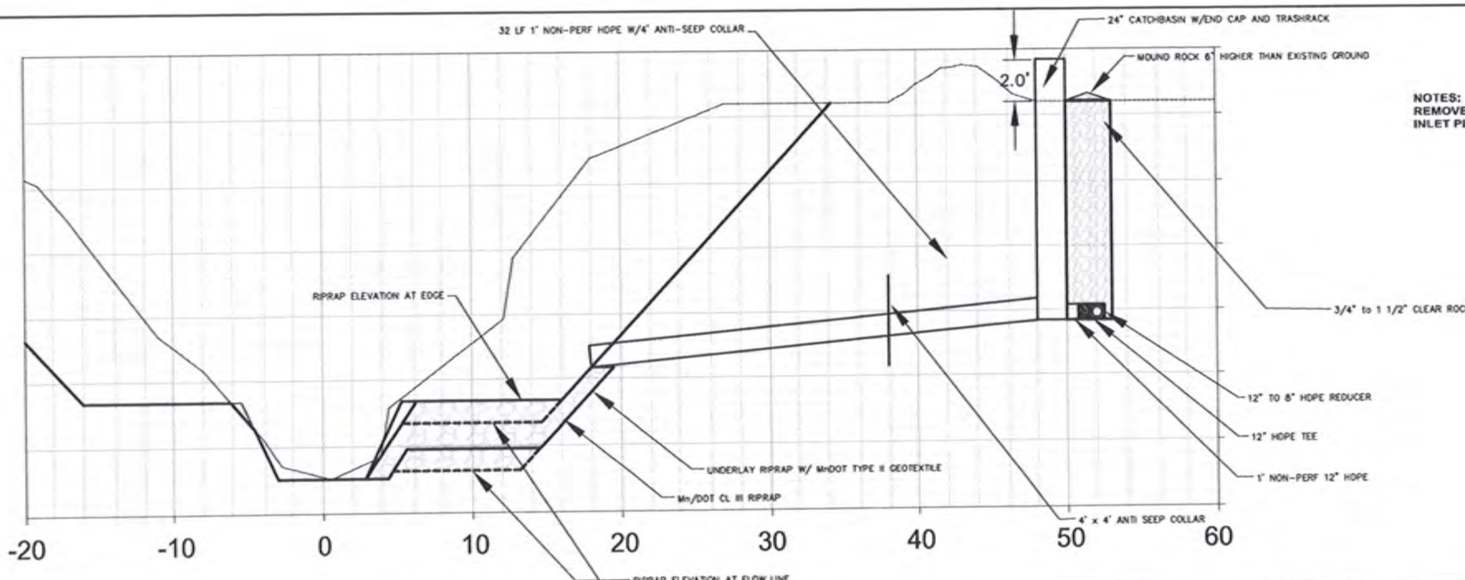


NOTES:
SIDES AND BOTTOM OF ROCK TRENCH SHALL BE COVERED WITH MN/DOT TYPE 1 GEOTEXTILE. OVERLAP SEAMS 1' MIN.

ALL SEALS OUTSIDE OF TRENCH SHALL BE WATERPROOF

ROCK SHALL BE APPROVED BEFORE PLACEMENT BY TNC AUTHORIZED REPRESENATIVE

ROCK TRENCH SIDE INLET



NOTES:
REMOVE AND DISPOSE OF EXISTING SIDE INLET PIPE (INCIDENTAL)

ROCK TRENCH SIDE INLET CROSS SECTION

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ENGINEERING SECTION

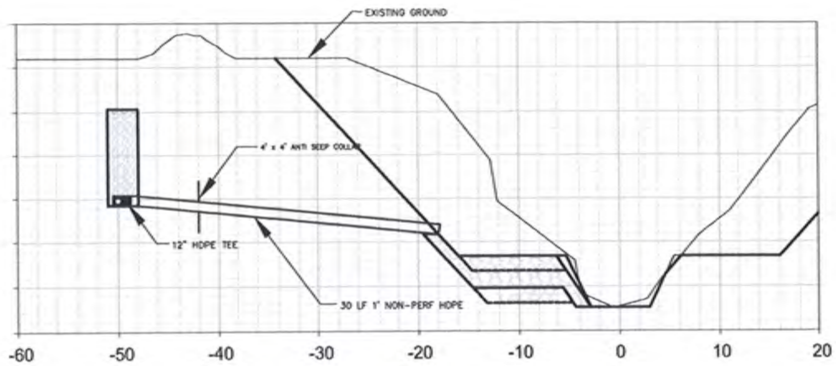
MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

