

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.

Hypothesis:

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.

Project Modification:

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.

How it Works:

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).

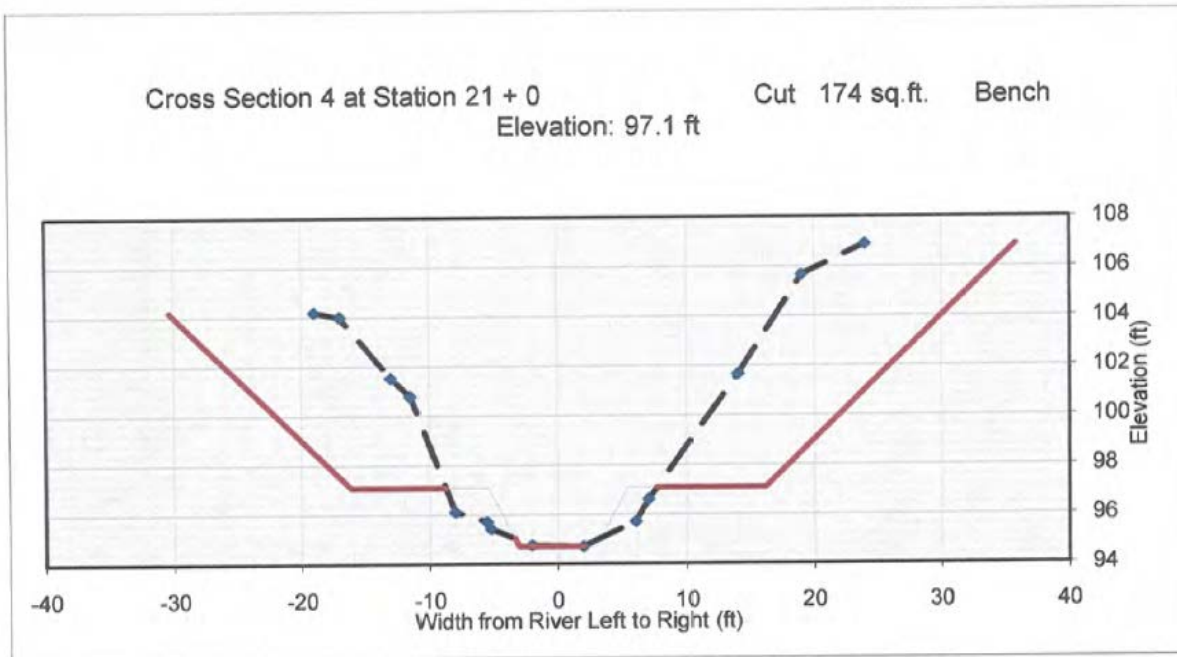


Figure 2. Survey of common existing cross section and 2-stage design.

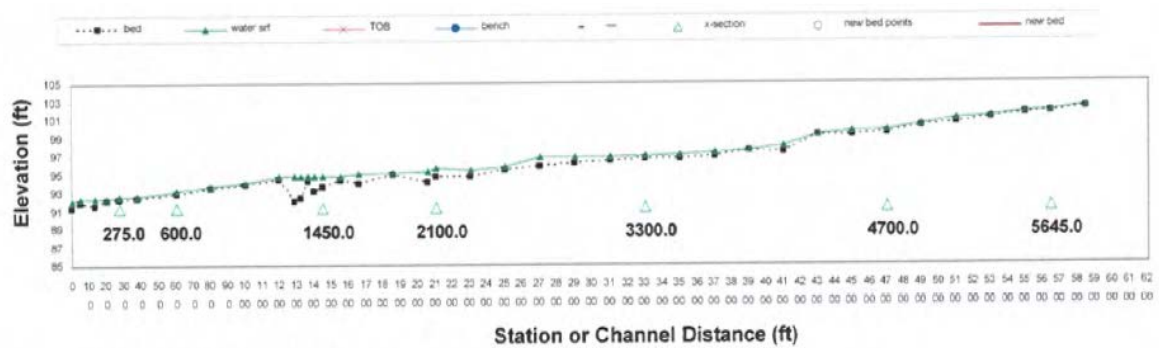


Figure 3. Longitudinal profile.



Figure 4. Identifying tile and side inlets.

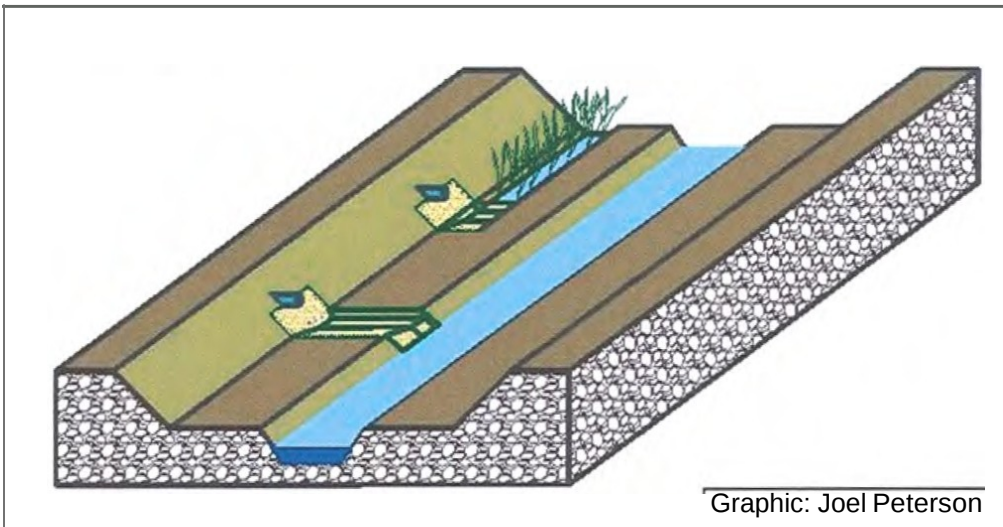


Figure 5. Graphic of linear wetland treating tile line.



