

COPY

HYDRAULIC STUDY  
For  
Culvert Recommendation  
Montpelier Township  
In NE 1/4 of NW 1/4 of Section 29, T 137 N, R 63 W.  
Stutsman County, ND  
July, 2019



7/18/19  
\_\_\_\_\_  
Date

\_\_\_\_\_  
Benjamin B. Aaseth  
License No. 10085

Interstate Engineering, Inc.  
Jamestown, North Dakota  
J19-04-090

I. GENERAL

This hydraulic study has been prepared to investigate the size of structure that would be required to convey the water at a crossing located in the NE 1/4 of NW 1/4 of Section 29, T 137 N, R 63 W, Montpelier Township in Stutsman County, North Dakota. There are no upstream structures that impact this site at the analyzed event year. This site will be designed for a 10-year event, based upon North Dakota Administrative Code 89 for township roads.

The existing pipe onsite has damaged end sections. The upstream end section has a damaged top as well as some rust. The downstream end section is split at the seams.

The existing site has the following characteristics:

- o Top of Road = 1489'
- o Existing Road Width = 22'
- o Tailwater = 10 foot bottom with 10:1 side slopes
- o Invert North end = 1484.19'
- o Channel elevation near north end = 1484.07'
- o Invert South end = 1484.13'
- o Channel elevation near south end = 1484.13'
- o Lat: 46° 39' 35.23" N Long: 98° 39' 42.12" W

II. HYDROLOGY

Originally when the quad maps were developed it appeared that this culvert drained a much larger area, since that time there has been some change in flow patterns. The water approximately one-mile south of the culvert located just south of the Section Line, flows primarily easterly thru an existing drainage channel. Originally it appeared that this water flowed north to the culvert in quad maps originally developed. Considering that this crossing is only to be sized for a 10-year event only 5% of the larger drainage flows were considered to flow north based upon aerial drone video and photo graphs that were taken in the spring of 2019. See Appendix B. If all of the area to the south would be considered when sizing the culvert, the size would need to be significantly larger. See sheet 3 for the original drainage area identified with the original quad maps, compared to the drainage used for sizing the culvert on Sheets 1 & 2.

The drainage area for this site was determined, using the USGS Quad Maps, to be approximately 0.95 square miles (approximately 608 acres). This area is shown on Sheets 1 & 2. The drainage basin flows through mainly farmland and wetland areas. The main use of the drainage area is agriculture land.

The discharges at the site were determined utilizing the USGS "Techniques for Estimating Peak-Flow Frequency Relations for North Dakota Streams 1992", which takes into consideration different soil types, vegetation, storage,

slope of the basin, and terrain. The area being studied is in Region C, with slopes of approximately 4 feet per mile.

### III. HYDRAULIC ANALYSIS

The FHWA HY-8 program was used in the analysis. The following data has been compiled and utilized to determine a sufficient and appropriate structure at this location.

Channel: Area identified on quad maps

Total Drainage Area: 0.95 square miles

Existing Structure at Site:  
18" Corrugated Steel Pipe

Existing Upstream Structure:  
None or Unknown

Existing downstream Structure:  
24" Corrugated Steel Pipe

#### Site Characteristics: (Small Drainage + 5% of the larger drainage)

Design (2):	9 cfs
Design (10):	43 cfs
Design (15):	56 cfs
Design (25):	74 cfs
Design (50):	103 cfs
Design (100):	136 cfs
Greatest Flood (500 year):	225 cfs

The structure was sized for 10-year event, restricting the headwater to be the pipe diameter + 2 feet which is based on the North Dakota Stream and Crossing Standards.

### IV. STRUCTURE COMPARISON

The following chart analyzes the proposed structure for the crossing of the roadway:

<u>Number of Lines</u>	<u>Structure Type</u>	<u>Total Waterway Opening (sq. ft.)</u>	<u>Allowable Headwater</u>
1	* 30" CSP	4.90	Dia. + 2 feet

\*24" CSP should be installed at this time due to downstream culvert sizes.

*Headwater Comparison*

Flood Event	Flow (cfs)	Headwater Existing (ft) 18" CSP	Headwater Proposed (ft) 30" CSP
2 Year	7	1486.06	1485.76
10 Year	32	1489.05	1488.50
25 Year	55	1489.10	1489.08
Overtops road (cfs)		15.01	46.79

V.

CONCLUSION & RECOMMENDATION

The recommendation pipe is a 30" Corrugated Steel Pipe, but considering that the downstream culvert is only 24", this culvert should be installed at only a 24" at this time. This pipe should be installed at the existing inverts. The pipe should be installed with end sections as there is evidence that the existing pipe has been damaged from machinery likely mowing the ditches. If further reports are done with a larger study, all the pipes on this drainage should be analyzed to the James River to create a system that would meet state laws.