Sec. 30 T. 101 R. 18 County MOWER Twp ADAMS

Sheet 3 of 7

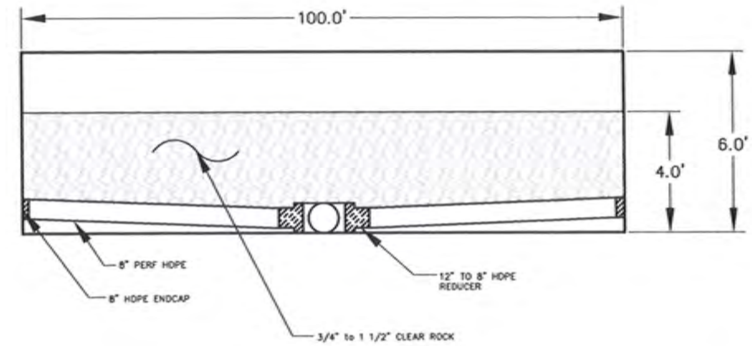
Minnesota Board of Water & Soil Resources



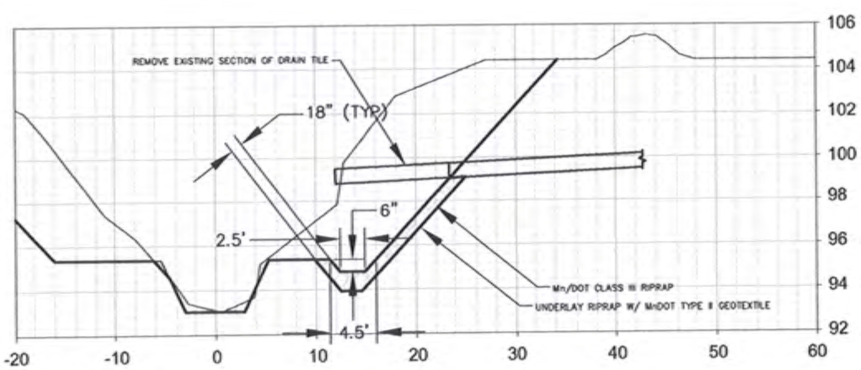
SEEPAGE TRENCH CROSS SECTION
(STA 4+75 TO 5+75)

NOTES:
SIDES AND BOTTOM OF ROCK TRENCH SHALL BE COVERED WITH MN/DOT TYPE 1 GEOTEXTILE. OVERLAP SEAMS 1' MIN.

