FINAL

HOUSTON ENGINEERING INC.

Technical Memorandum

To: Chad Martini
Stearns County

From: Garrett Monson PE
Adam Scow EIT
Houston Engineering, Inc.

Subject: Stearns County Ditch 28 Conditions Report

Date: June 3, 2020

Project: R006364-0010.004

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am duly Licensed Professional Engineer under the laws of the State of MN.

Garrett Monson 6-19-2020

Garrett Monson Date
Reg. No. 54326

INTRODUCTION

Stearns County (County) has received complaints of high-water levels around Two Rivers Lake causing local flooding on properties neighboring the lake. Two Rivers Lake is in line with the Two Rivers River which is also designated as Stearns County Ditch (CD) 28 in this location. The County recently completed a correction of the public drainage system record on CD 28 to better inform management decisions for the public drainage system. Because CD 28 is the outlet to Two Rivers Lake, County staff retained Houston Engineering, Inc. (HEI) to determine if the condition of the public drainage system downstream of the outlet may be contributing to the flooding around Two Rivers Lake. Additionally, there is a carp trap at the outlet that has been observed to be plugged with debris on numerous occasions. HEI was also asked to determine the carp traps impact on lake levels.

METHODS

Consistent with the County's obligation to inspect public drainage systems, the County utilized the Stearns County Sheriff's Department to complete aerial reconnaissance using an unmanned aerial vehicle (UAV) equipped with GPS tracking and a high-resolution camera/video recorder in 2018. The Sheriff's Department completed flights over the entire length of CD 28. The video was reviewed by HEI to identify potential problem locations that may require maintenance.

HEI has also completed updates to an existing HEC-RAS model and extended the scope of the model to evaluate the impact of CD 28's condition downstream of Two River's Lake on lake levels for the 2-year, 10-year, and 100-year precipitation events.

OBSERVATIONS OF PHYSICAL CONDITION

HEI completed a review of the UASs video captured by the Sheriff's Department in 2018. Spread throughout the CD 28 system are several dead or dying trees that partially block the channel (**Photo 1**). There are also reaches of dense tree cover immediately adjacent to the channel that diminish access for maintenance activities and are

likely to eventually fall into the channel and become blockages (**Photo 2**). Though assessing the efficiency of the channel bottom is unclear from UAS video, the channel bottom upstream of Two Rivers Lake appears to be an undulating bottom with several areas where sediment is near or at the surface of the channel. Downstream of Two Rivers Lake, there is an obvious sediment delta at the confluence with Krain Creek.

The County also completed physical survey as part of the recent Record Reestablishment that was completed for CD 28. Observations on the channel profile were included in that report and include a note that there are areas of significant sediment accumulation in excess 3-feet downstream of Two Rivers Lake. Additionally, during the channel bottom survey, County survey staff observed the carp trap at the outlet of Two Rivers Lake to be plugged with vegetation (see **Photos 3, 4, and 5**).

HYDRAULIC ASSESSMENT

MODELING OVERVIEW

The County provided a steady-state HEC-RAS hydraulic model of CD 28 previously completed by Bolton & Menk on behalf of the Two Rivers Lake Association. HEI updated this model's scope and geometry and converted it to an unsteady model to simulate a full synthetic event rainfall hydrograph, the storage capacity within Two Rivers Lake, and the variable timing of peak flow from the outlet of Two Rivers Lake and Krain Creek.

The conversion of the model from a steady to unsteady state allows for the model to account for storage, and particularly change in storage during an event. Therefore, using an unsteady state model is necessary to evaluate the varying water surface elevations of Two Rivers Lake during an event and the changes caused to those water surface elevations by changes to the outlet or downstream channel.

To develop runoff hydrographs to simulate through the HEC-RAS model, HEI developed a HEC-HMS hydrologic model for approximately 75 square miles of the CD 28 watershed upstream of Holdingford, MN. The drainage areas included in this model are shown in **Figure 1.** The hydrologic model was used to simulate the synthetic 2-year, 10-year, and 100-year 24-hour rainfall events. The 2-year event can provide insight into the prevalence of nuisance flooding, the 10-year event is often tied to culvert and stormwater design, and the 100-year event is important for assessing structural flooding.

The unsteady model was used to determine the effects on CD 28 and Two Rivers Lake during various storm events and channel repair scenarios. Three scenarios were analyzed for this study:

- **Scenario 1**: The current condition, with a 100% clogged fish barrier to an elevation of 1130[1] at lake outlet and with no channel repairs to CD 28.
- **Scenario 2**: Removal of fish barrier with no channel repairs to CD 28.
- **Scenario 3**: Removal of fish barrier and repair of CD 28 to the As Constructed and Subsequently Improved Condition (ACSIC) downstream of Two Rivers Lake.

[1] All elevations provided herein are in North American Vertical Datum of 1988 (NAVD 88) unless otherwise noted.

A more thorough discussion of the modeling approach and description of modeling scenarios is included in **Appendix A**. The ACSIC of CD 28 has previously been reestablished by the County in 2019 through a legal proceeding under MN Statute 103E.101 Subp.4. The plan and profile drawings reflecting the ACSIC are included as **Appendix B**.

The results of analyzing these scenarios is shown below, in **Table 1.**

Table 1: Maximum flood elevations at Two Rivers Lake (feet).

Scenario	2-year*	10-year	100-year
1: Existing Conditions	1132.49	1134.40	1136.82
2: Barrier Removed	1131.95 *(-0.54)***	1134.09 *(-0.31)*	1136.67 *(-0.15)*
3: Full Repairs	1131.66 *(-0.83)*	1133.94 *(-0.46)*	1136.58 *(-0.24)*

**All rainfalls modeled are 24-hour duration*

***Values in italic are reduction in peak water surface elevations relative to Existing Condition*

RESULTS OF MODELING

The modeling results show a reduction in peak water elevation and subsequently flooding extents from removal of the fish barrier and repair of CD 28 to the ACSIC. The maximum 2-year event flood elevation at Two Rivers Lake is decreased by 0.54 feet from removal of the fish barrier, and by 0.83 feet for barrier removal and completing channel repairs to the ACSIC. The effects of barrier removal and ACSIC channel repairs on floodplain extents is shown in **Figure 2**. This reduction also extends along CD 28, reducing the amount and extent that CD 28 exceeds its banks as seen in **Figure 3**. Modeling results indicate the reductions along CD 28 are due to both the removal of the fish barrier and the ACSIC channel repairs. Removal of the fish barrier results in a slightly lower normal water level on Two Rivers Lake which allows for additional storage during a rainfall event.

Although the floodplain extents are reduced along CD 28 downstream of Two Rivers Lake following a repair to the ACSIC, the reduction is floodplain area does not inherently provide a benefit by reducing damages. The land that is inundated by the 2-year event in the current condition is low lying wetlands and hayed land. Depending on the duration of inundation, the temporary flooding of these lands may result in no damages or loss of crop. Modeling does indicate that removing the fish barrier and completing repairs consistent with the ACSIC downstream of Two Rivers Lake would result in the 2-year event being contained within the channel banks for most of its length, which may consequentially lower water levels on lateral ditches or streams. The reduction of the 2-year flood elevation will likely protect the channel banks and provide a more reliable and predictable outlet for agricultural and municipal drainage.

The 10-year and 100-year events also show reductions in maximum flood elevation at Two Rivers Lake as shown in **Table 1.** The floodplain extents in upland areas along the lake for these events will continue to be substantial due to the volume of water passing through Two Rivers Lake. The floodplain extent for the current condition and the condition with barrier removal and ACSIC channel repairs for the 10-year rainfall event is shown in **Figures 4 and 5,** and the 100-year event in **Figures 6 and 7.**

The modeling indicates that in the current condition, several structures around Two Rivers Lake experience flooding for the 100-year rainfall event, many of which are dwellings on the eastern and southern shores. The LiDAR topography and aerial photography suggest that no structures within the 100-year floodplain in the current condition will be removed from the floodplain following removal of the barrier or repair of the CD 28 channel to the ACSIC downstream of Two Rivers Lake. However, a decrease of 0.24-feet (about 3-inches) of flood elevation may reduce damages in some dwellings and will provide some reduction in the recurrence interval of flooding. The modeling indicates that the repairs will provide a reduction in damages resulting from the 10-year and 100-year events. In addition, detailed survey may indicate that the reduction in flood elevation of 3-inches for the 100-year event may remove some structures from the floodplain. Therefore, additional information about structures within or near the floodplain, including low floor and low opening elevations, are necessary to further evaluate the impacts of repairs or outlet modifications.

RECOMMENDATIONS

We recommend that the fish barrier at the outlet of Two Rivers Lake be removed immediately, as the barrier is an unauthorized obstruction to the public drainage system. Removal of the barrier is expected to realize most of the available reduction in peak water surface elevation amongst the options evaluated in this report. Additionally,

Subsequent to the removal of the fish barrier, we recommend that the County pursue the completion of a Repair Report for the CD 28 public drainage system consistent with the ACSIC pursuant to MN Statute 103E. Stearns County Ditch 28 (CD 28) is in disrepair downstream of Two Rivers Lake. The hydraulic assessment shows that repairing the CD 28 channel will result in a reduction in flooding around Two Rivers Lake, and along the CD 28 channel. This reduction is most significant for the 2-year event along the CD 28 channel, and for the 10- and 100-year events at Two Rivers Lake. The Repair Report, which would include a detailed survey of at-risk structures, will further evaluate repair options. In most cases, repairs would consist of excavating accumulated sediment from the channel bottom and removal of trees located within and adjacent to the channel. Furthermore, the County may wish to evaluate a phased approach to address key areas within the scope of the repair report. However, note that phasing the repair may result in an overall increase in project cost, as it will require multiple mobilizations of equipment and will not take advantage of an economy of scale.

It is also known that the Benefits for CD 28 are not up to date. The County should complete a Redetermination of Benefits prior to incurring larger expenses for the system, for instance, development of the repair report.