Photo: Brad Hansen



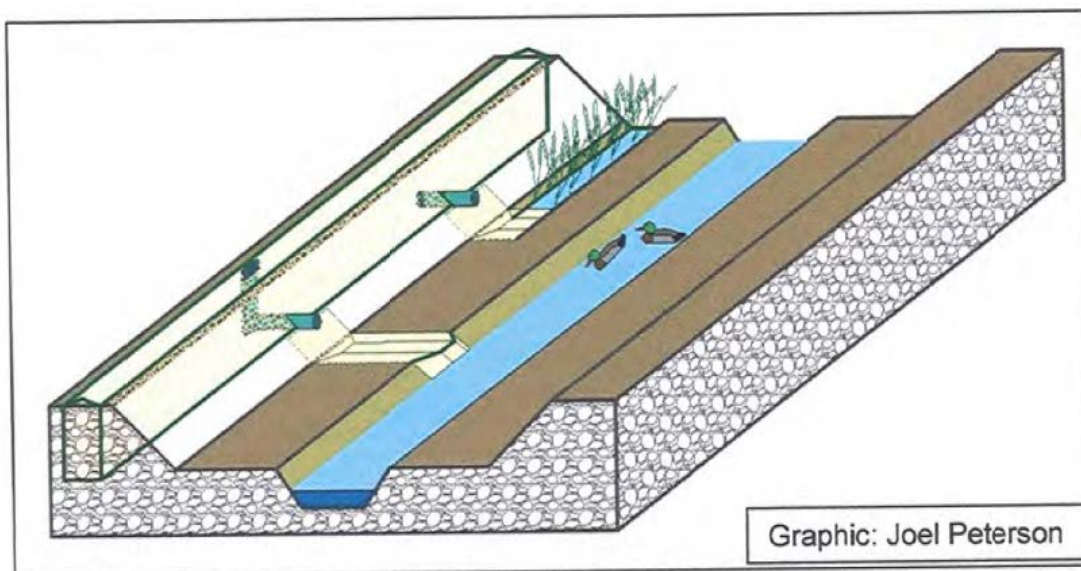
Photo: Rich Biske

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.



Graphic: Joel Peterson

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.

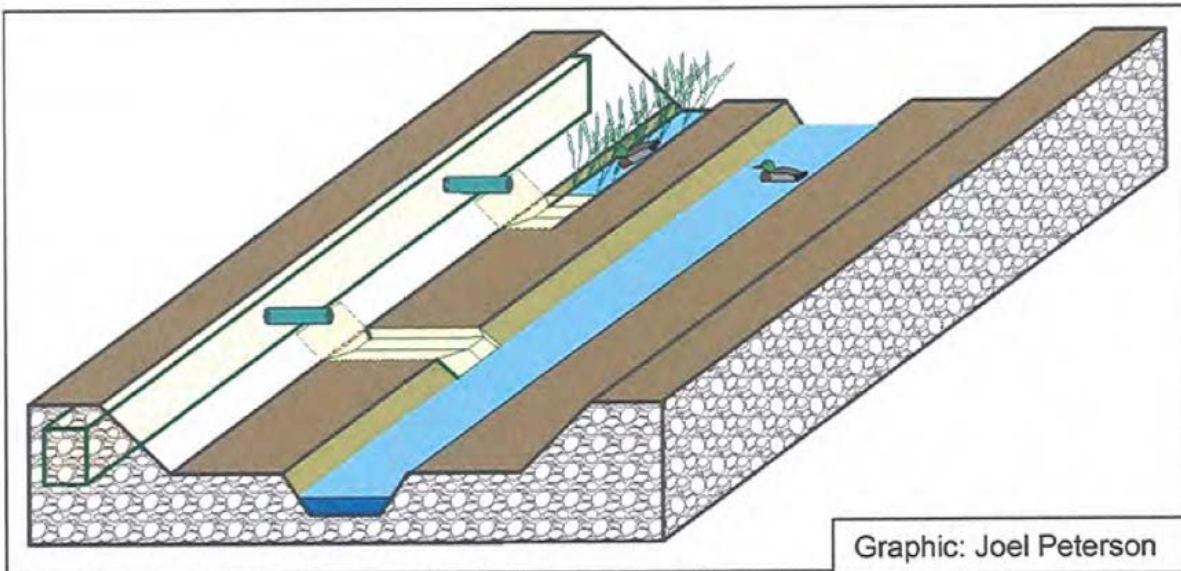


Figure 10. Diagram of seepage trench.

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	<i>Avena sativa</i>	25
Fringed Brome	<i>Bromus ciliatus</i>	1
Canada Wild Rye	<i>Elymus canadensis</i>	2.5
Slender Wheat Grass	<i>Elymus trachycaulus</i>	2.5
Virginia Wild Rye	<i>Elymus virginicus</i>	2
Fowl Bluegrass	<i>Poa Palustris</i>	2
Switchgrass	<i>Panicum virgatum</i>	3
Big Bluestem	<i>Andropogon gerardii</i>	2
Indiangrass	<i>Sorghastrum nutans</i>	1
Western Wheat Grass	<i>Elytrigia smithii</i>	1
Little Bluestem	<i>Schizachyrium scoparium</i>	2
Forbs:		
Purple Prairie Clover	<i>Dalea purpureum</i>	0.09
Showy Tic-trefoil	<i>Desmodium canadense</i>	0.09
Early Sunflower	<i>Heliopsis helianthoides</i>	0.08
Wild Bergamot	<i>Monarda fistulosa</i>	0.07
Black-eyed susan	<i>Rudbeckia hirta</i>	0.1
Blue Vervain	<i>Verbena hastata</i>	0.07
Swamp Milkweed	<i>Asclepias incarnata</i>	0.07
Golden Alexanders	<i>Zizia aurea</i>	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

Assessments

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

- o 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.