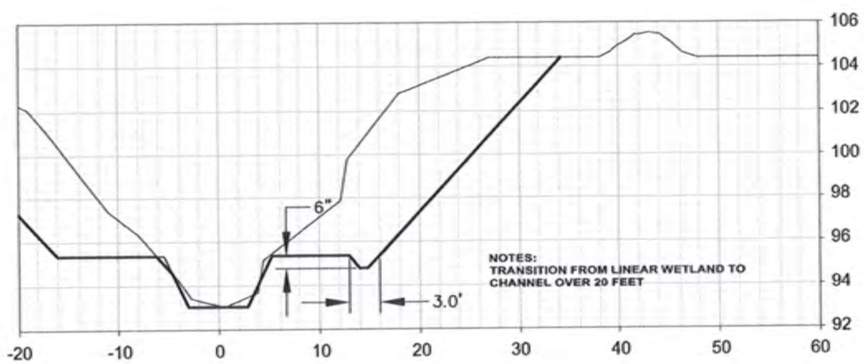
ROCK SHALL BE APPROVED BEFORE PLACEMENT BY TNC AUTHORIZED REPRESENATIVE



SEEPAGE TRENCH DETAIL



TILE OUTLET AT LINEAR WETLAND DETAIL



NOTES:
TRANSITION FROM LINEAR WETLAND TO CHANNEL OVER 20 FEET

LINEAR WETLAND TYPICAL CROSS SECTION

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ENGINEERING SECTION

MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

County MOWER

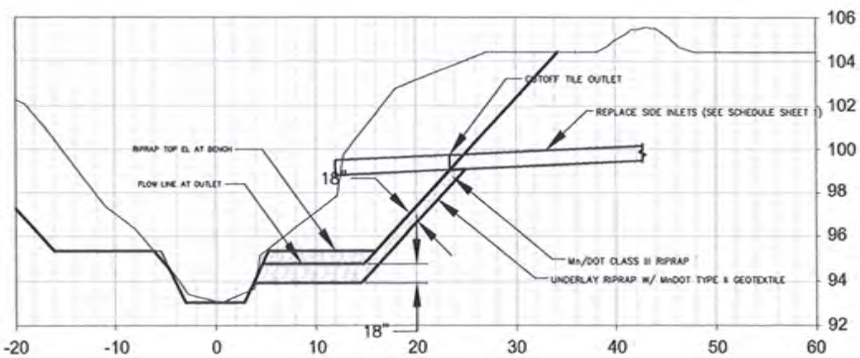
Twp ADAMS

Sheet 4 of 7

Minnesota Board of Water & Soil Resources

NOTES:

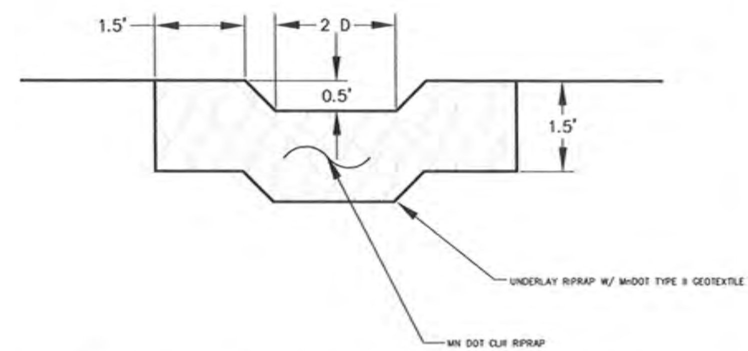
SPEC FOR SIDE INLET REPLACEMENT SHOWN ON SHEET 7



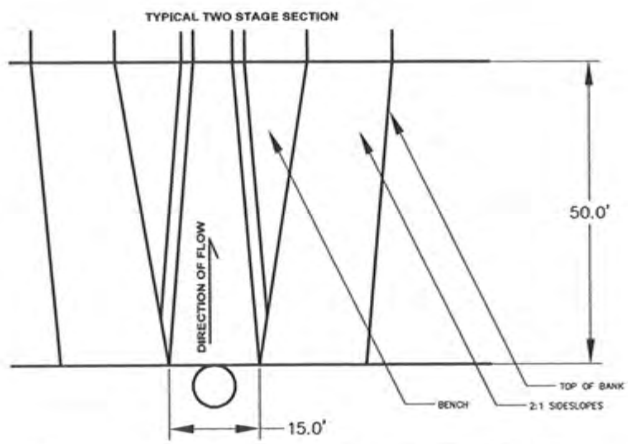
TILE INLET AND SIDE INLET OUTFALL DETAIL

NOTES:

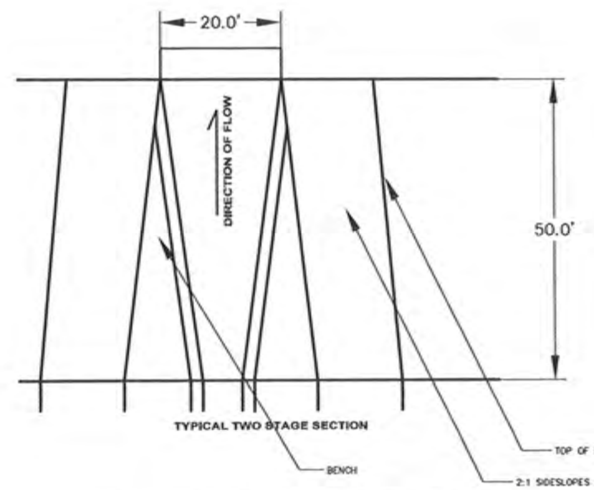
D IN CROSS SECTION DIMENSION IS PIPE DIAMETER