Photo 1: Deadfalls in ditch

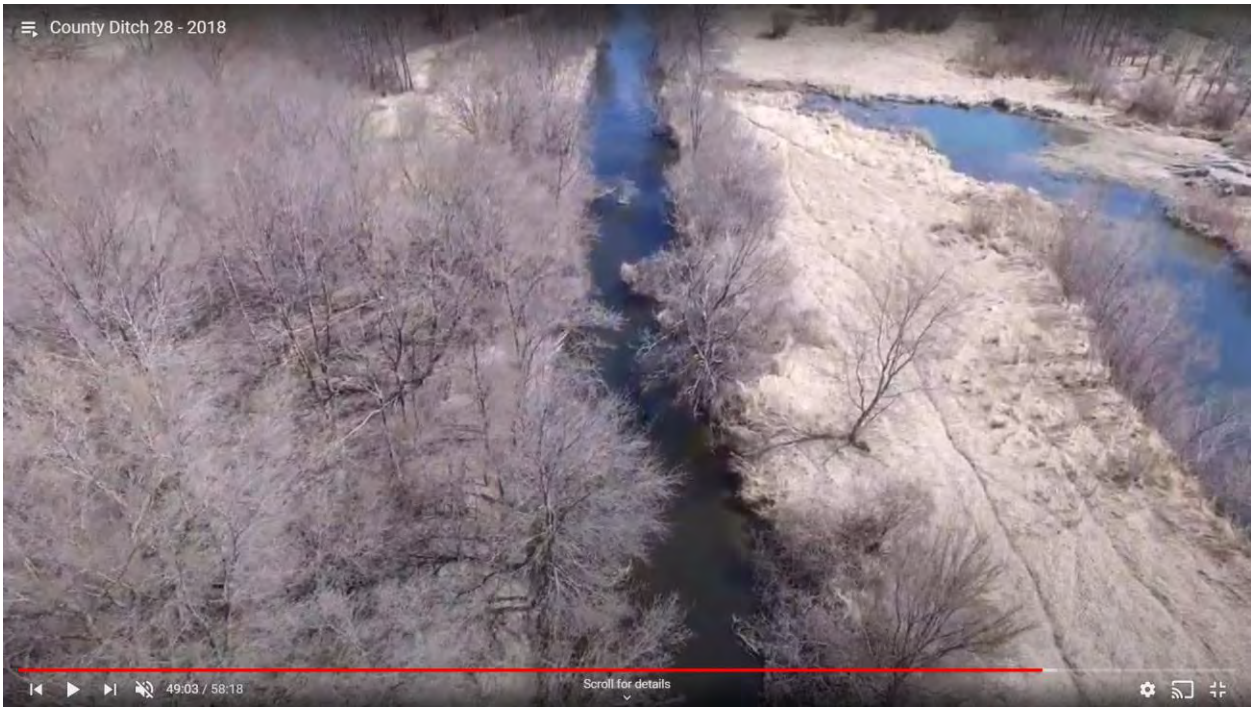
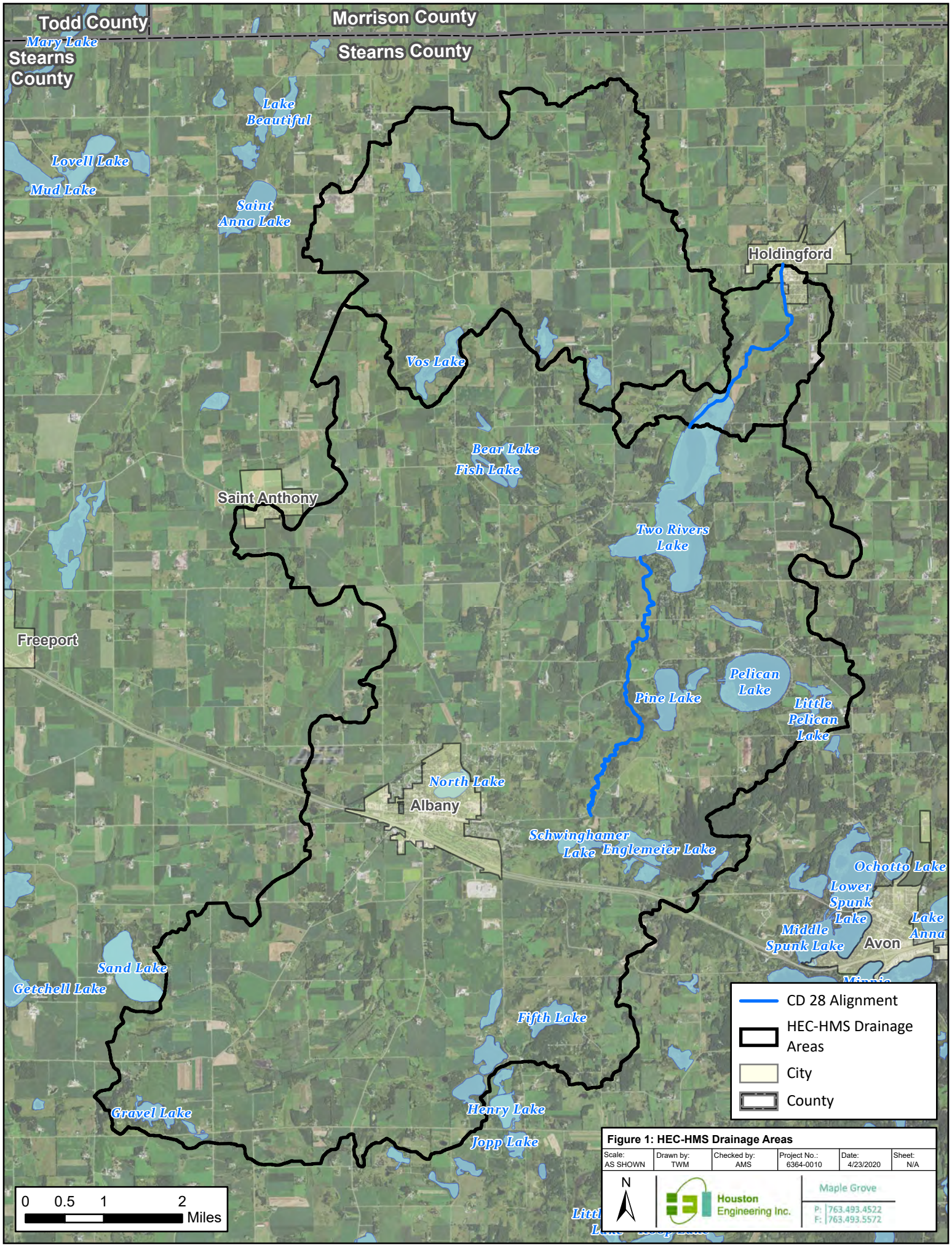


Photo 2: Trees along the ditch

Photo 3: Fish barrier at the outlet of Two Rivers Lake.

Photo 4: Fish barrier meeting the bank at the outlet of Two Rivers Lake.

Photo 5: Clearing out the fish barrier improves flow.


Todd County
Morrison County
Stearns County
Stearns County
Mary Lake
Lake Beautiful
Lovell Lake
Mud Lake
Saint Anna Lake
Holdingford
Vos Lake
Bear Lake
Fish Lake
Saint Anthony
Two Rivers Lake
Freeport
Pelican Lake
Pine Lake
Little Pelican Lake
North Lake
Albany
Schwinghamer Lake
Englemeier Lake
Ochotto Lake
Lower Spunk Lake
Lake Anna
Middle Spunk Lake
Avon
Sand Lake
Getchell Lake
Fifth Lake
Gravel Lake
Henry Lake
Jopp Lake
0 0.5 1 2 Miles
CD 28 Alignment
HEC-HMS Drainage Areas
City
County
Figure 1: HEC-HMS Drainage Areas
Scale: AS SHOWN
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Checked by: AMS
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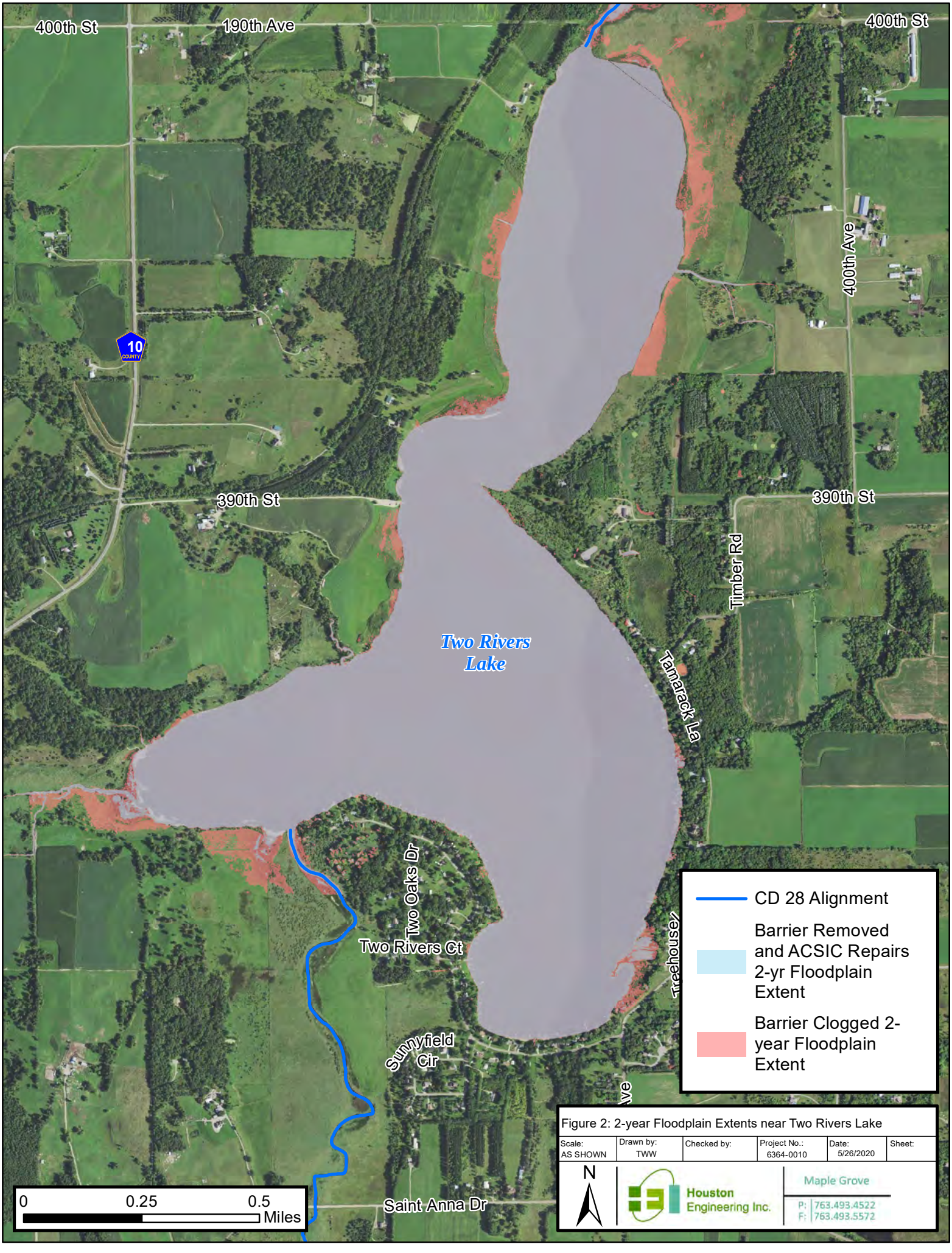