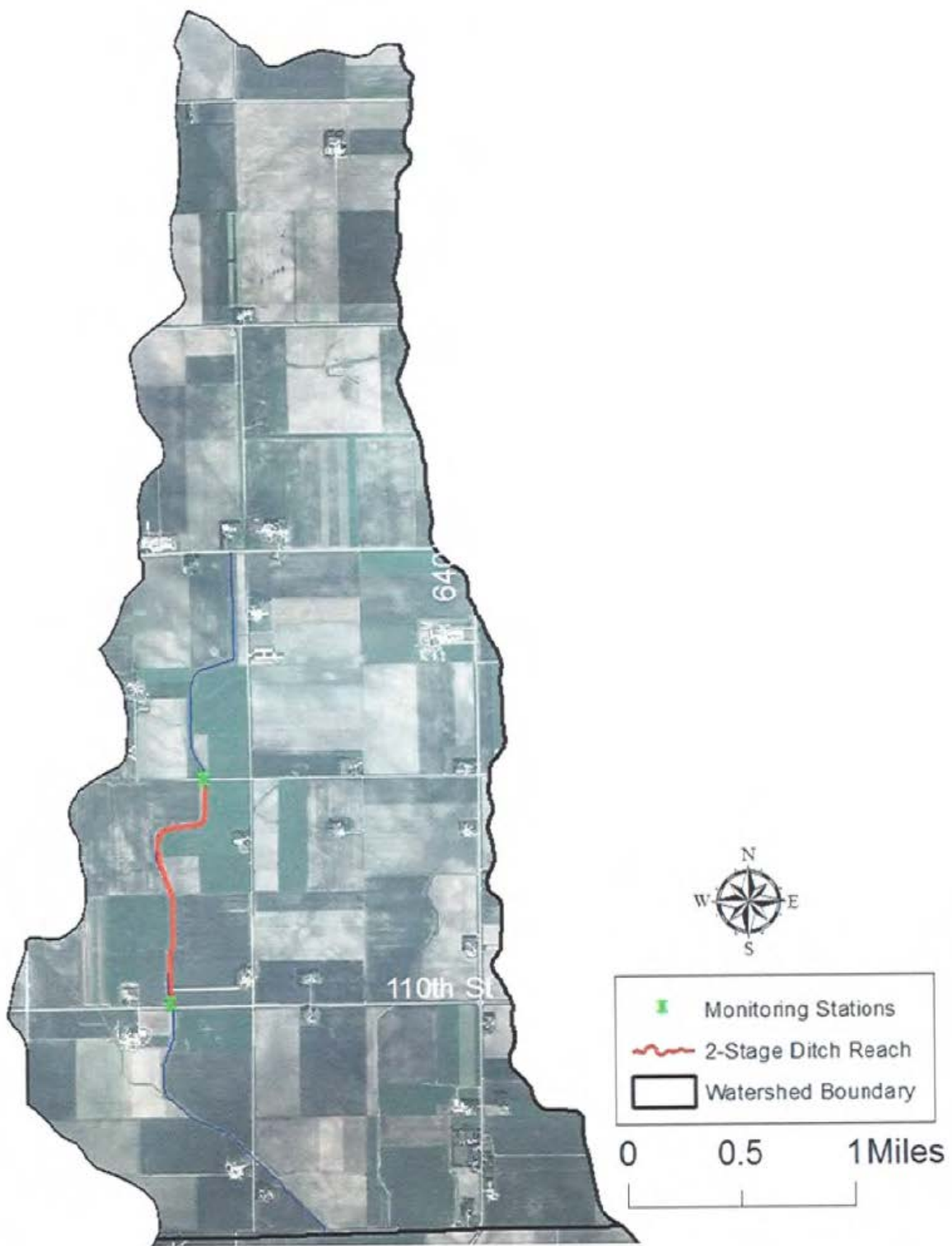


Figure 25. Watershed map of 2-Stage ditch.



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.

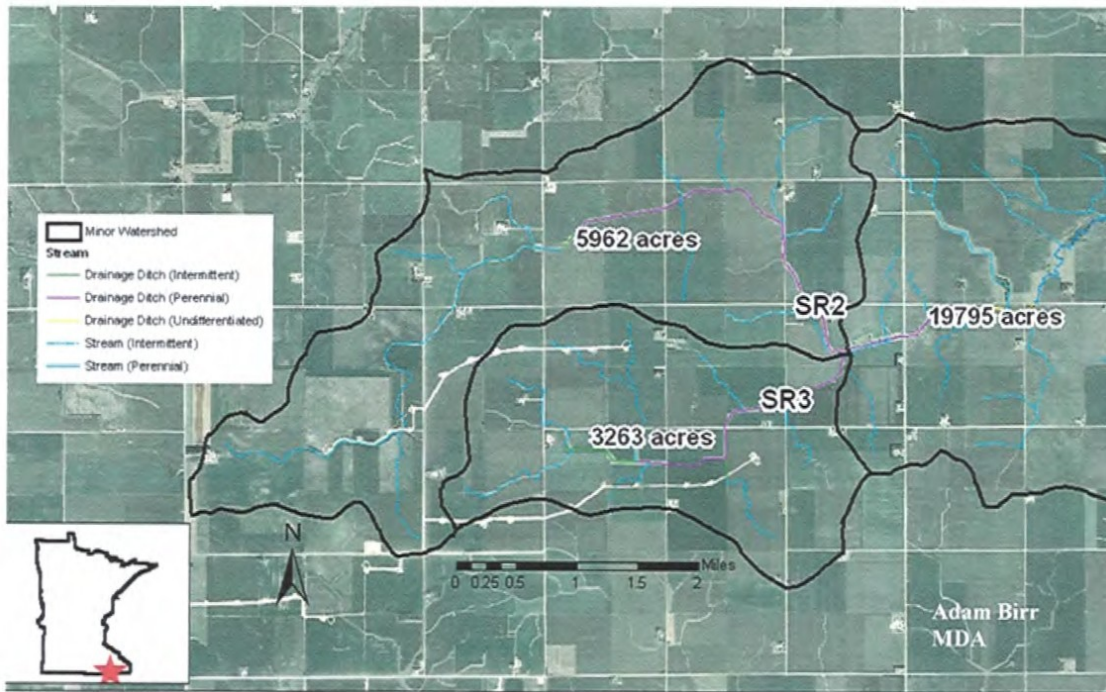


Figure 29. Watershed map of reference ditches.



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.

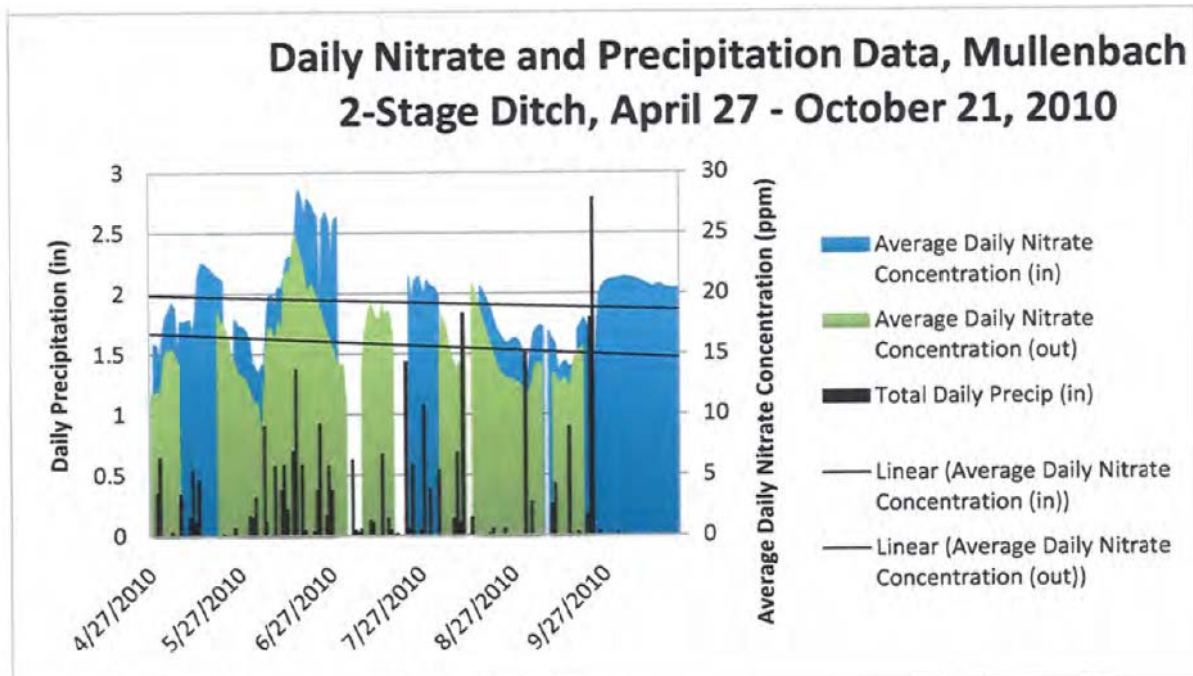


Figure 34. Daily nitrate and precipitation data.