As per the North Dakota permit from the USACE, counter sinking is only required when there is a stable stream bed. This stream bed is not stable and therefor no need for counter sinking.

Please call at any time if you have any questions or need any further information.

Ben Aaseth

## Existing Site Photos

Existing site looking south.



Existing Culvert Invert.



Existing Site Looking North.



Existing Culvert Outlet



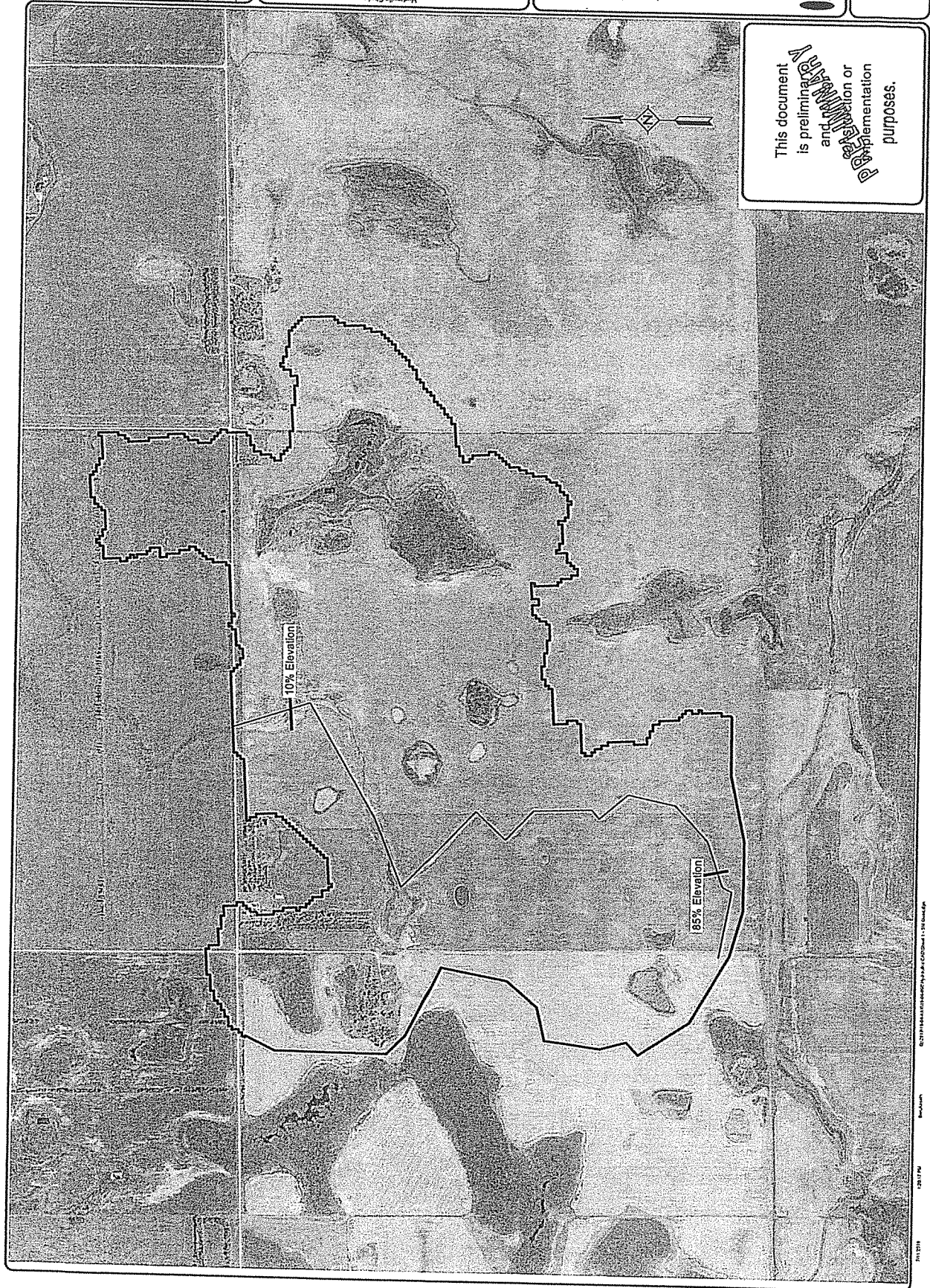
## APPENDIX A .