Figure 2: 2-year Floodplain Extents near Two Rivers Lake

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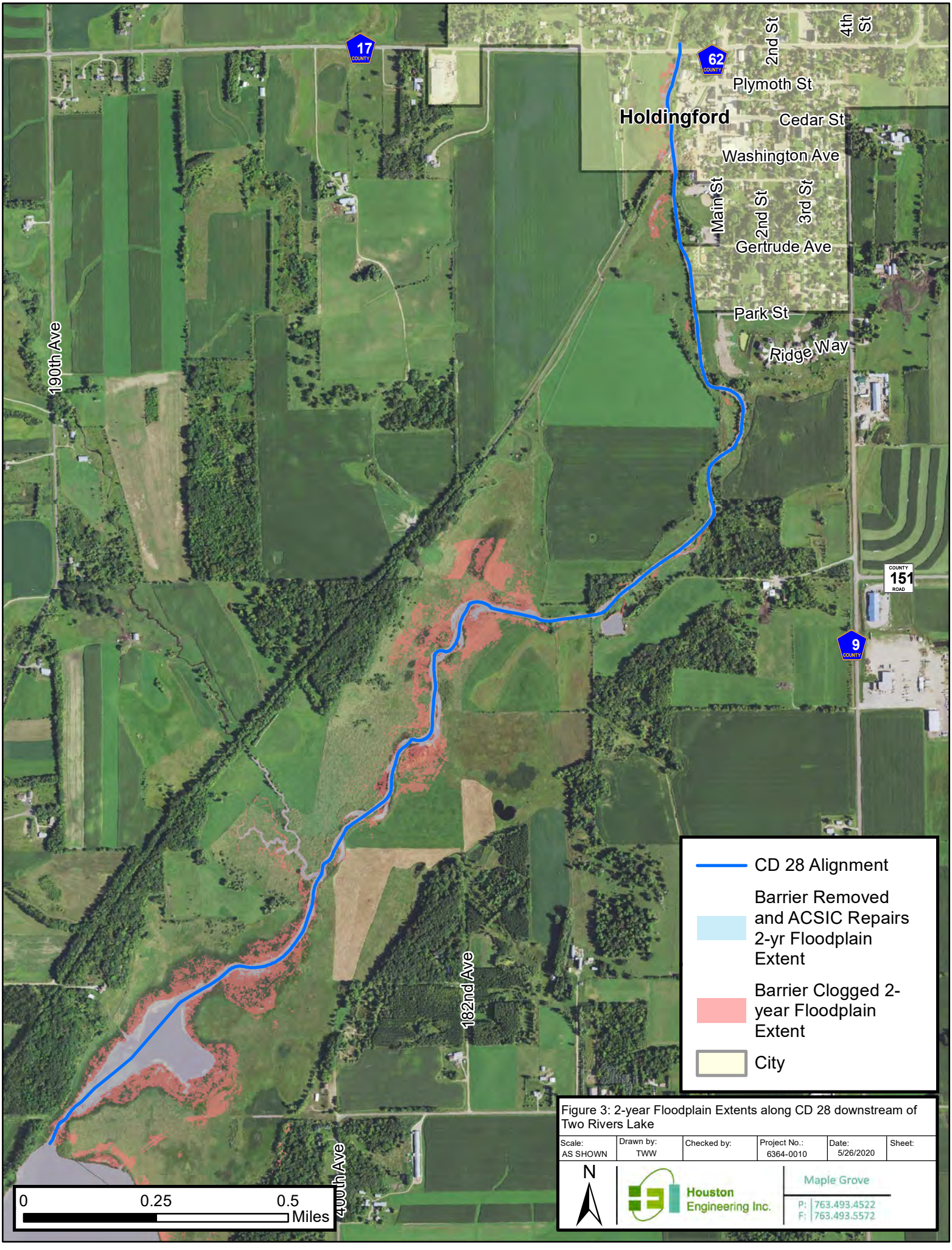

Figure 3: 2-year Floodplain Extents along CD 28 downstream of Two Rivers Lake

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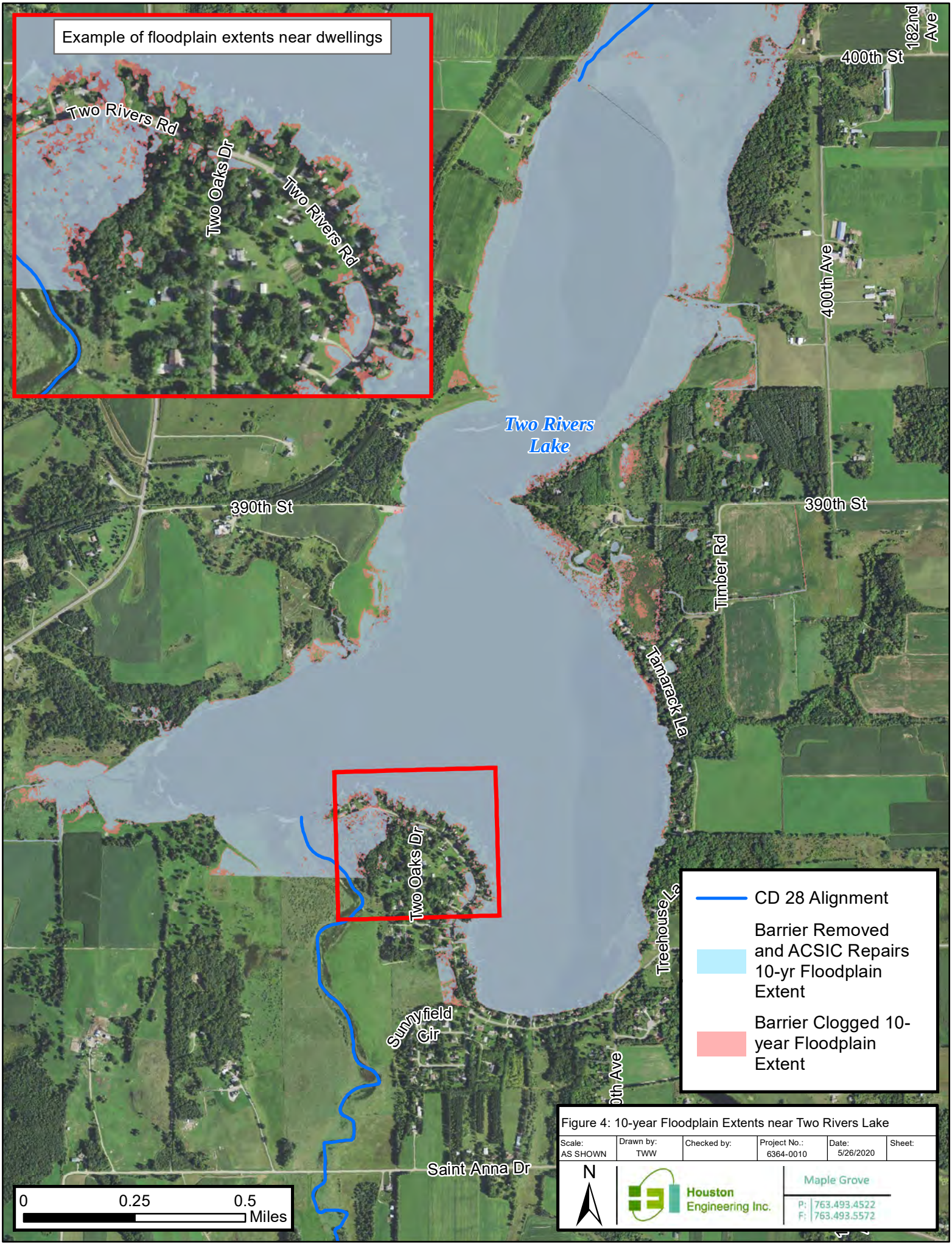

Figure 4: 10-year Floodplain Extents near Two Rivers Lake

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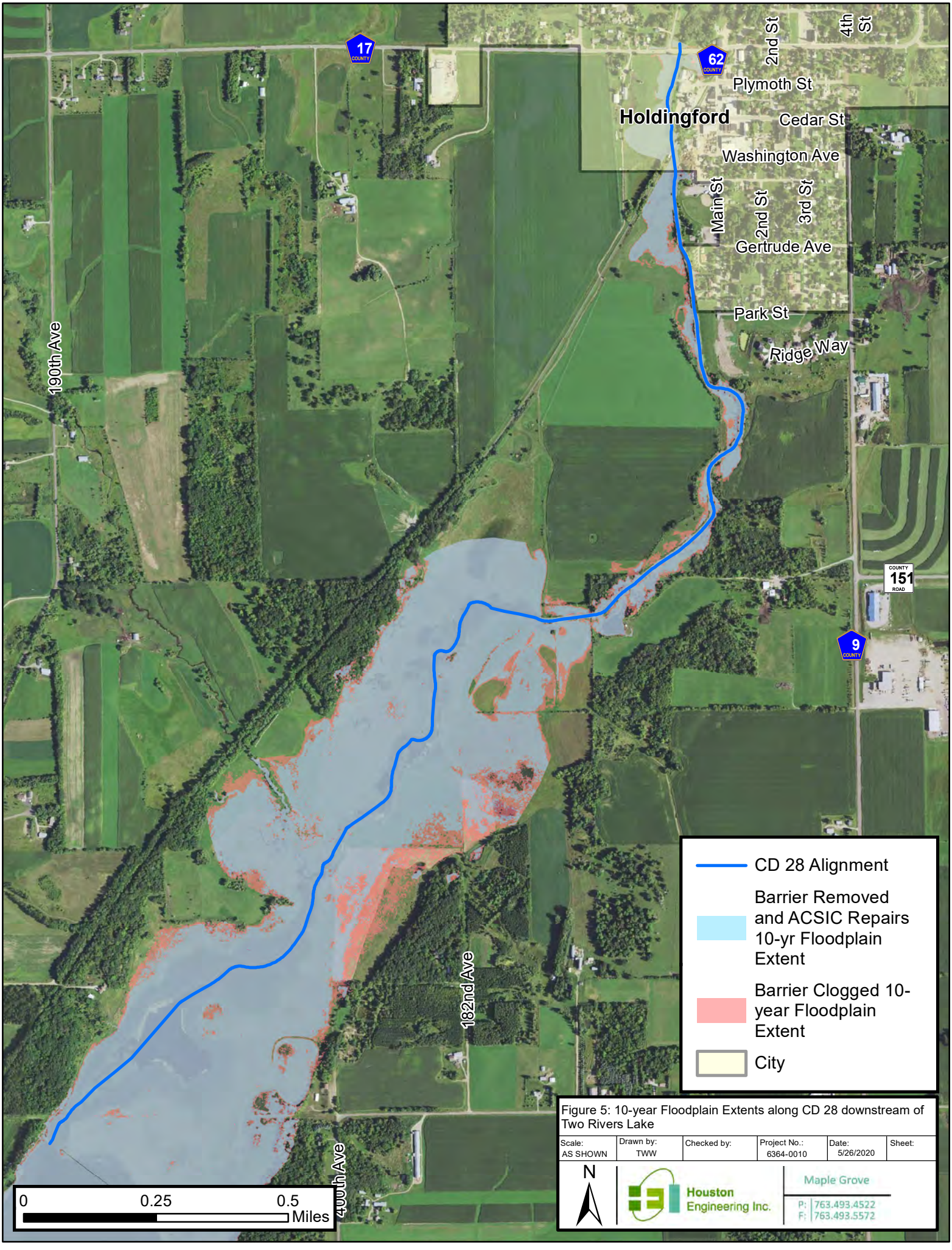