Discussion

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-drainage 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 | • Minnesota Dept. of Agriculture |
| • Pollution Control Agency reps | • Agricultural Producers |
| • County Drainage Engineers | • Board of Water and Soil Resources |
| • Private Drainage Firms | • University of Minnesota |
| • Ditch Contractors | 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 awarded 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://cornandsoybeandigest.com/conservation/bank-it-two-stage-drainage-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/wherewework/northamerica/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.

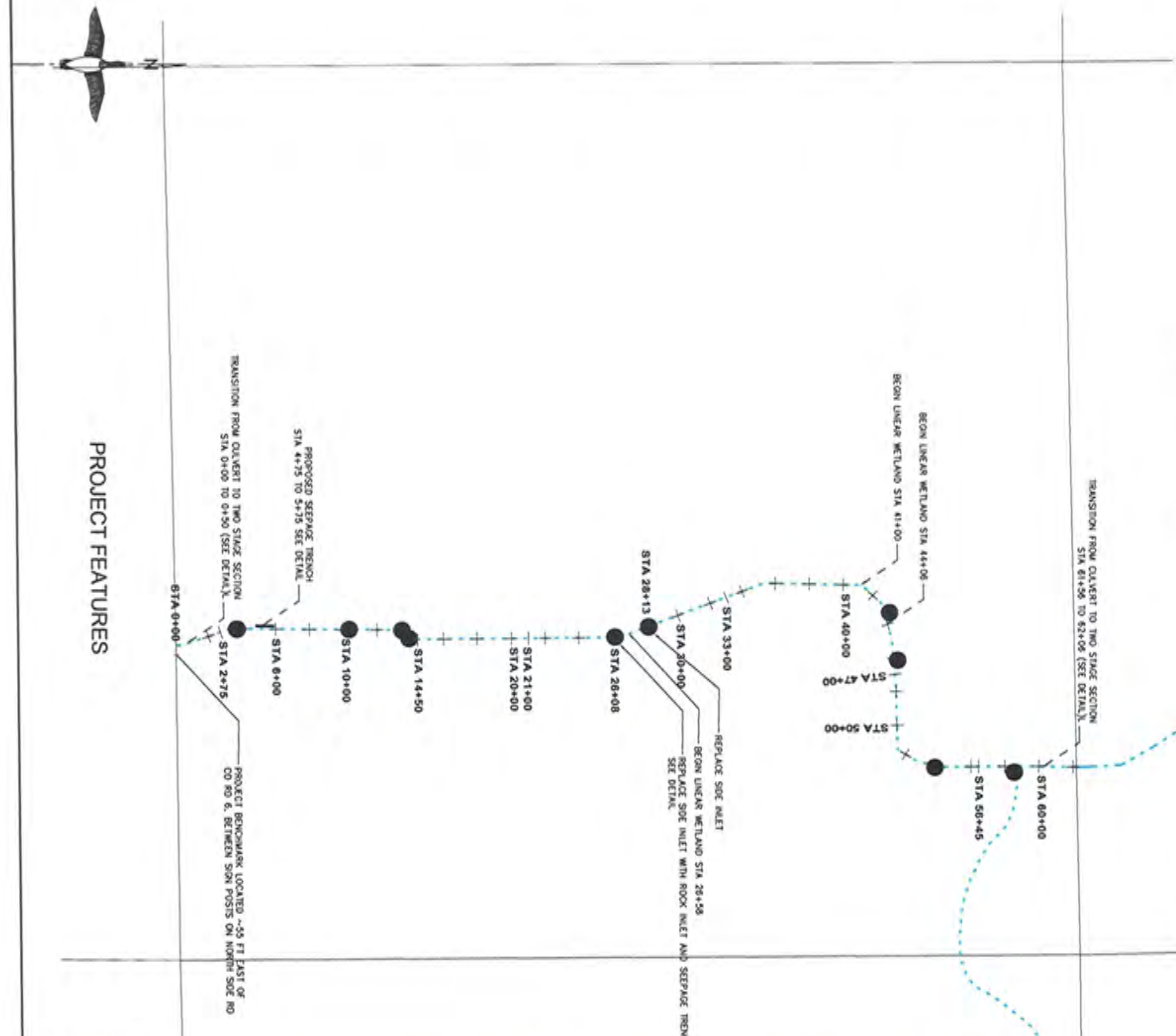
Project Partners

- 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

References:

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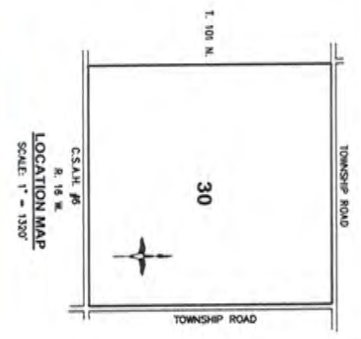
MULLENBACK TWO STAGE DITCH