### PROJECT MAPS

Rev	Date	By	Description

Drawn By: <input type="text"/>	
Checked By: <input type="text"/>	
Surveyed By: <input type="text"/>	Project No: <input type="text"/>
Designed By: <input type="text"/>	Date: <input type="text"/>
Drainage Area - Aerial	
Hydrologic Study Section 26, 112th, R3SW Buchanan Township Buchanan County ND	

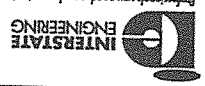
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**INTERSTATE ENGINEERING**  
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 Jamestown, ND 58402-2025  
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 www.interstateeng.com



This document  
 is preliminary  
 and for informational  
 purposes only.  
 It is not to be used for  
 design or  
 construction  
 purposes.

Sheet Number

1

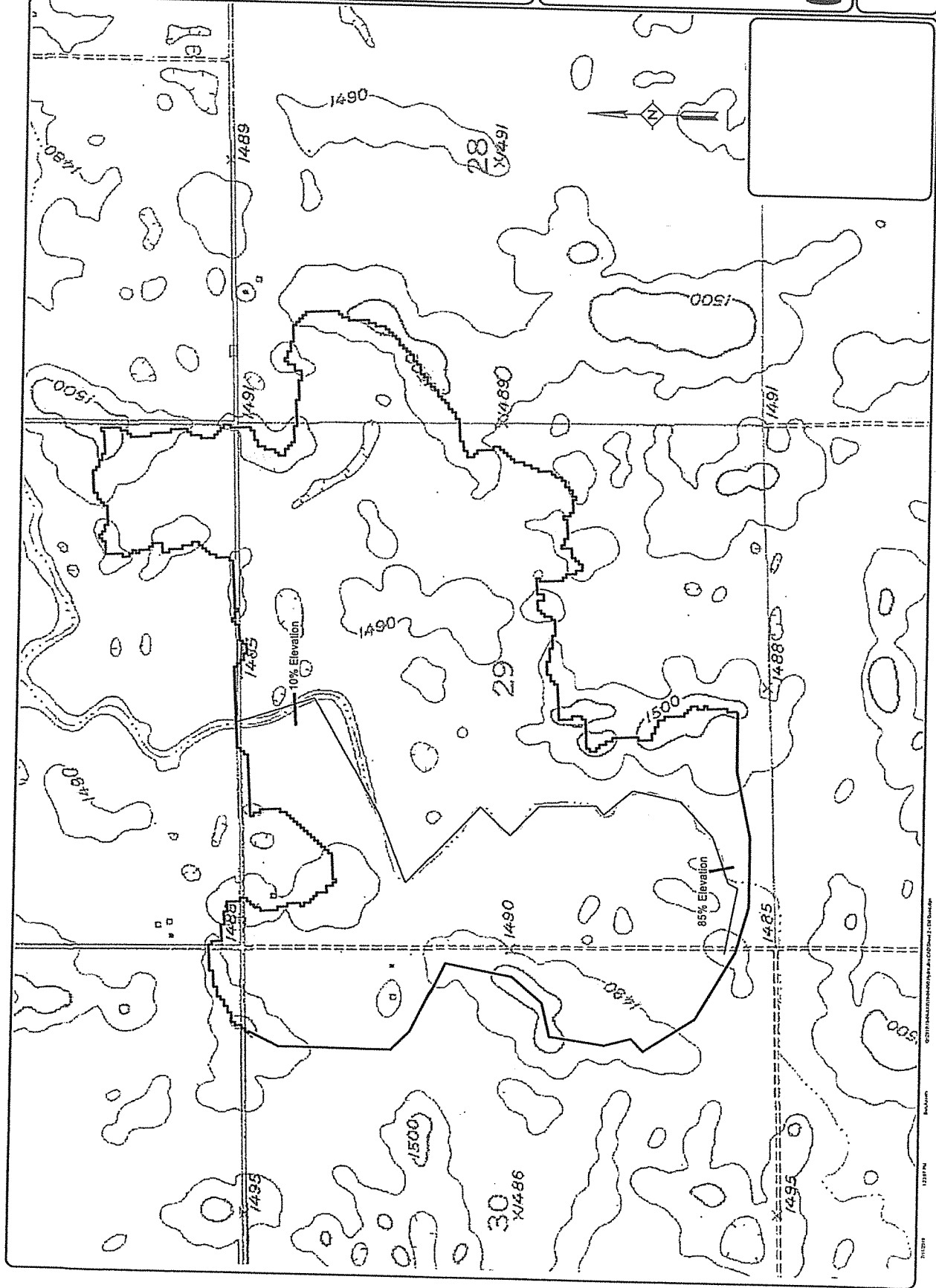


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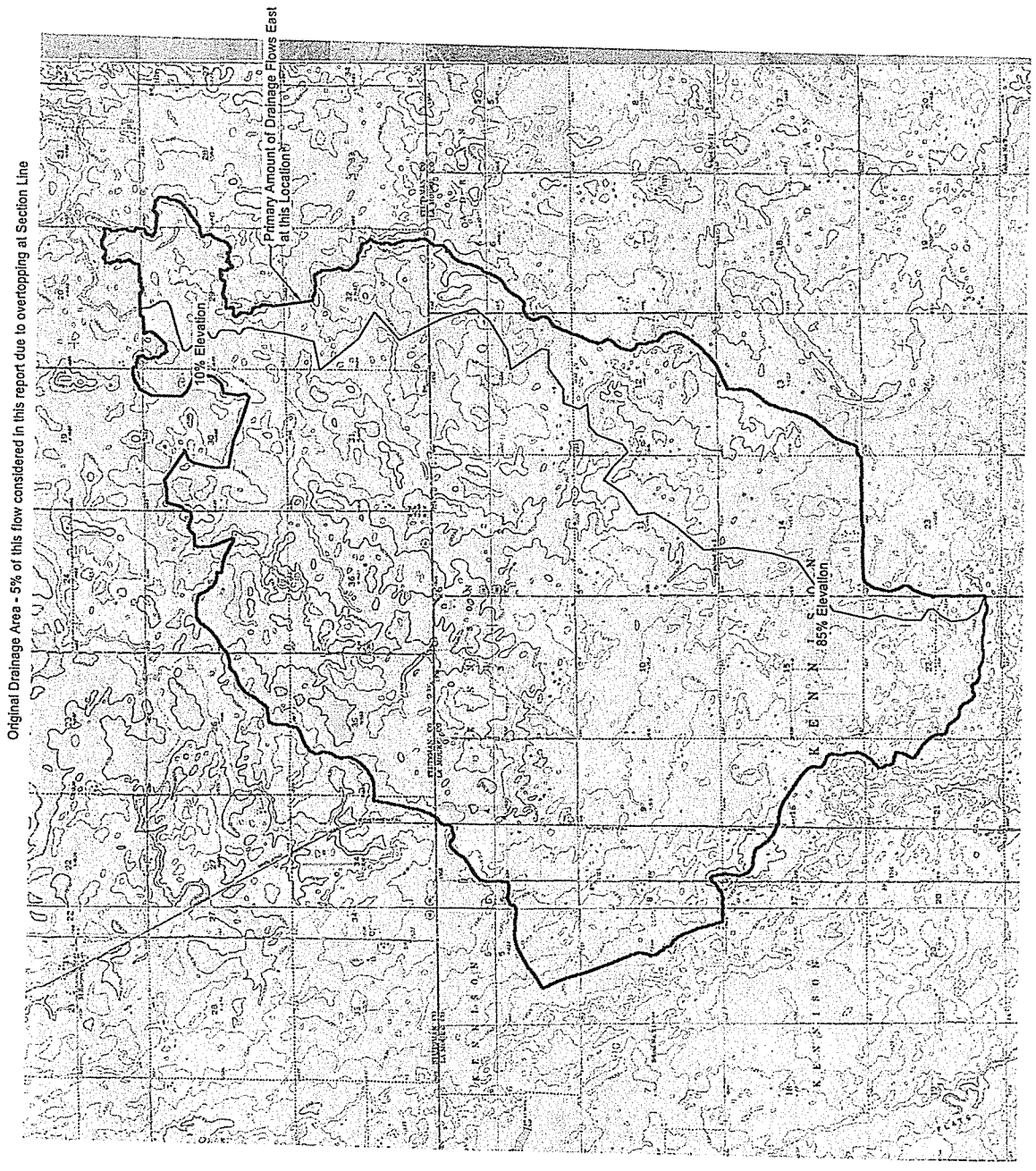
Drawn By:	RA
Checked By:	RA
Designed By:	RA
Project No:	J1244-013
Date:	07/11/19
Hydrologic Study Spec 45, 11/17/11, RSW Montgomery Township Stearns County, ND	
Drainage Area - Quad	