Figure 5: 10-year Floodplain Extents along CD 28 downstream of Two Rivers Lake

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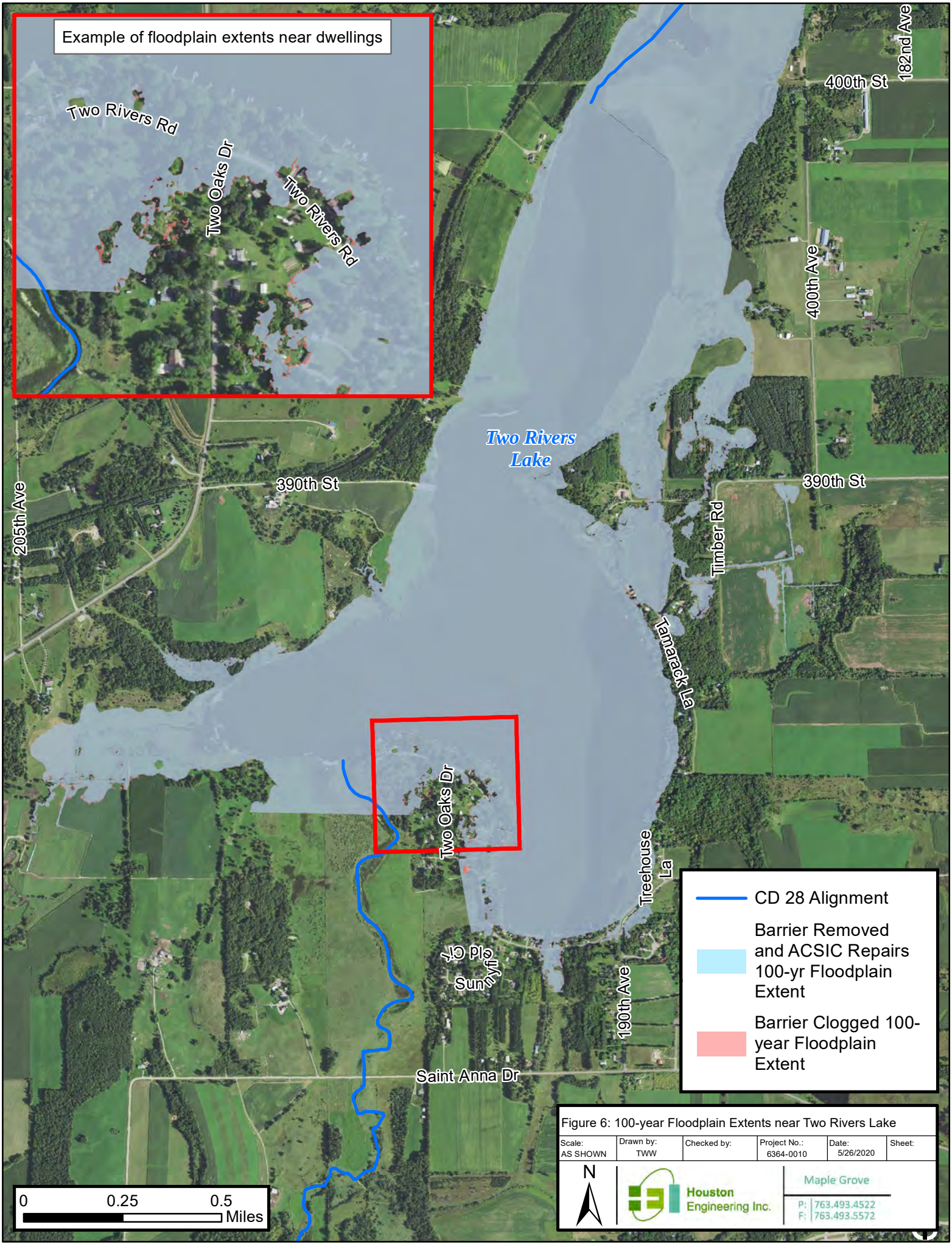

Figure 6: 100-year Floodplain Extents near Two Rivers Lake

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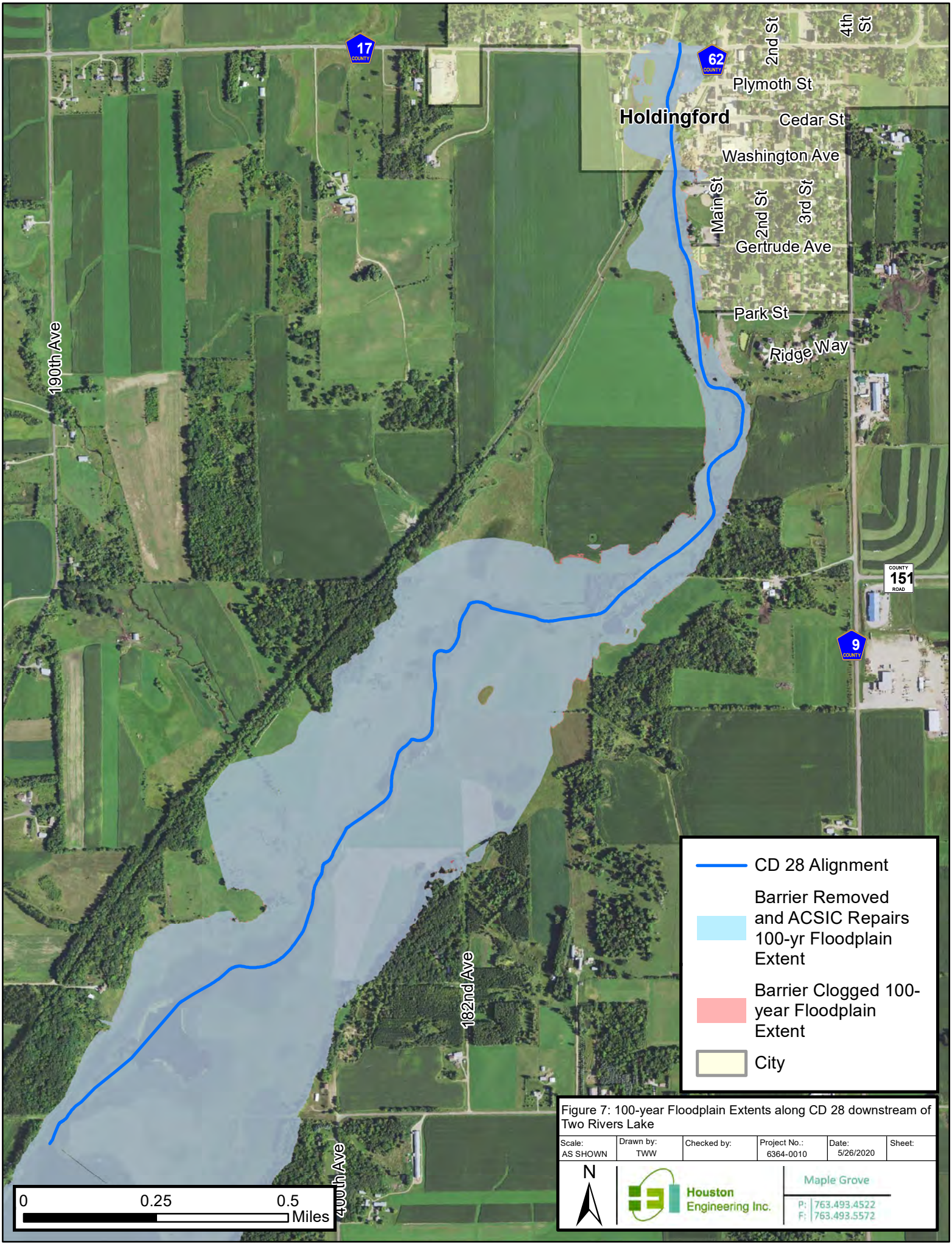

Figure 7: 100-year Floodplain Extents along CD 28 downstream of Two Rivers Lake

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APPENDIX A – MODELING PROCEDURE

A HEC-HMS hydrologic model was developed for approximately 75 square miles of the County Ditch 28 watershed above Holdingford, MN. Digital elevation data (LiDAR) for this analysis was acquired from the DNR topographic data viewer, MNTopo. The LiDAR data was used to delineate subbasins for the hydrologic model and was also used for elevation data in the hydraulic model. The HEC-HMS model consists of 3 subbasins; the watershed upstream of Two Rivers Lake, the Krain Creek watershed, and the local drainage area along CD 28 upstream of Holdingford. These drainage areas can be seen in **Figure 1.**

The hydrologic model uses the SCS Curve Number runoff method. This method uses curve numbers to determine the amount of runoff generated during a specific rainfall event. The average Curve Number for the hydrologic model area is 75. NOAA Atlas 14 rainfall depths were simulated in the hydrologic model. The rainfall depths were applied with a nested distribution. The model was used to simulate the synthetic 2-year, 10-year, and 100-year 24-hour rainfall events. The runoff hydrographs from these events were then simulated through the hydraulic model.

An existing steady-state HEC-RAS hydraulic model, developed in 2016 by Bolton & Menk, was used as a base model for this study. The 2016 HEC-RAS model was updated with 2018 topographic field survey obtained by the County and available LiDAR data. The CD 28 model extends from the Two Rivers Lake to River Street in Holdingford. Two Rivers Lake is included in the model as the HEC-RAS storage area element. LiDAR data was used to develop an elevation-storage curve for the lake. The HEC-RAS modeling schematic is shown in **Figure A-1.** Combined HEC-HMS and HEC-RAS models comprise of an unsteady modeling system for CD 28. The unsteady model allows for the simulation of a full synthetic event rainfall hydrograph. The unsteady model accounts for the storage capacity within Two Rivers Lake. The models were not calibrated.

The unsteady model was used to determine the effects on CD 28 and Two Rivers Lake during various storm events and channel repair scenarios. Three scenarios were considered for this study.

Scenario 1 is the current condition, with a 100% clogged fish barrier to an elevation of 1130 (NAVD ’88) at lake outlet and with no channel repairs to CD 28. The fish barrier was modeled as a weir at the elevation of 1130. This was based off the 2018 topographic survey. A normal water level of 1130 was also used at the start of the model run. A plot of Two Rivers Lake elevation vs time for Scenario 1 can be seen in **Figure A-2.**

Scenario 2 includes removal of the fish barrier but no channel repairs to CD 28. The weir representing the fish barrier was removed from the model so that the normal channel cross-section at the outlet of Two Rivers Lake was unaltered. A normal water level of 1127.8 was used at the start of the model run, assuming the normal water level was lowered by barrier removal but allowing it to rise to an appropriate elevation by the time the concentrated storm event reaches Two Rivers Lake. A plot of Two Rivers Lake elevation vs time for Scenario 2 can be seen in **Figure A-3.**

Scenario 3 includes removal of the fish barrier and repair of CD 28 to the As Constructed and Subsequently Improved Condition (ACSIC) downstream of Two Rivers Lake. The channel cross-sections in the HEC-RAS model were edited to the ACSIC condition. The ACSIC channel condition with a 10-foot bottom width and 1:1 side slopes was used to lower the current HEC-RAS cross-sections to the ACSIC elevation, given in **Appendix**

B. A normal water level of 1127.8 was used at the start of the model run for this scenario as well. A plot of Two Rivers Lake elevation vs time for Scenario 3 can be seen in **Figure A-4.**