PROJECT FEATURES

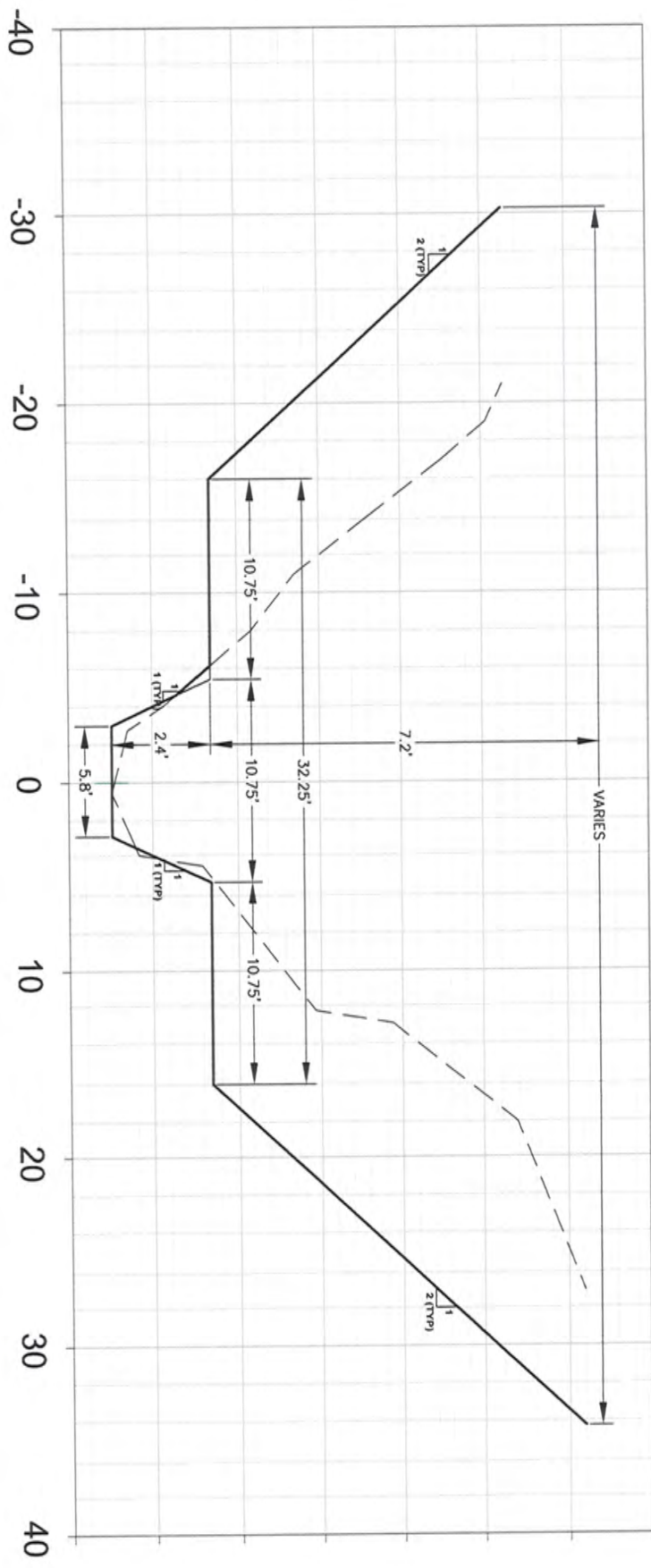
Item	Description	Units	Quantity
1	COMMON CHANNEL EXCAVATION (CY)	CY	30.000
2	CLEANED AND GRASSING	LN	24
3	12" NON-PSYB PIPE (EQUALLY ON EQUAL)	LF	62
4	8" PIPE FROM DRAIN TILE (EQUALLY ON EQUAL)	LF	199
5	12" CAP	LF	40
6	15" CAP	LF	30
7	24" CAP	LF	30
8	24" CAP	LF	30
9	24" HOPE CONC BURN BLT W/ ENCAP A	EA	1
10	TRUSS ROCK	EA	8
11	4" HOPE ANTI-SEEP COLAR	EA	4
12	300 HOPE ANTI-SEEP COLAR	EA	4
13	12" HOPE ANTI-SEEP COLAR	EA	4
14	12" HOPE ANTI-SEEP COLAR	EA	4
15	3" HOPE ENCAP (EQUALLY ON EQUAL)	LN	30
16	3" HOPE ENCAP (EQUALLY ON EQUAL)	LN	290
17	WADOT C. 4" RIBBON	SV	100
18	WADOT TYPE 1 FIBERGLASS	SV	215
19	WADOT TYPE 1 FIBERGLASS	SV	215
20	SEEDING	AC	10
21	MATCH	AC	10

Sheet	Title
1	TITLE SHEET
2	TYPICAL TWO STAGE DITCH SECTION
3	ROCK TRENCH-ROCK INLET DETAIL
4	SEEPAGE TRENCH AND LINEAR WETLAND DETAIL
5	LINEAR WETLAND INLET DETAIL AND TRANSITION
6	SECTION 2-75 - 14+50
7	SECTION 4+75 - 56+45



STATION	SIZE	ACTION
3+05	3070'	REPLACE CONSTRUCT OUTFALL
4+23	2470'	REPLACE CONSTRUCT OUTFALL
9+20	1870'	REPLACE CONSTRUCT OUTFALL
12+65	2470'	REPLACE CONSTRUCT OUTFALL
20+06	2470'	REPLACE CONSTRUCT OUTFALL
28+13	2470'	REPLACE CONSTRUCT OUTFALL
43+42	2470'	REPLACE CONSTRUCT OUTFALL
44+45	2470'	REPLACE CONSTRUCT OUTFALL
55+70	1070'	REPLACE CONSTRUCT OUTFALL
56+42	3070'	REPLACE CONSTRUCT OUTFALL

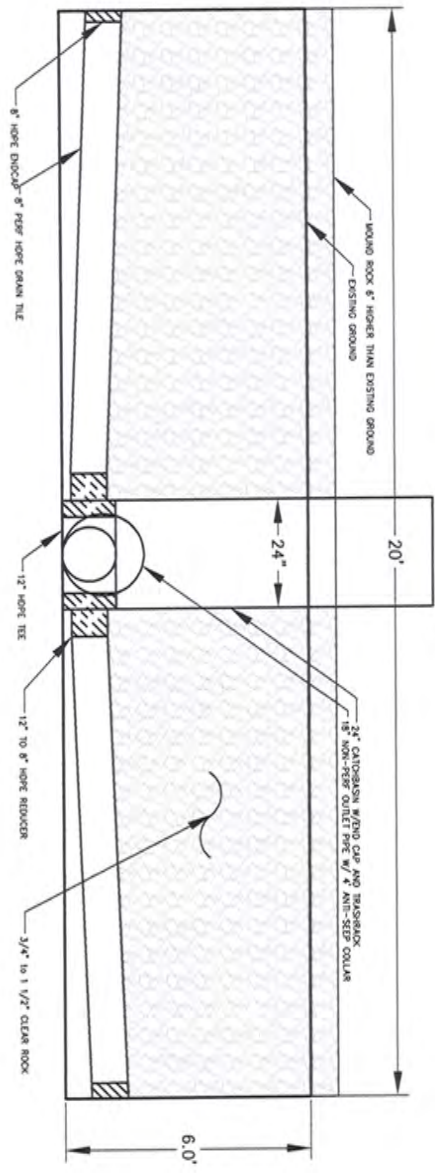
MINNESOTA BOARD OF WATER & SOIL RESOURCES	
MULLENBACK DITCH	
TWO-STAGE DITCH	
DATE: 10/20/2023	PROJECT NO: 2023-01
DESIGNED BY: J. J. J.	CHECKED BY: J. J. J.
APPROVED BY: J. J. J.	REVIEWED BY: J. J. J.