Rev	Date	By	Description



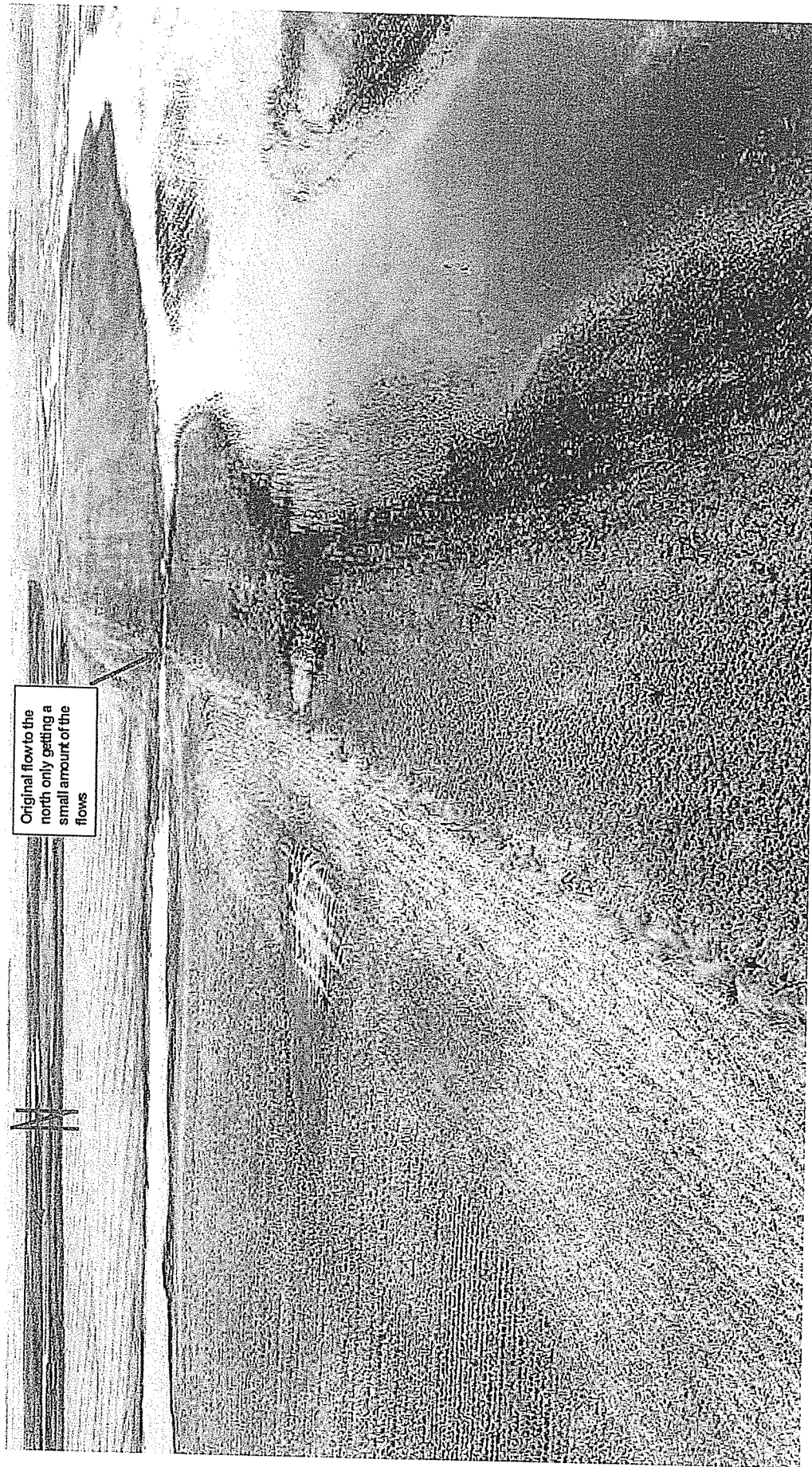
<b>INTERSTATE ENGINEERING</b> Professionals you need, people you trust. Interstate Engineering, Inc. 1901 12th Avenue SW P.O. Box 2005 Jamestown, ND 58402-2005 Fax (701) 252-0703 www.interstateeng.com		Drawn By: BA Checked By: BA Surveyed By: BA Project No: J1304-00 Date: 07/11/13 Drainage Area - Original	Map Scale: 1" = 100' N.T.S. Sec 29, T17N, R13W Moorhead Township Cassin County ND
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No.	Date	By	Description



## APPENDIX B

### DRONE PHOTOS



Original flow to the north only getting a small amount of the flows

Looking East



DJI 0037

Looking Southeast



Overlaps road  
here before  
going north

## APPENDIX C

### CALCULATIONS

# HY-8 Culvert Analysis Report

### Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 9 cfs

Design Flow: 43 cfs

Maximum Flow: 74 cfs

**Table 1 - Summary of Culvert Flows at Crossing: Small Area - Existing**

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1486.46	9.00	9.00	0.00	1
1488.94	15.50	14.90	0.00	100
1489.03	22.00	15.06	6.79	10
1489.05	28.50	15.09	13.16	4
1489.06	35.00	15.12	19.77	4
1489.08	41.50	15.14	26.09	3
1489.08	43.00	15.15	27.76	3
1489.10	54.50	15.18	39.14	3
1489.11	61.00	15.20	45.73	3
1489.12	67.50	15.22	51.81	2
1489.13	74.00	15.24	58.14	2
1489.00	15.01	15.01	0.00	Overtopping