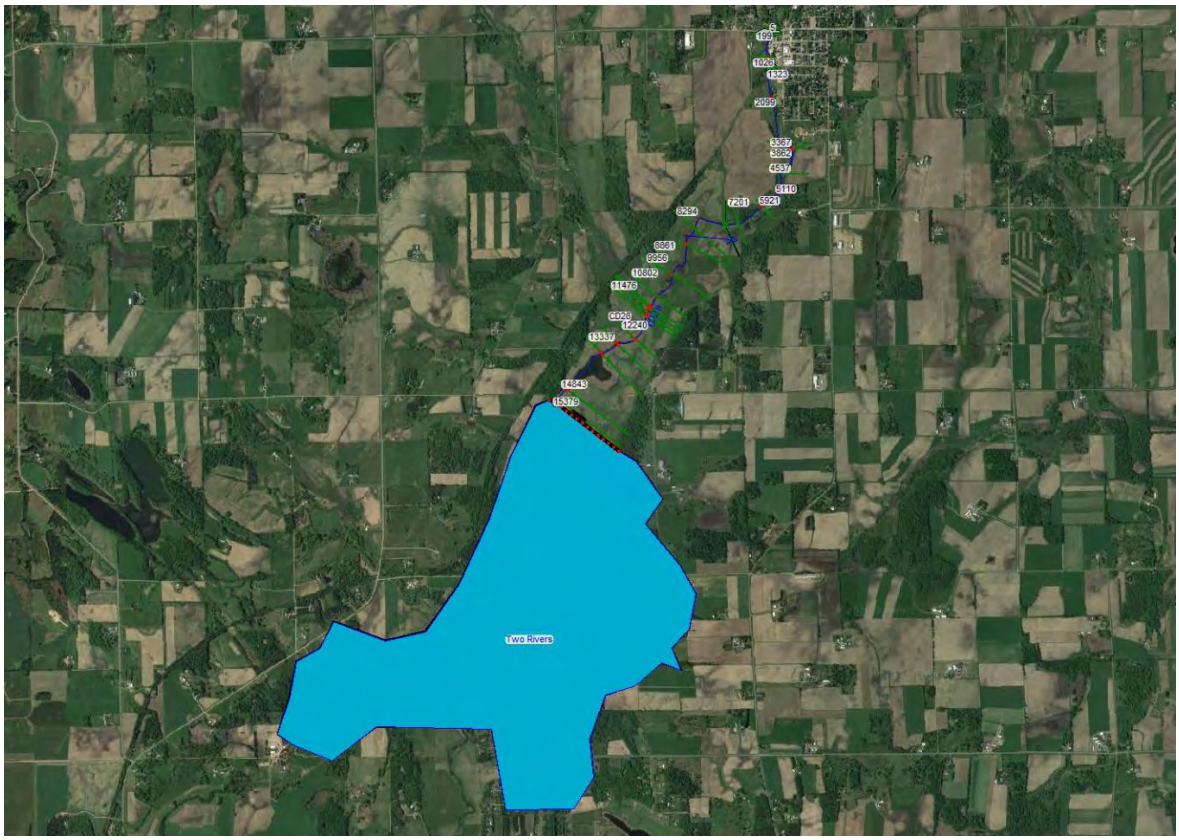


Figure A-1: HEC-RAS schematic of the CD 28 hydraulic model.

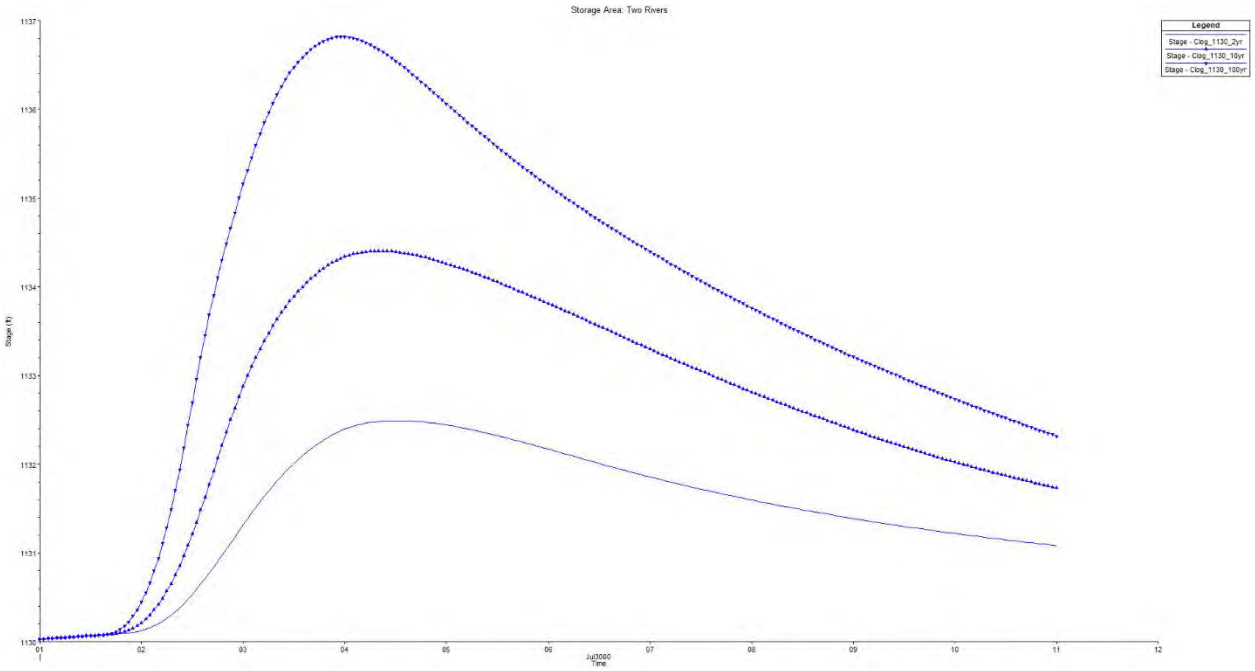


Figure A-2: Two Rivers Lake elevation vs time for Scenario 1 for the 2-year, 10-year, and 100-year events.

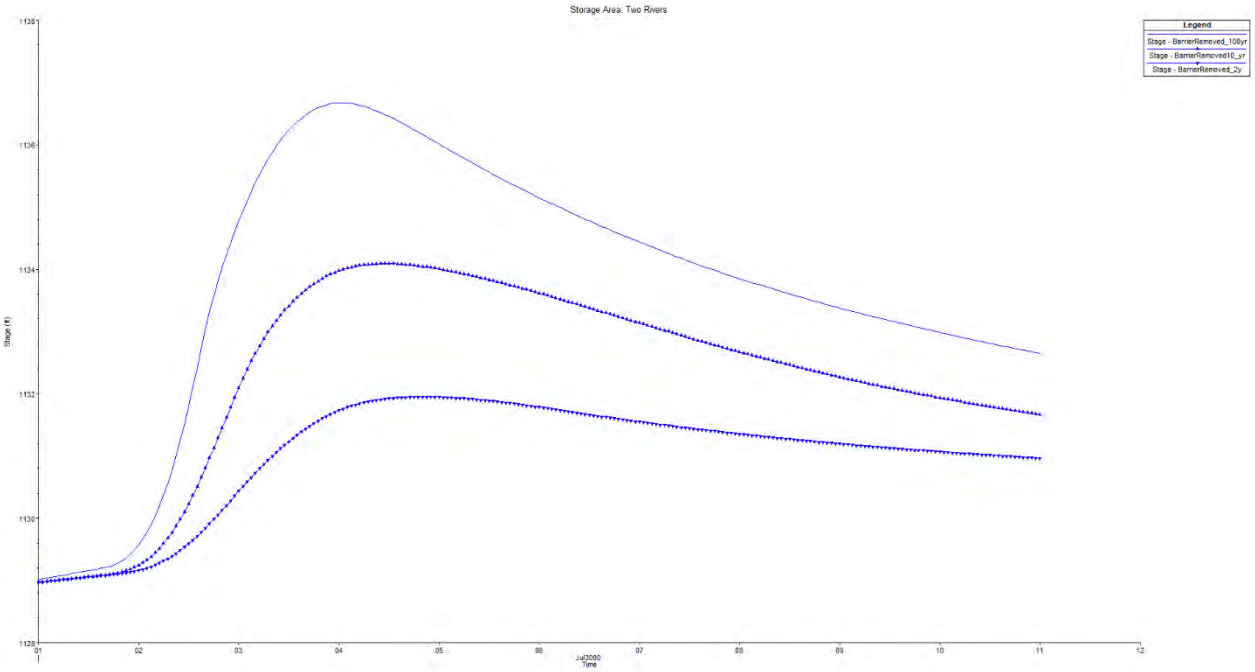


Figure A-3: Two Rivers Lake elevation vs time for Scenario 2 for the 2-year, 10-year, and 100-year events.

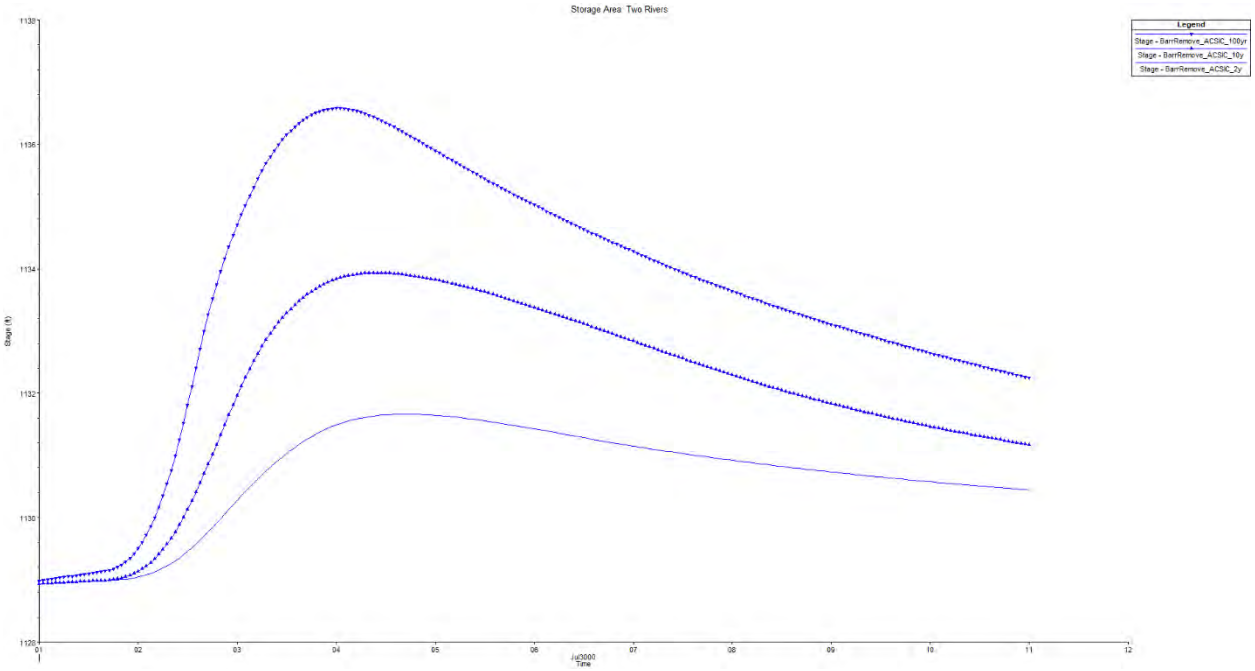


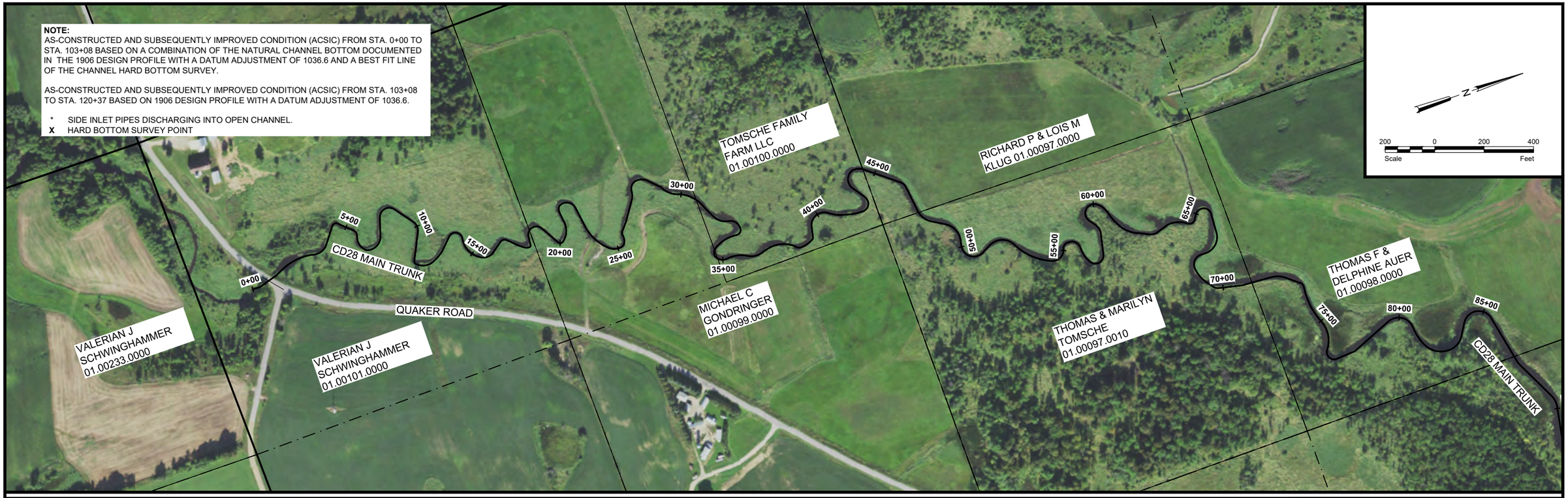
Figure A-4: Two Rivers Lake elevation vs time for Scenario 3 for the 2-year, 10-year, and 100-year events.