TYPICAL CROSS SECTION

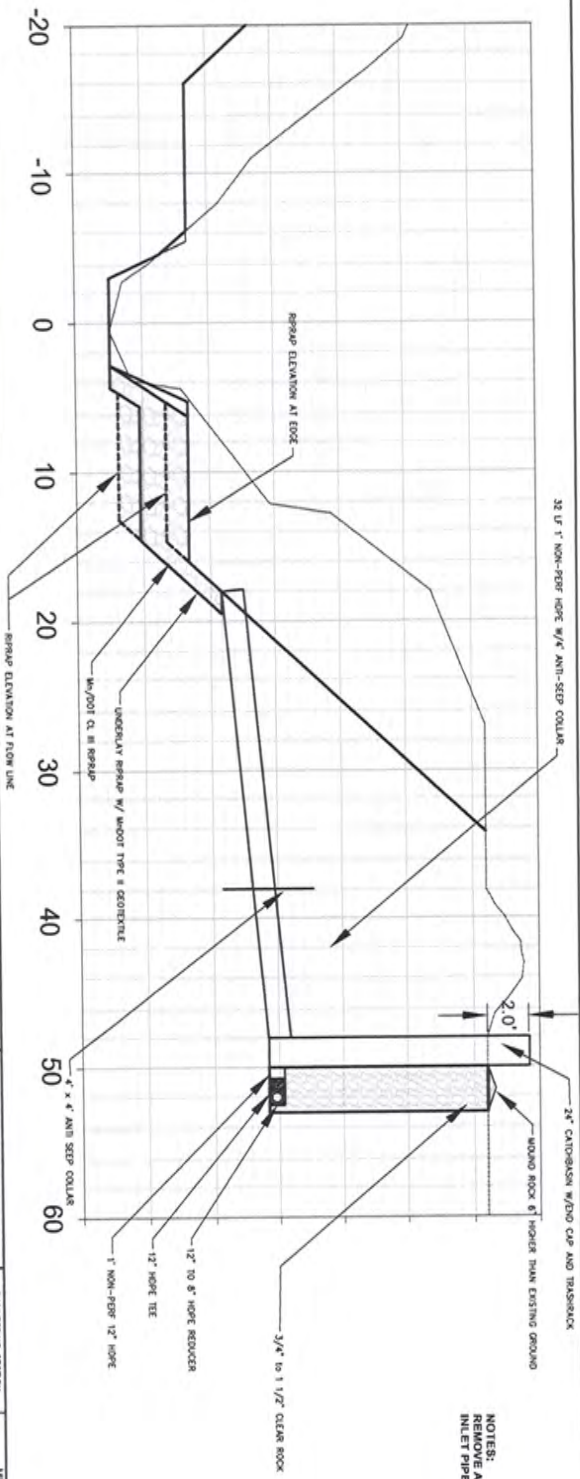
NOTES:
1. DISTURBED AREAS
IN ACCORDANCE WITH SPECIFICATIONS

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.		MINNESOTA BOARD OF WATER & SOIL RESOURCES	
PROJECT NAME: MULEBACK DITCH TWO-STAGE DITCH		ENGINEERING SECTION DATE: _____	
LICENSE # _____		SIGNATURE: _____	



NOTES:
 SIDES AND BOTTOM OF ROCK TRENCH
 SHALL BE COVERED WITH MINOT TYPE 1
 GEOTEXTILE OVERLAP BEARS 1 MIN.
 ALL SEALS OUTSIDE OF TRENCH SHALL BE
 WATERPROOF
 ROCK SHALL BE APPROVED BEFORE
 PLACEMENT BY TNC AUTHORIZED
 REPRESENTATIVE

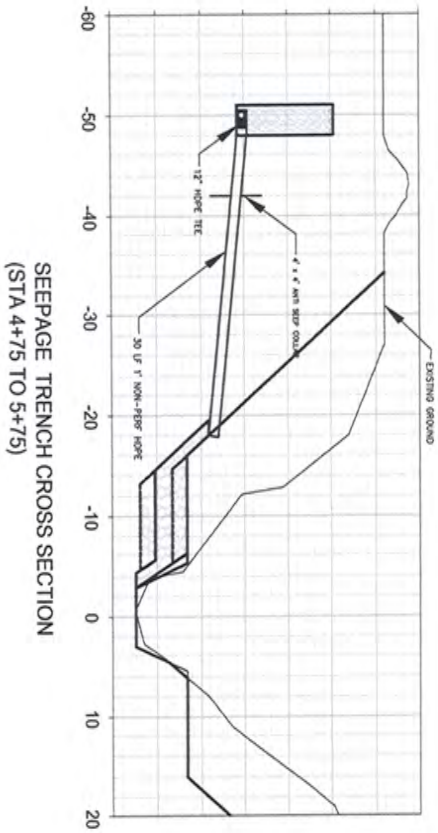
ROCK TRENCH SIDE INLET



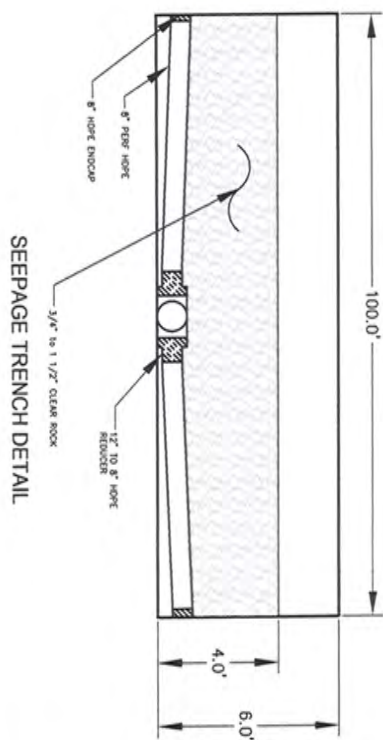
NOTES:
 REMOVE AND DISPOSE OF EXISTING SIDE
 INLET PIPE (INCIDENTAL)