TILE INLET AND SIDE INLET TYPICAL CROSS SECTION



UPSTREAM TRANSITION FROM 7' CULVERT TO DITCH



LINEAR WETLAND TYPICAL CROSS SECTION

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ENGINEERING SECTION

MINNESOTA BOARD OF WATER & SOIL RESOURCES

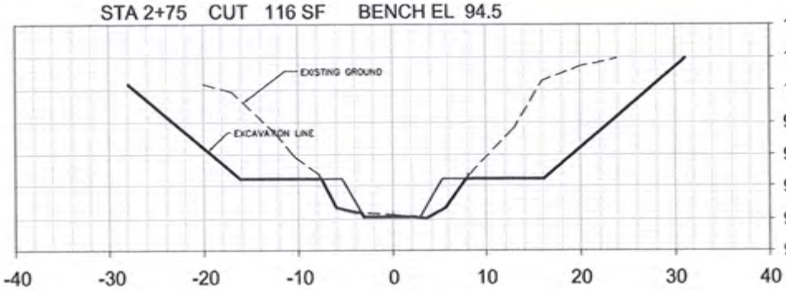
MULLENBACK DITCH
TWO-STAGE DITCH

Sec. 30 | T. 101 | R. 18 | County MOWER | Twp ADAMS

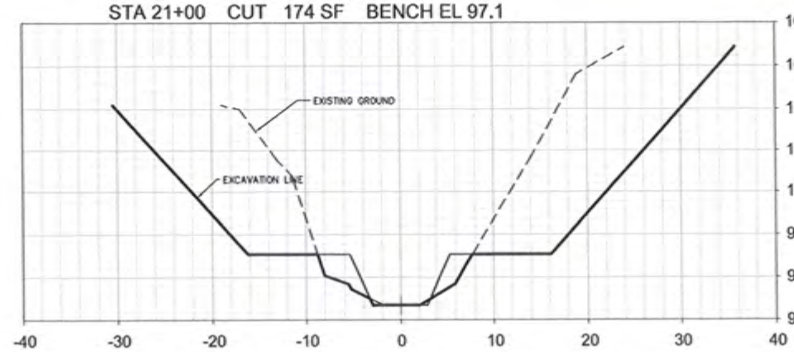
Plan Sheet 5 of 7

Minnesota Board of Water & Soil Resources

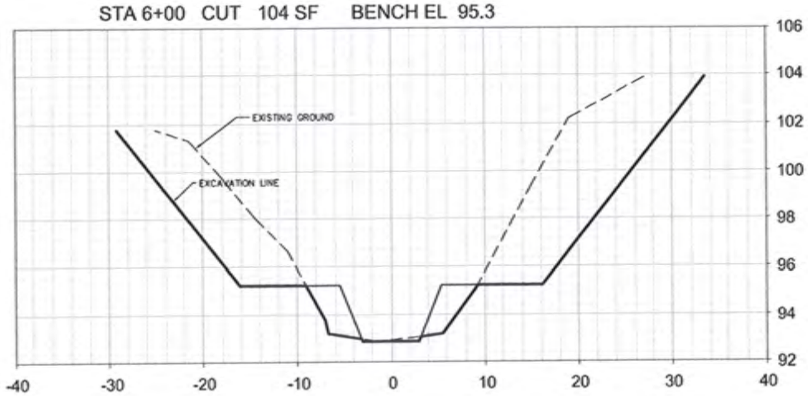
STA 2+75 CUT 116 SF BENCH EL 94.5



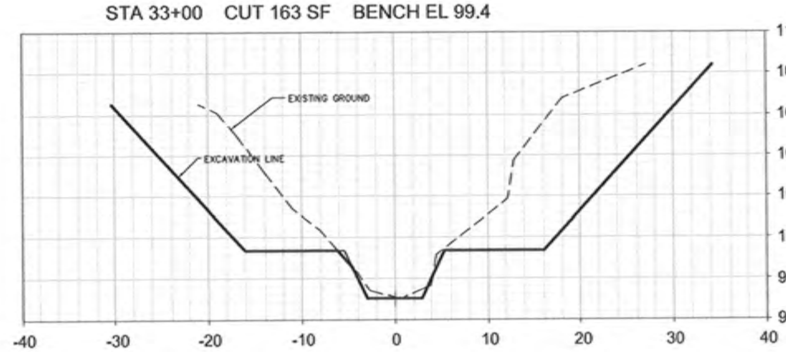
STA 21+00 CUT 174 SF BENCH EL 97.1



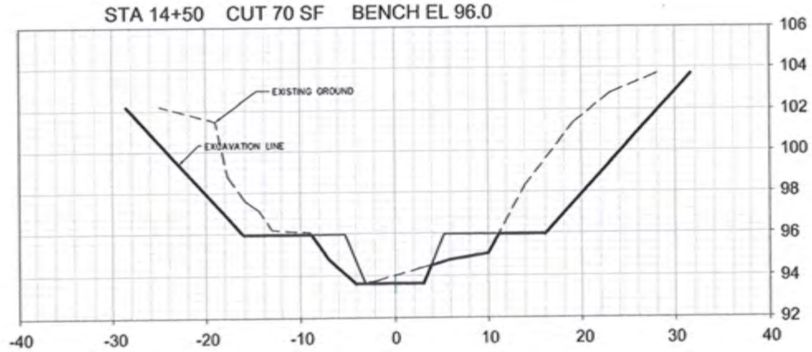
STA 6+00 CUT 104 SF BENCH EL 95.3



STA 33+00 CUT 163 SF BENCH EL 99.4



STA 14+50 CUT 70 SF BENCH EL 96.0



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ENGINEERING SECTION

Survey N/A | Designed
Drawn JRP | Drawn JRP