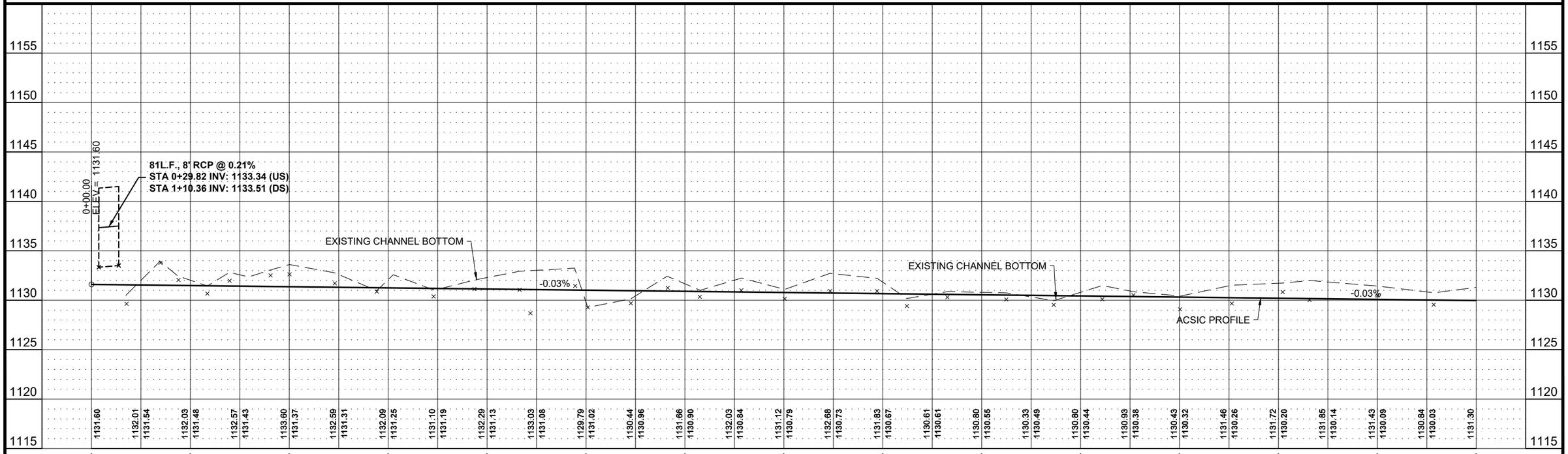
APPENDIX B – CD 28 PLAN AND PROFILES

NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) FROM STA. 0+00 TO STA. 103+08 BASED ON A COMBINATION OF THE NATURAL CHANNEL BOTTOM DOCUMENTED IN THE 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6 AND A BEST FIT LINE OF THE CHANNEL HARD BOTTOM SURVEY.

AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) FROM STA. 103+08 TO STA. 120+37 BASED ON 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6.

* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT





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REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
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PROJECT NO. 6364-010

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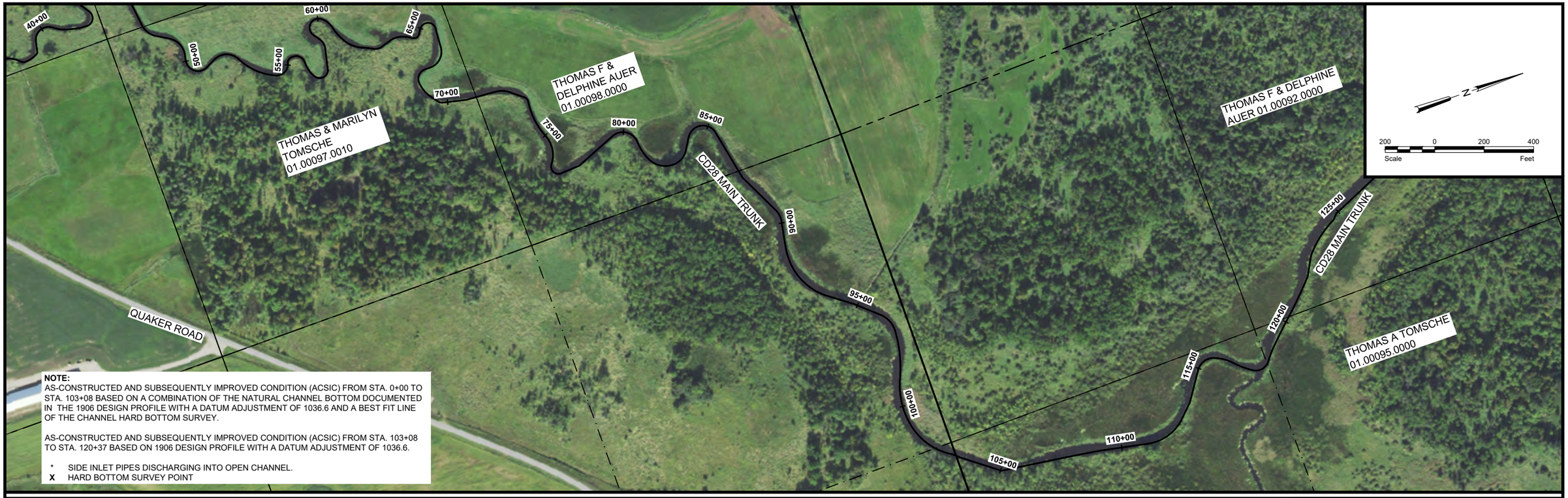
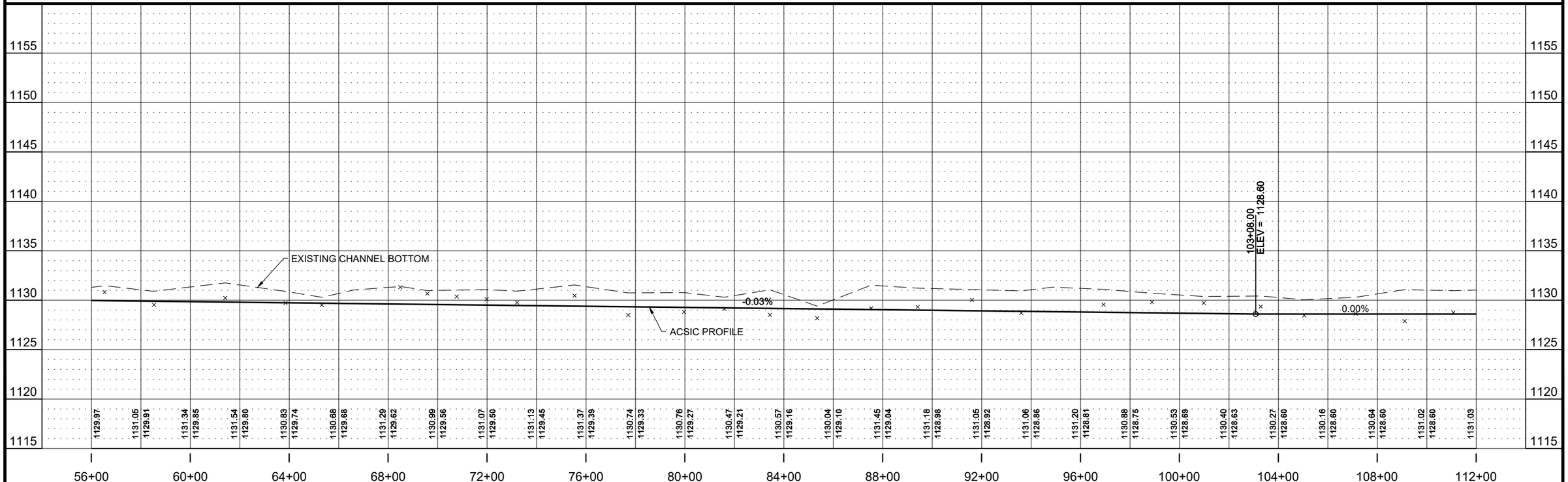


NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) FROM STA. 0+00 TO STA. 103+08 BASED ON A COMBINATION OF THE NATURAL CHANNEL BOTTOM DOCUMENTED IN THE 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6 AND A BEST FIT LINE OF THE CHANNEL HARD BOTTOM SURVEY.

AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) FROM STA. 103+08 TO STA. 120+37 BASED ON 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6.

* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT



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REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 56+00 - 112+00
PROJECT NO. 6364-010

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NOTE:
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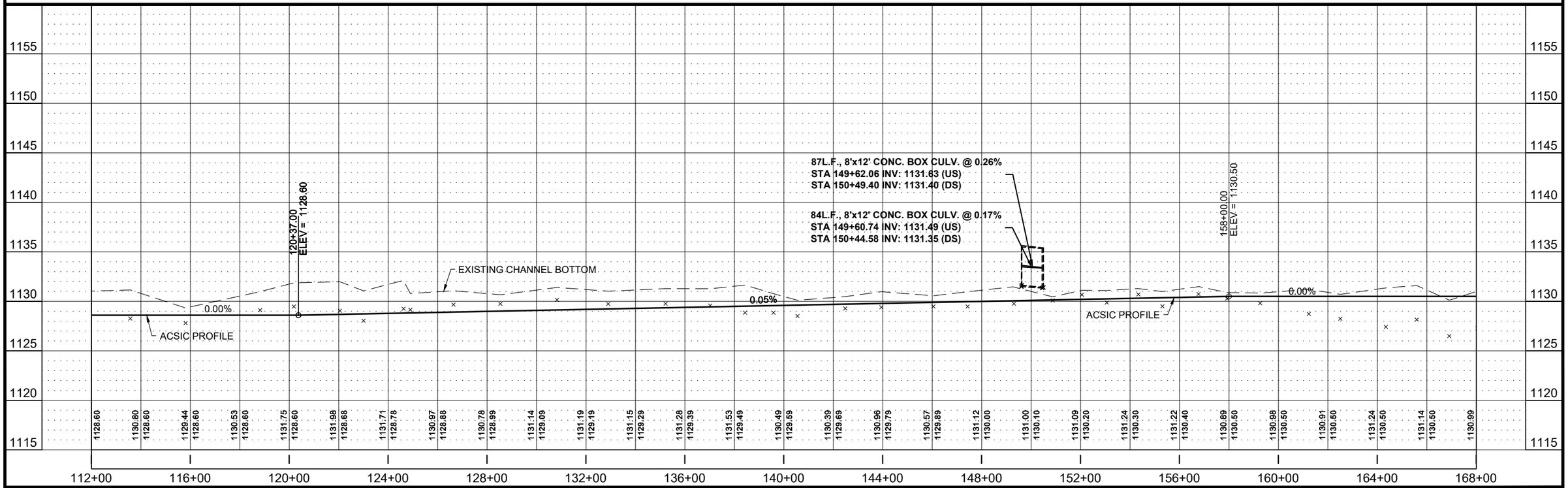
* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT



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REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 112+00 - 168+00
PROJECT NO. 6364-010

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NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY APPROVED CONDITION (ACSIC) FROM STA. 120+37 TO STA. 264+00 BASED ON A BEST FIT LINE OF THE CHANNEL HARD BOTTOM SURVEY AND CONSISTENT WITH THE RISING AND FALLING CHARACTERISTICS OF THE NATURAL CHANNEL BOTTOM DOCUMENTED IN 1906 DESIGN PROFILE.