ROCK TRENCH SIDE INLET CROSS SECTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, AND REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA. PRINT NAME: _____ SIGNATURE: _____ LICENSE # _____		MINNESOTA BOARD OF WATER & SOIL RESOURCES MULLENBACK DITCH TWO-STAGE DITCH SHEET NO. 3 OF 7 DATE: 3/1/7	
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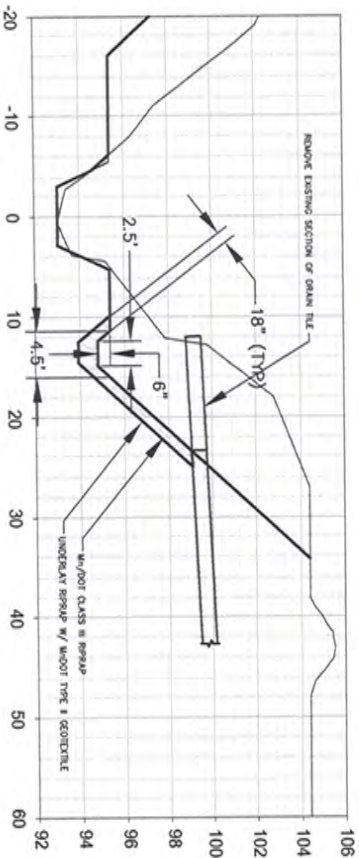


SEEPAGE TRENCH CROSS SECTION
(STA 4+75 TO 5+75)

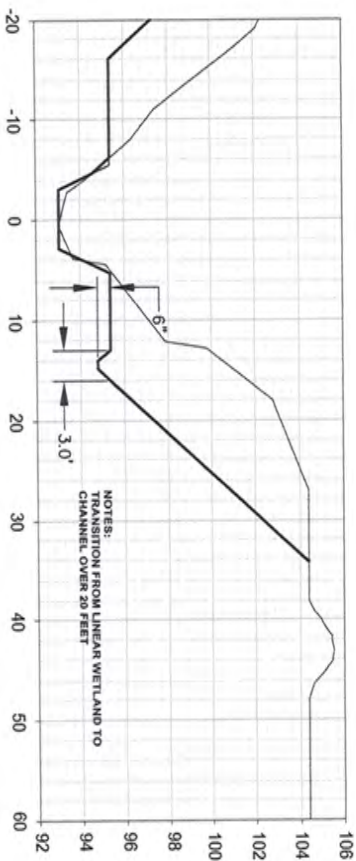


SEEPAGE TRENCH DETAIL

NOTES:
1. TOP AND BOTTOM OF ROCK TRENCH SHALL BE COVERED WITH MINOT TYPE 1 GEOTEXTILE. OVERLAP SEAMS 1 MIN.
2. ROCK SHALL BE APPROVED BEFORE INSTALLATION BY A NC AUTHORIZED REPRESENTATIVE

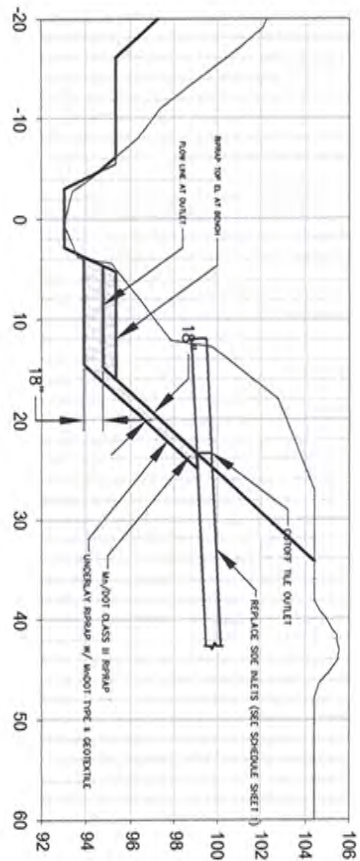


TILE OUTLET AT LINEAR WETLAND DETAIL

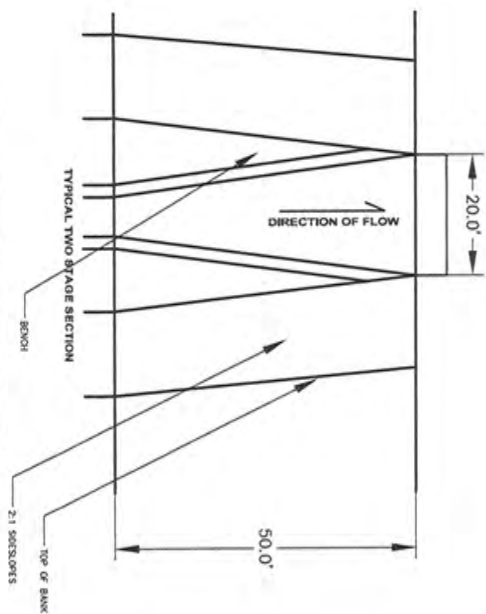
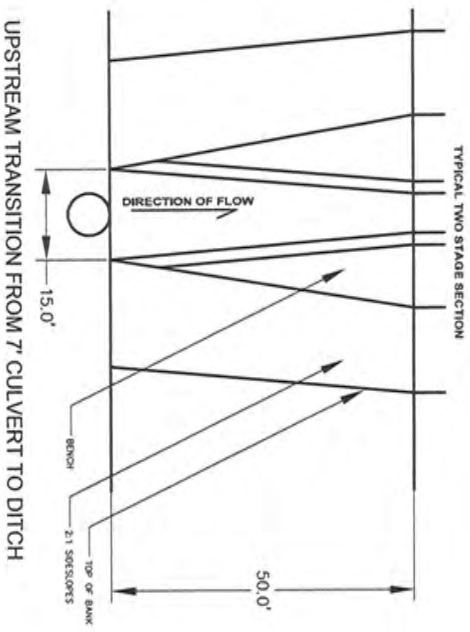
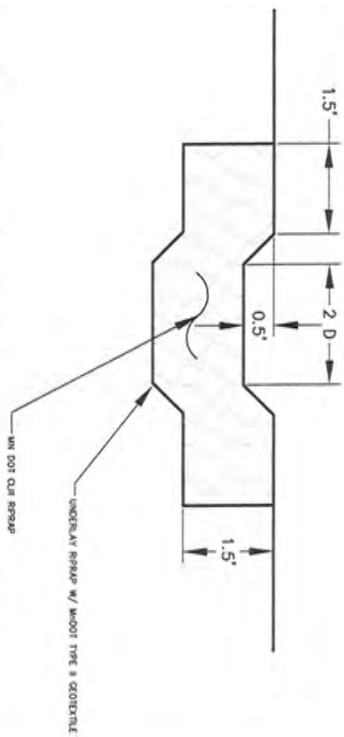


LINEAR WETLAND TYPICAL CROSS SECTION

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY CLOSE PERSONAL SUPERVISION AND THAT I AM A duly LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA. PROJECT NAME: MULLENBACK DITCH TWO-STAGE DITCH DRAWING NO.: 2024-01 DATE: 10/25/24		ENGINEERING SECTION NAME: JOHN J. MULLENBACK TITLE: REGISTERED PROFESSIONAL ENGINEER NO. 1000000000 EXPIRATION DATE: 10/25/25 MINNESOTA BOARD OF WATER & SOIL RESOURCES MULLENBACK DITCH TWO-STAGE DITCH DRAWING NO. 2024-01 DATE: 10/25/24	
--	--	--	--