**Rating Curve Plot for Crossing: Small Area - Existing**

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
9.00	9.00	1486.46	2.357	2.266	7-JH2c	-1.000	1.156	1.156	0.360	5.994	1.836
15.50	14.90	1488.94	4.837	3.598	7-JH2c	-1.000	1.405	1.405	0.483	8.527	2.163
22.00	15.06	1489.03	4.931	3.646	7-JH2c	-1.000	1.409	1.409	0.581	8.608	2.395
28.50	15.09	1489.05	4.947	3.654	7-JH2c	-1.000	1.410	1.410	0.664	8.622	2.579
35.00	15.12	1489.06	4.962	3.662	7-JH2c	-1.000	1.410	1.410	0.737	8.634	2.732
41.50	15.14	1489.08	4.974	3.668	7-H2c	-1.000	1.411	1.411	0.803	8.645	2.864
43.00	15.15	1489.08	4.978	3.670	7-H2c	-1.000	1.411	1.411	0.818	8.648	2.892
54.50	15.18	1489.10	4.998	3.680	7-H2t	-1.000	1.412	1.412	0.920	8.665	3.087
61.00	15.20	1489.11	5.008	3.686	7-JH2c	-1.000	1.413	1.413	0.972	8.674	3.182
67.50	15.22	1489.12	5.017	3.690	7-JH2c	-1.000	1.413	1.413	1.021	8.682	3.271
74.00	15.24	1489.13	5.027	3.695	7-H2c	-1.000	1.413	1.413	1.068	8.689	3.352

\*\*\*\*\*

## Straight Culvert

Inlet Elevation (invert): 1484.10 ft, Outlet Elevation (invert): 1484.10 ft

Culvert Length: 48.00 ft, Culvert Slope: 0.0000

\*\*\*\*\*

**Site Data - Culvert 1**

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1484.10 ft

Outlet Station: 48.00 ft

Outlet Elevation: 1484.10 ft

Number of Barrels: 1

**Culvert Data Summary - Culvert 1**

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

**Table 3 - Downstream Channel Rating Curve (Crossing: Small Area - Existing)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
9.00	1484.46	0.36	1.84	0.22	0.61
15.50	1484.58	0.48	2.16	0.30	0.63
22.00	1484.68	0.58	2.39	0.36	0.65
28.50	1484.76	0.66	2.58	0.41	0.66
35.00	1484.84	0.74	2.73	0.46	0.67
41.50	1484.90	0.80	2.86	0.50	0.68
43.00	1484.92	0.82	2.89	0.51	0.68
54.50	1485.02	0.92	3.09	0.57	0.69
61.00	1485.07	0.97	3.18	0.61	0.70
67.50	1485.12	1.02	3.27	0.64	0.70
74.00	1485.17	1.07	3.35	0.67	0.70

**Tailwater Channel Data - Small Area - Existing**

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 10.00 (1:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0350

Channel Invert Elevation: 1484.10 ft

**Roadway Data for Crossing: Small Area - Existing**

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 ft

Crest Elevation: 1489.00 ft

Roadway Surface: Gravel

Roadway Top Width: 22.00 ft

## **HY-8 Culvert Analysis Report**

### Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 9 cfs

Design Flow: 43 cfs

Maximum Flow: 74 cfs

**Table 1 - Summary of Culvert Flows at Crossing: Small Area - Proposed**

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1485.76	9.00	9.00	0.00	1
1486.34	15.50	15.50	0.00	1
1486.91	22.00	22.00	0.00	1
1487.23	28.50	28.50	0.00	1
1487.58	35.00	35.00	0.00	1
1488.31	41.50	41.50	0.00	1
1488.50	43.00	43.00	0.00	1
1489.03	54.50	47.02	7.19	17
1489.05	61.00	47.15	13.62	4
1489.06	67.50	47.25	19.80	3
1489.08	74.00	47.34	26.34	3
1489.00	46.79	46.79	0.00	Overtopping