Checked | Checked
Horz Datum | Vert Datum ASSUMED

Sec. 30 T. 101 N. R. 16 W. County MOWER Twp ADAMS

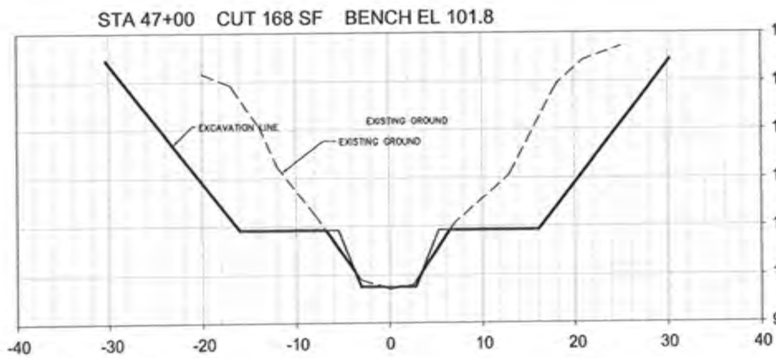
Job No. | Easement No. | File

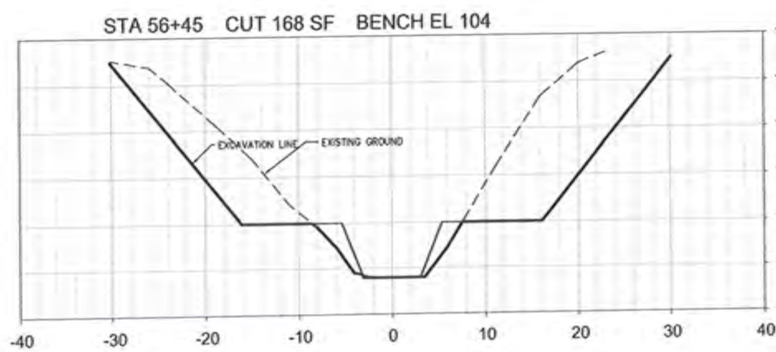
MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

Plan Sheet 6 of 7

Minnesota Board of Water & Soil Resources





CONSTRUCTION SPECIFICATIONS (HORIZONTAL PIPE):

GENERAL

All pipes, anti-seep diaphragms, connecting bands and other appurtenant sections shall be of the size, length, gauge and type specified on the drawing.

All materials are to be supplied by the Contractor unless otherwise specified in the plans. All materials must be handled and stored in a careful and workmanlike manner. Unless otherwise noted, all pipes and fittings must be attached according to manufacturers' recommendations. All materials shall be carefully inspected before they are installed.