TILE INLET AND SIDE INLET OUTFALL DETAIL



I HEREBY CERTIFY THAT I AM AN APPLICANT FOR THE POSITION OF **ENGINEER** AND THAT I AM A duly licensed professional engineer under the laws of the state of **MINNESOTA**.
 PRINT NAME: _____
 SOCIAL SECURITY: _____
 ADDRESS: _____
 DATE: _____

MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACH DITCH

TWO-STAGE DITCH

ENGINEERING SECTION									
Year	Month	Day	Hour	Minute	Second	Year	Month	Day	Hour
19	10	10	10	10	10	19	10	10	10

I hereby certify that I am an applicant for the position of **ENGINEER** and that I am a duly licensed professional engineer under the laws of the state of **MINNESOTA**.
 PRINT NAME: _____
 SOCIAL SECURITY: _____
 ADDRESS: _____
 DATE: _____

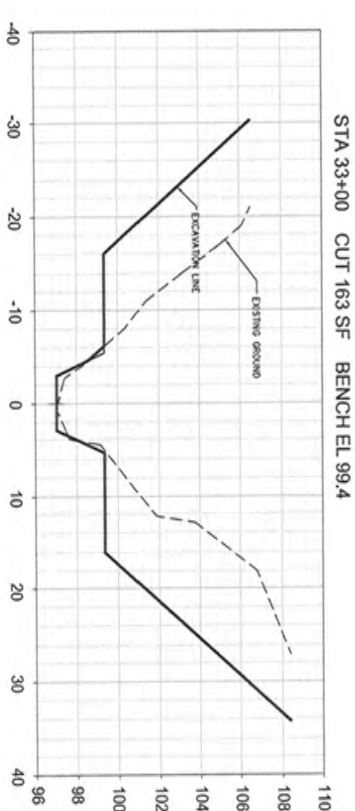
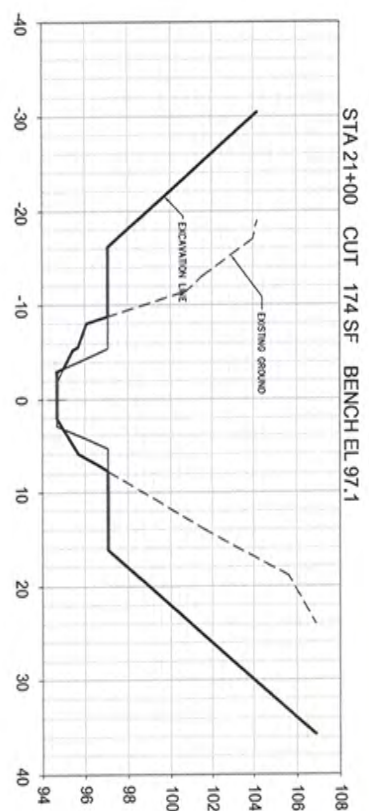
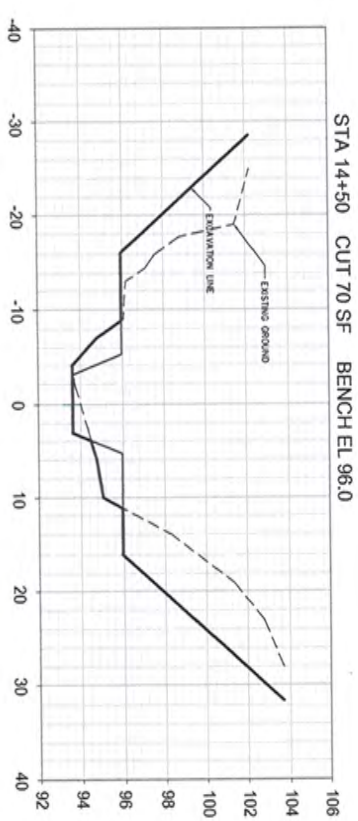
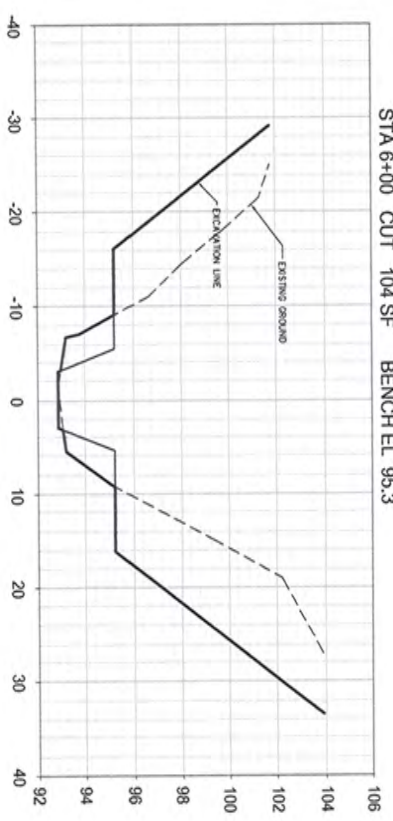
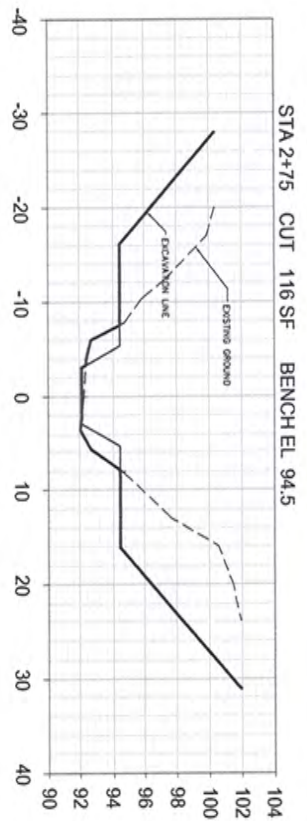
MINNESOTA BOARD OF WATER & SOIL RESOURCES

MULLENBACH DITCH

TWO-STAGE DITCH

MINNESOTA

STATE SEAL



I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER IN THE STATE OF MINNESOTA.

PROJECT NAME: MULLENBACK DITCH TWO-STAGE DITCH

DATE: 10/26/2011 LOCATION: 6

ENGINEERING SECTION	
Drawn by: <u>NA</u>	Checked by: <u>NA</u>
Designed by: <u>NA</u>	Reviewed by: <u>NA</u>
Estimated by: <u>NA</u>	Approved by: <u>NA</u>
Quantity by: <u>NA</u>	Final by: <u>NA</u>

MINNESOTA BOARD OF WATER & SOIL RESOURCES

6 of 7