**Rating Curve Plot for Crossing: Small Area - Proposed**

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
9.00	9.00	1485.76	1.397	1.663	7-H2c	-1.000	0.995	0.995	0.360	4.941	1.836
15.50	15.50	1486.34	1.927	2.242	7-H2c	-1.000	1.326	1.326	0.483	5.860	2.163
22.00	22.00	1486.91	2.379	2.812	7-H2c	-1.000	1.592	1.592	0.581	6.670	2.395
28.50	28.50	1487.23	2.876	3.129	7-H2c	-1.000	1.818	1.818	0.664	7.453	2.579
35.00	35.00	1487.58	3.481	3.448	7-JH2c	-1.000	2.007	2.007	0.737	8.087	2.732
41.50	41.50	1488.31	4.214	3.833	7-JH2c	-1.000	2.160	2.160	0.803	9.008	2.864
43.00	43.00	1488.50	4.401	3.931	7-JH2c	-1.000	2.189	2.189	0.818	9.248	2.892
54.50	47.02	1489.03	4.932	4.211	7-JH2c	-1.000	2.258	2.258	0.920	9.900	3.087
61.00	47.15	1489.05	4.949	4.220	7-JH2c	-1.000	2.260	2.260	0.972	9.919	3.182
67.50	47.25	1489.06	4.962	4.228	7-JH2c	-1.000	2.262	2.262	1.021	9.935	3.271
74.00	47.34	1489.08	4.975	4.234	7-JH2c	-1.000	2.263	2.263	1.068	9.951	3.352

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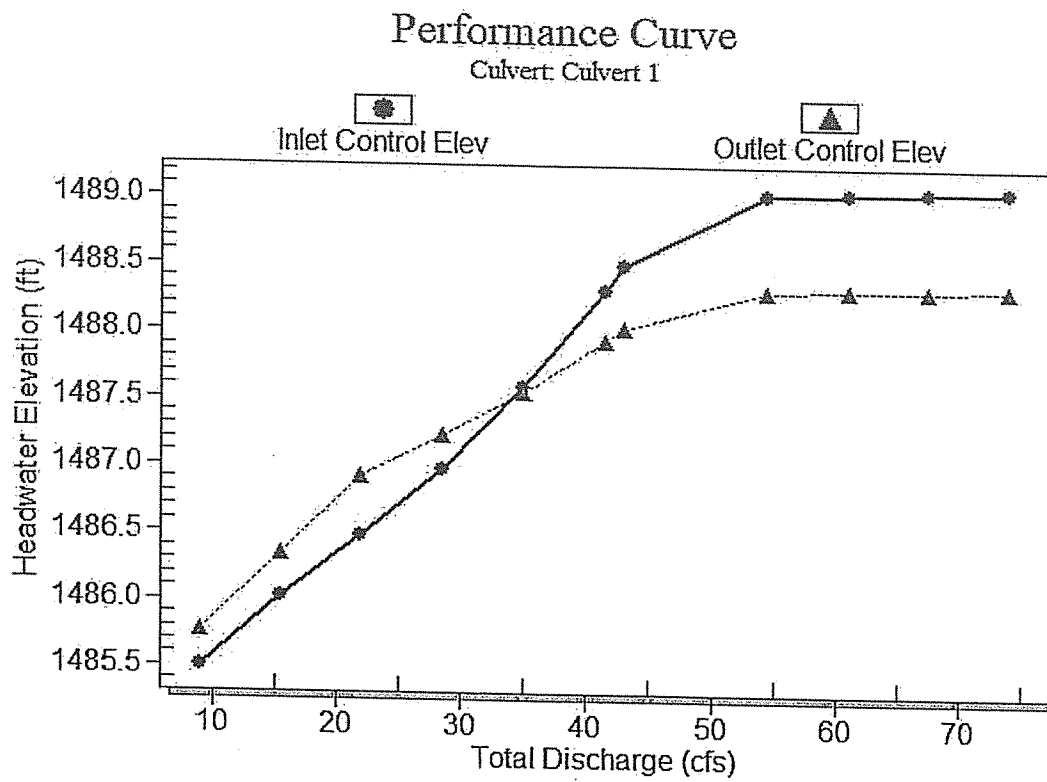
## Straight Culvert