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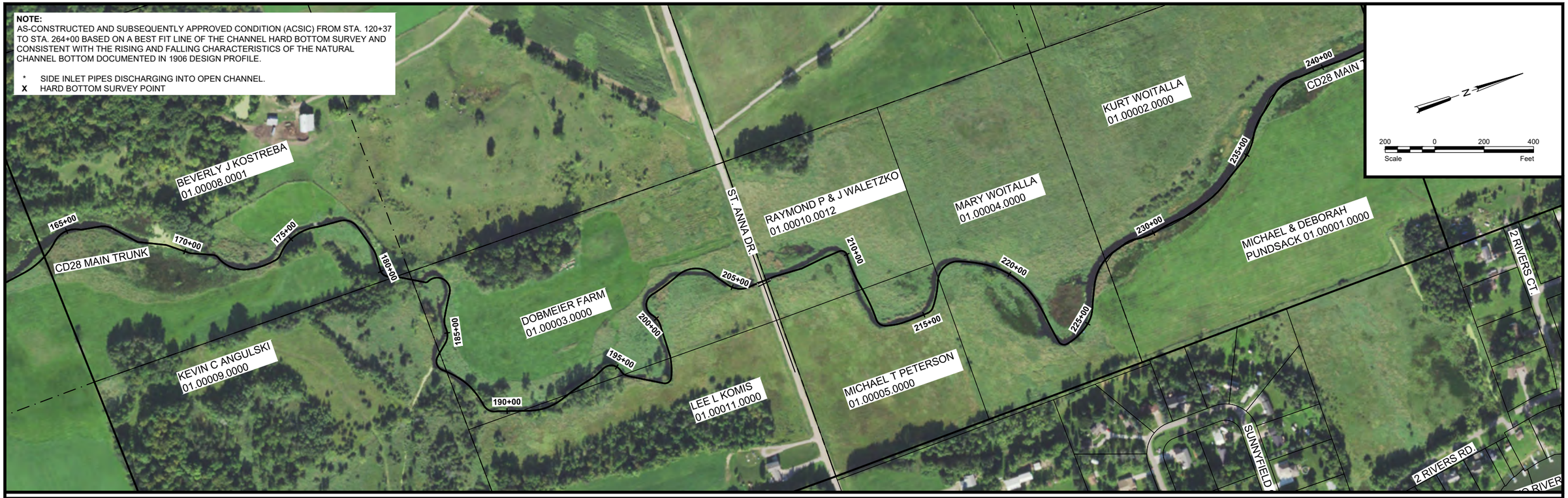

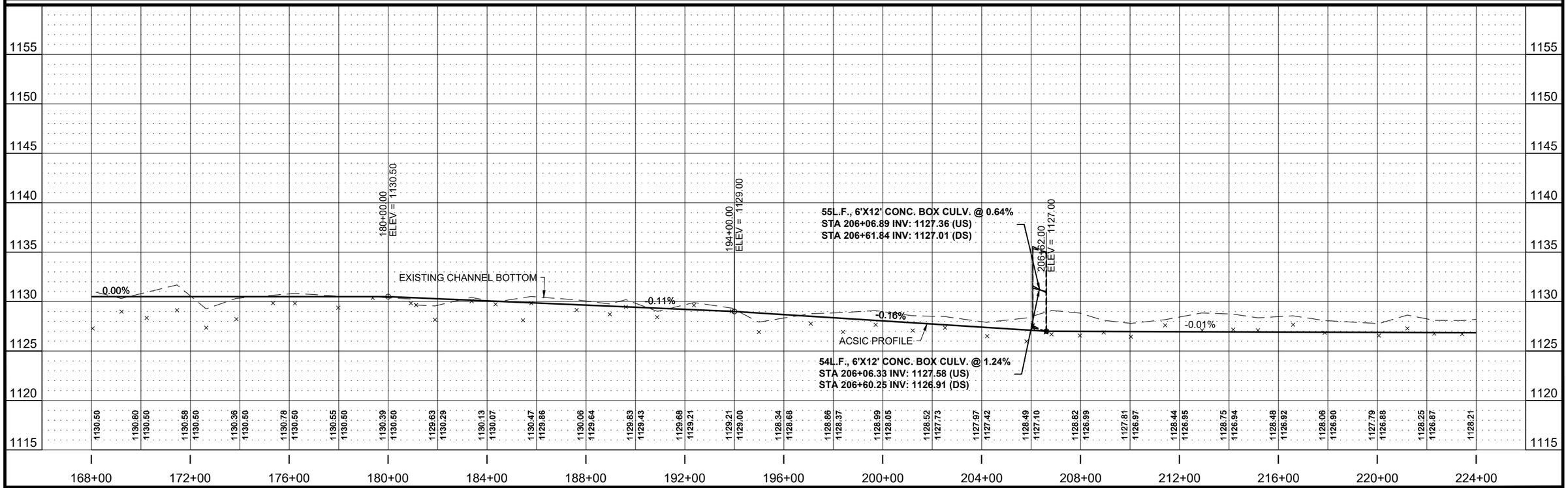

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Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572

Drawn by	Date
TAM	5-09-2019
Checked by	Scale
GM	AS SHOWN

REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 168+00 - 224+00
PROJECT NO. 6364-010

SHEET
4 of 8

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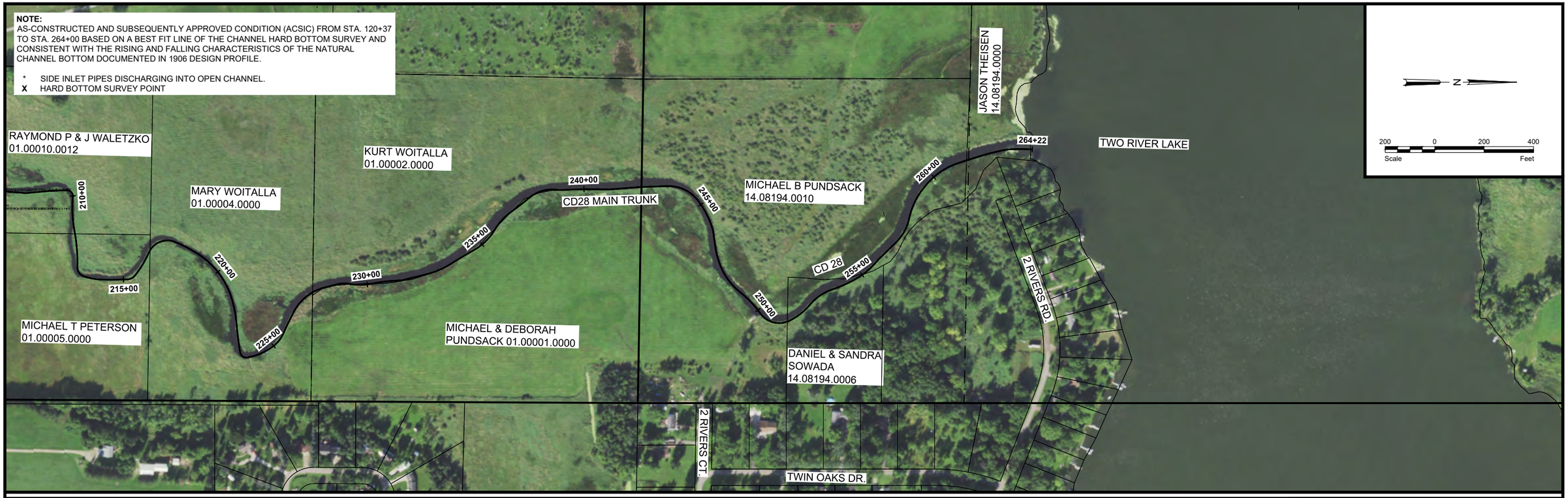
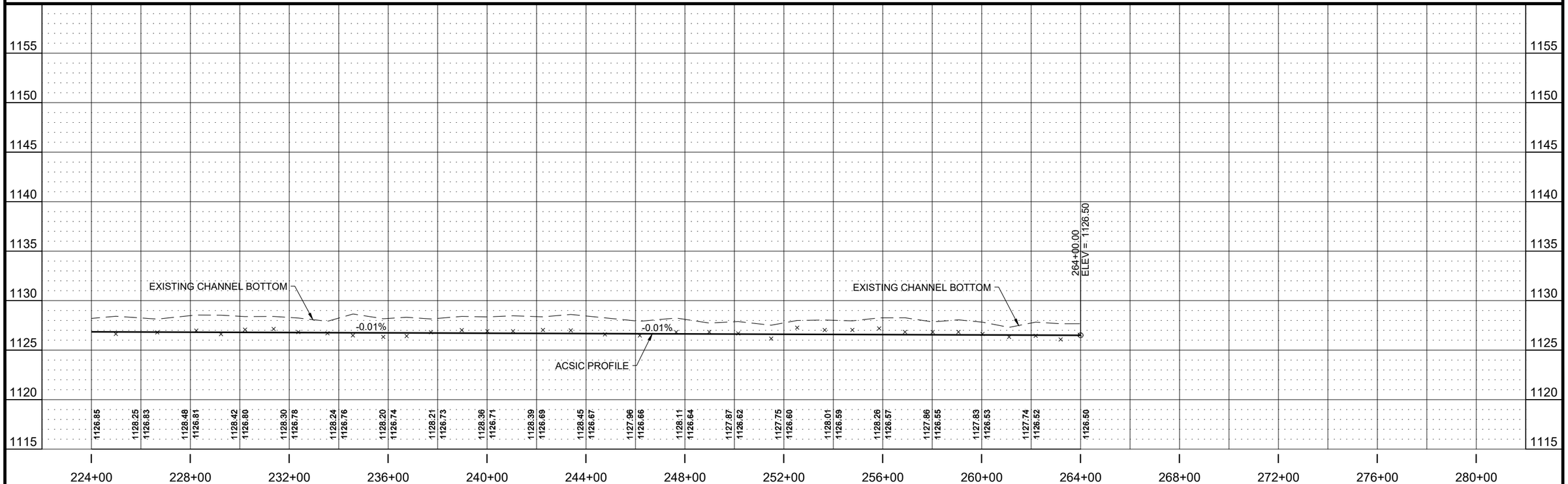
NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY APPROVED CONDITION (ACSIC) FROM STA. 120+37 TO STA. 264+00 BASED ON A BEST FIT LINE OF THE CHANNEL HARD BOTTOM SURVEY AND CONSISTENT WITH THE RISING AND FALLING CHARACTERISTICS OF THE NATURAL CHANNEL BOTTOM DOCUMENTED IN 1906 DESIGN PROFILE.

* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT





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STA. 224+00 - 264+00
PROJECT NO. 6364-010

SHEET
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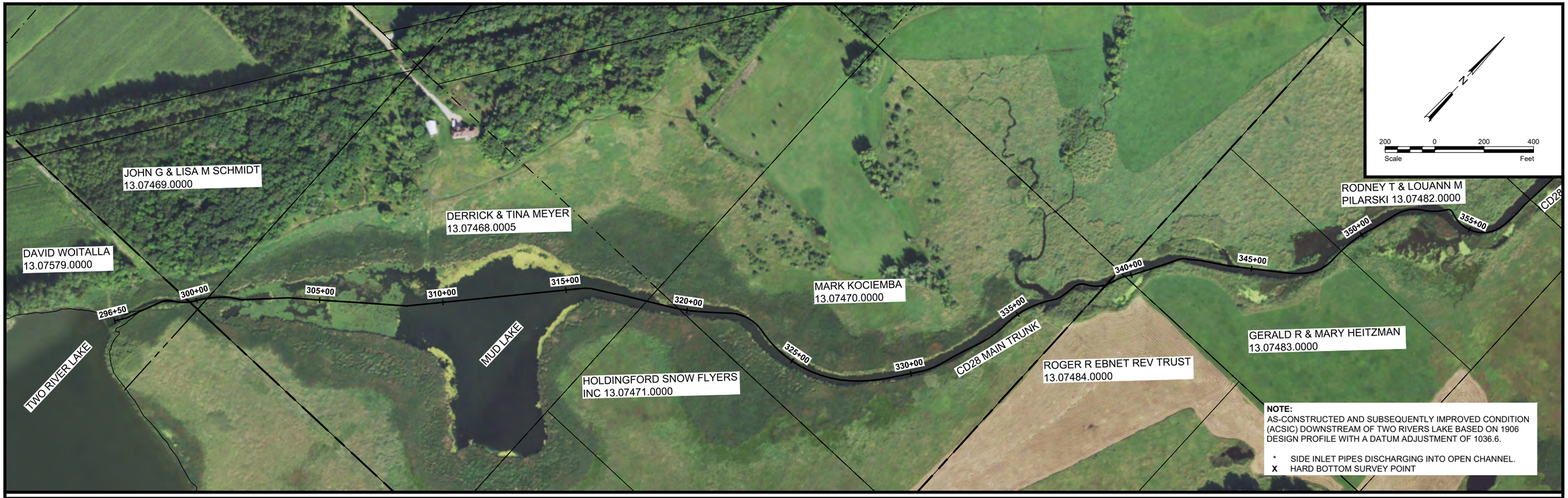

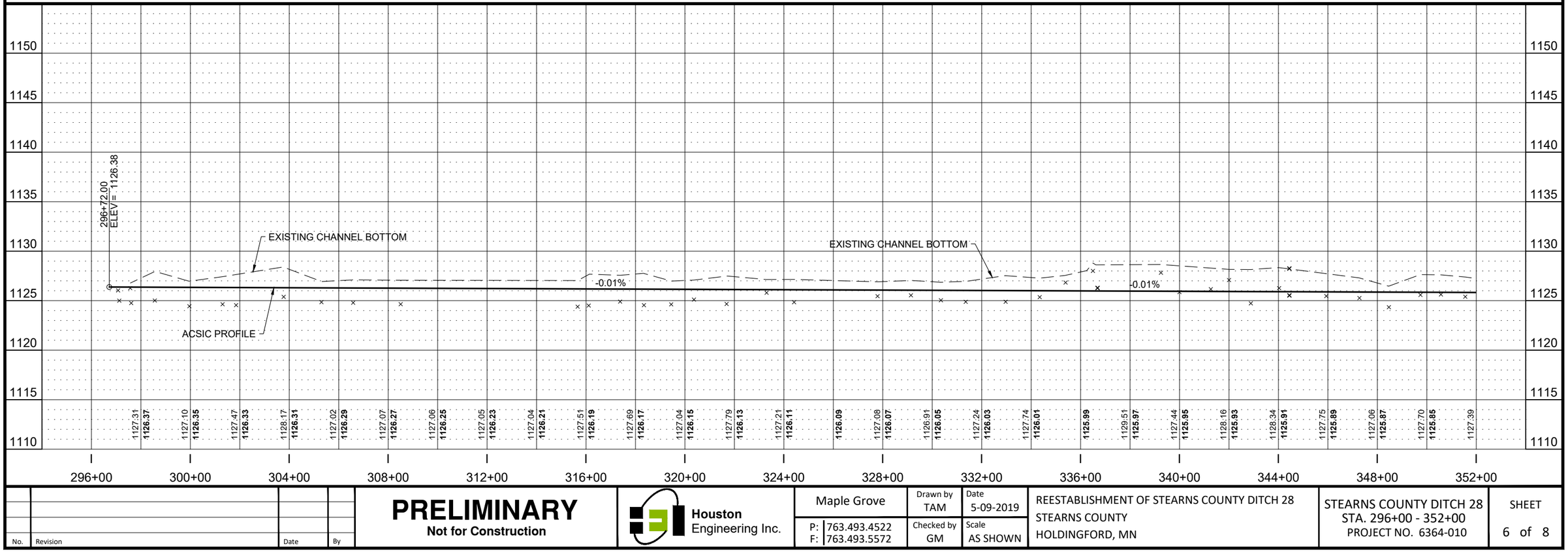

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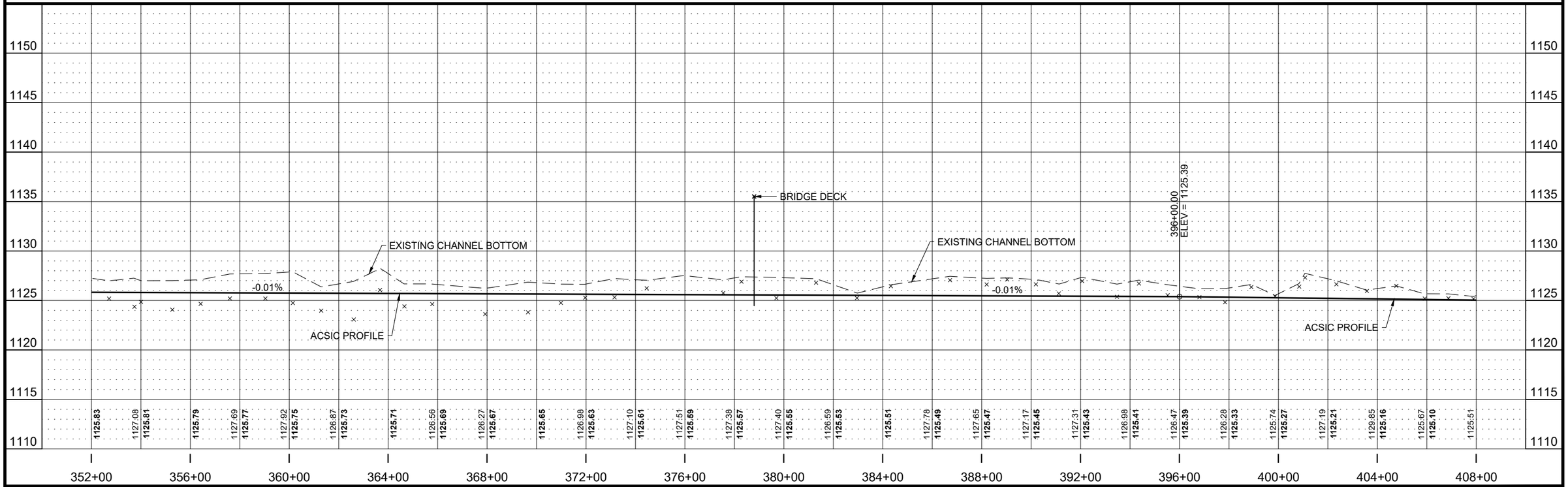
REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 296+00 - 352+00
PROJECT NO. 6364-010

NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) DOWNSTREAM OF TWO RIVERS LAKE BASED ON 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6.

* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT



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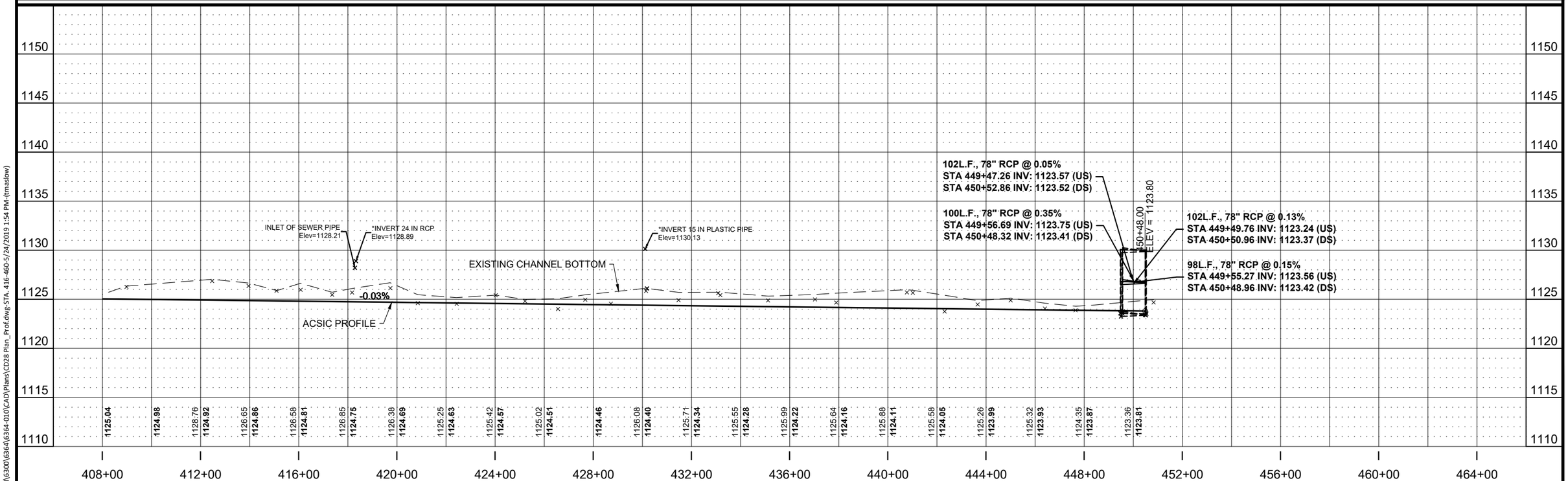
REESTABLISHMENT OF STEARNS COUNTY DITCH 28
STEARNS COUNTY
HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 356+00 - 408+00
PROJECT NO. 6364-010

NOTE:
AS-CONSTRUCTED AND SUBSEQUENTLY IMPROVED CONDITION (ACSIC) DOWNSTREAM OF TWO RIVERS LAKE BASED ON 1906 DESIGN PROFILE WITH A DATUM ADJUSTMENT OF 1036.6.

* SIDE INLET PIPES DISCHARGING INTO OPEN CHANNEL.
X HARD BOTTOM SURVEY POINT



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REESTABLISHMENT OF STEARNS COUNTY DITCH 28
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HOLDINGFORD, MN

STEARNS COUNTY DITCH 28
STA. 408+00 - 464+00
PROJECT NO. 6364-010

SHEET
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