MATERIALS (CORRUGATED METAL PIPE)

Unless otherwise specified, the pipe corrugations may be either riveted annular or lock-seam helical. Lock-seam helical pipe shall have re-rolled ends with each end having a minimum of four corrugations.

All corrugated metal pipe (CMP) shall be metallic zinc-coated unless otherwise specified. Other coatings include aluminum-coated, aluminum-zinc alloy-coated. The pipe shall conform to the requirements of ASTM-A-760, A 762, A-885, for the specified type, class, and fabrication of pipe and coating. When necessary, fittings including coupling bands shall be made from steel conforming to ASTM-A-444, A-742, A-806, and A-885. The coating of fittings shall be the same as that specified for the corrugated metallic-coated pipe.

When specified, aluminum corrugated pipe shall be used conforming to the requirements of ASTM-B-745 or B-790 for the specified pipe sheet thickness, shape type, and fabrication method. When necessary, fittings including coupling bands shall be made from sheet aluminum meeting the requirements contained in ASTM-B-744. The coating of fittings shall be the same as that specified for the corrugated aluminum pipe.

When coatings in addition to metallic coatings are specified, they shall conform to the requirements of ASTM-A-762, A-849 and A-885 for the specified type. These coatings shall be applied equally both on the inside and outside of the pipe surface. Polymer coated pipe shall be coated with a minimum thickness of 0.01 inches (10 mils), designated as grade 10/10 in ASTM-A-762.

Coupling bands of the appropriate size and type are to be provided for each pipe joint. The hardware for fastening the coupling bands to the connecting pipes shall be fabricated to permit sufficient tightening to provide the required joint tensile strength and water tightness, without failure of the fastening. Gaskets, if specified, are to be provided for each coupling band and fitting. These gaskets shall be those recommended by the manufacturer for use with the coupler, fitting, and pipe.

Annular Pipe
Watertight coupling bands for annular pipe shall either be an annular corrugated band with a minimum width of 25.5 inches (10 corrugations) and equipped with four rods and lugs for each band or a 12-inch wide "Hugger" band with O-ring gaskets or equal. Annular corrugated connecting bands for corrugated metal pipe shall be a minimum of 16 gauge. Annular corrugated coupling bands shall be coated on the inner surface with Trumbull 5x mastic sealer or other acceptable polymer caulking material.

Helical Pipe
Watertight coupling bands for helical pipe shall either be an annular corrugated band with a width of 20.4 inches (8 corrugations) and equipped with four rods and lugs for each band or a 12-inch wide "Hugger" band with O-ring gaskets or equal.

MATERIALS ("DUAL-WALL" HDPE PIPE)

Unless otherwise specified, the High Density Polyethylene Pipe (HDPE) shall have a smooth interior and annular exterior corrugations. Manning's "n" value for the pipe shall not exceed 0.012.

For pipe sizes 12 inches and larger, the pipe shall meet the requirements of AASHTO M294 Type S. Pipe and fitting material shall be high-density polyethylene meeting the requirements of ASTM D3350 Cell Classification 325420C. Where joints are necessary, pipes shall be joined with a bell-and-spigot joint meeting the requirements of AASHTO M252 or M294. The bell shall be an integral part of the pipe and provide a minimum pull-apart strength of 400 lbs. The bell-and-spigot joint shall incorporate a rubber gasket meeting the requirements of ASTM F477 and shall be watertight meeting ASTM D3212. Gaskets shall be installed on the pipe or as recommended by the pipe manufacturer. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

For pipe sizes 10 inches & smaller, the pipe shall meet the requirements of AASHTO M252 Type S. Pipe and fitting material shall be high-density polyethylene meeting the requirements of ASTM D3350 minimum Cell Classification 324420C. Gasketed couplers shall be provided for each pipe joint and must meet the requirements of ASTM F477. The gaskets shall be those recommended by the manufacturer for use with the coupler, fittings, and pipe to provide water tightness to the joint.