Inlet Elevation (invert): 1484.10 ft, Outlet Elevation (invert): 1484.10 ft

Culvert Length: 48.00 ft, Culvert Slope: 0.0000

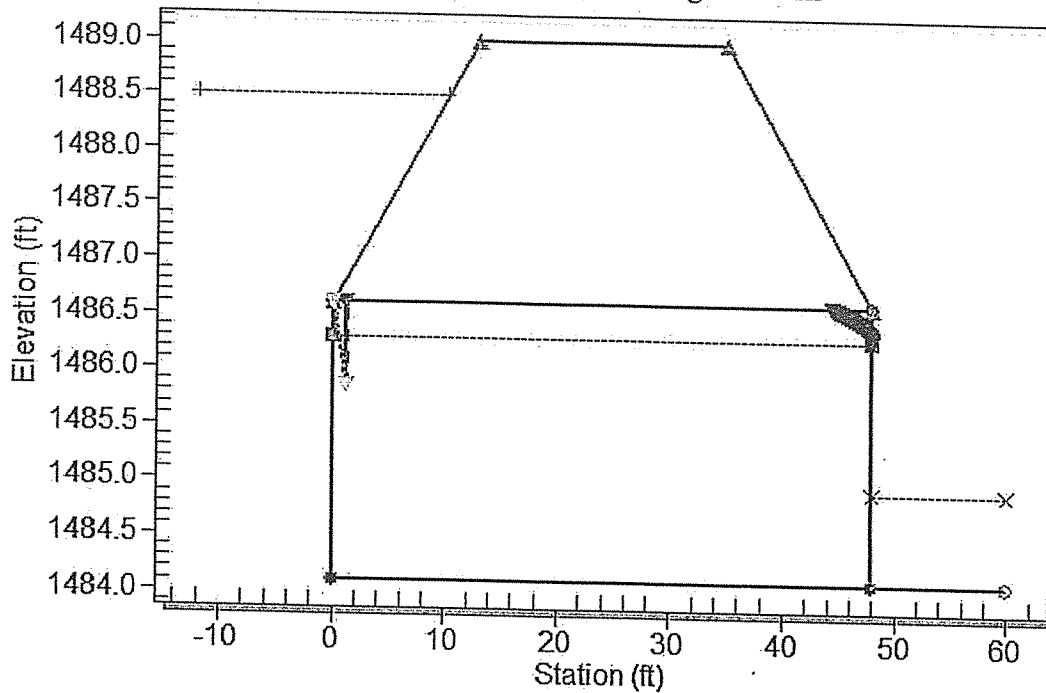
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## Culvert Performance Curve Plot: Culvert 1



**Water Surface Profile Plot for Culvert: Culvert 1**

**Crossing - Small Area - Proposed, Design Discharge - 43.0 cfs**  
Culvert - Culvert 1, Culvert Discharge - 43.0 cfs

**Site Data - Culvert 1**

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1484.10 ft

Outlet Station: 48.00 ft

Outlet Elevation: 1484.10 ft

Number of Barrels: 1

**Culvert Data Summary - Culvert 1**

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Beveled Edge (1:1)

Inlet Depression: None

**Table 3 - Downstream Channel Rating Curve (Crossing: Small Area - Proposed)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
9.00	1484.46	0.36	1.84	0.22	0.61
15.50	1484.58	0.48	2.16	0.30	0.63
22.00	1484.68	0.58	2.39	0.36	0.65
28.50	1484.76	0.66	2.58	0.41	0.66
35.00	1484.84	0.74	2.73	0.46	0.67
41.50	1484.90	0.80	2.86	0.50	0.68
43.00	1484.92	0.82	2.89	0.51	0.68
54.50	1485.02	0.92	3.09	0.57	0.69
61.00	1485.07	0.97	3.18	0.61	0.70
67.50	1485.12	1.02	3.27	0.64	0.70
74.00	1485.17	1.07	3.35	0.67	0.70

**Tailwater Channel Data - Small Area - Proposed**

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 10.00 (1:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0350

Channel Invert Elevation: 1484.10 ft

**Roadway Data for Crossing: Small Area - Proposed**

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 ft

Crest Elevation: 1489.00 ft

Roadway Surface: Gravel

Roadway Top Width: 22.00 ft

Project No.: 1904090

Date: 6/20/2019

Location: Montpelier

Existing Conditions: 18" CMP

Contributing Drainage Area (CA):

Contributing Area (SQ. FT.): 2.65E+07 (Fill In)

Contributing Area (Acres): 608.1088384

Contributing Area (SQ. MI.): 0.95

Main-channel Slope (S):

Elevation located 85% of longest water course: 1485

Elevation located 10% of longest water course: 1480

Distance Between Elevations: 6033

Main-channel Slope (FT/MI): 4.3759324

Peak Flow:

Region: c

Q(2) = 7

Q(10) = 32

Q(15) = 42

Q(25) = 55

Q(50) = 77

Q(100) = 101

Q(500) = 166

Project No.: 1904090

Date: 7/15/2019

Location: Montpelier

Existing Conditions: 18" CMP

Contributing Drainage Area (CA):

Contributing Area (SQ. FT.): 5.05E+08 (Fill In)

Contributing Area (Acres): 11590.11816

Contributing Area (SQ. MI.): 18.11

Main-channel Slope (S):

Elevation located 85% of longest water course: 1504

Elevation located 10% of longest water course: 1481

Distance Between Elevations: 34253

Main-channel Slope (FT/MI): 3.5453829

Peak Flow:

Region: c

Q(2) = 40

Q(10) = 217

Q(15) = 284

Q(25) = 379

Q(50) = 527

Q(100) = 699

Q(500) = 1171