MATERIALS (ANTI-SEEP DIAPHRAGM)

When required, the anti-seep diaphragm shall be manufactured from high density polyethylene (HDPE), unless otherwise stated. It shall be a two piece collar that conforms to the pipe material specified. The HDPE material shall be no less than 1/4 inch in thickness. The two portions of the anti-seep diaphragm shall overlap 1.5 inches prior to being bolted together. 3/8 inch holes shall be spaced 8 inches on center to allow for bolting of two portions together. 1/4 inch stainless steel bolts and hardware shall be supplied and used to connect the sheets together. Stainless steel bands shall also be supplied and used to clamp the collar to the pipe. Unless otherwise specified by the manufacturer, the inside yoke of the collar shall be coated with Trumbull 5X mastic sealer or other acceptable polymer caulking material prior to securing the pipe. All other installation requirements/instructions shall be in accordance with the recommendation of the manufacturer. The anti-seep diaphragm shall be located as staked or determined in the field by the Project Technician. Approved manufacturer: Scholb Drainage Products #660-445-2343 or equivalent.
observed.

HANDLING THE PIPE

The Contractor shall furnish all equipment necessary to transport and place the pipe without damaging it or its coatings. Measures shall be taken to prevent impact blows, abrasion damage, and gouging or cutting (by equipment or other site materials). The pipe shall be placed with care and shall not be dropped or dumped into the trench. All special handling requirements of the manufacturer shall be strictly observed. Special care shall be taken to avoid impact when the pipe must be handled at temperatures of 40 ° F or less.

LAYING AND BEDDING

The pipe shall be uniformly and continuously supported. Blocking or mounding shall not be done to bring the pipe to grade. Prior to any back filling, the pipe shall be firmly and uniformly bedded throughout its full length to the depth and in the manner specified on this drawing. Bell holes shall be made in the bedding under bells or couplings to prevent the pipe from being supported by the bell/coupling. The trench width shall be as shown to permit installation and provide adequate bedding conditions suitable to support the load on the conduit.

Unless otherwise stated, the HDPE pie shall be installed with the bell end facing upstream. Annular CMP pipe shall be laid with the outside laps of circumferential joints pointing upstream and the with longitudinal laps at the sides at about the vertical mid height of the pipe.

BACK FILLING

Compaction of the initial backfill shall be by hand tamping or manually directed power tampers adjacent to and to a depth of 2 feet over the pipe to provide adequate lateral support to the pipe. The backfill around any anti-seep diaphragms shall be done in a comparable manner. The initial backfill material shall be selected friable soil free from rocks or stones larger than 1 inch in diameter and earth clods greater than 2 inches in diameter. At the time of placement, the moisture content of the material shall be such that a firm compacted fill can be achieved. During the initial backfill, the thickness of layers before compaction shall not exceed 4 inches. The moisture content of the backfill material shall be maintained within the limits required to: a) allow the soil to form a ball that does not readily separate when kneaded in the hand; b) prevent adherence of the fill material to the equipment treads or tracks; c) prevent rutting by equipment, and; d) ensure that blending of the soil results in a reasonably homogenous mass. Initial backfill shall be compacted to a density equal to that of the surrounding undisturbed soil. Special care shall be taken to obtain compaction under the lower half of the pipe. The pipe shall be loaded sufficiently during backfilling around the sides to prevent it from being lifted from the bedding or sub grade and to maintain full contact with the bedding during placement operations.

The final backfill material shall be free of large rocks, frozen soil, and other debris larger than 4 inches in diameter. The material shall be placed and spread in approximately uniform layers in such a manner that there will be no unfilled spaces in the backfill and the backfill will be level with the natural ground or the design grade. Rolling equipment shall not be used to compact the final backfill until at least a 2-foot depth of cover has been placed over the pipe. During the final backfill, the thickness of layers before compaction shall not exceed 9 inches.

The use of compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive displacements or which may damage the installed pipe will not be permitted. All special backfilling requirements of the pipe manufacturer shall be met.

OTHER:

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PRINT NAME: ______

SIGNATURE: ______

DATE: ______ LICENSE #: ______

ENGINEERING SECTION

MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACK DITCH
TWO-STAGE DITCH

Vert. Datum ASSUMED

Sec. 30 T. 101 N. R. 15 W. County MOWER Twp ADAMS

Plan Sheet 7 of 7

Minnesota Board of Water & Soil Resources