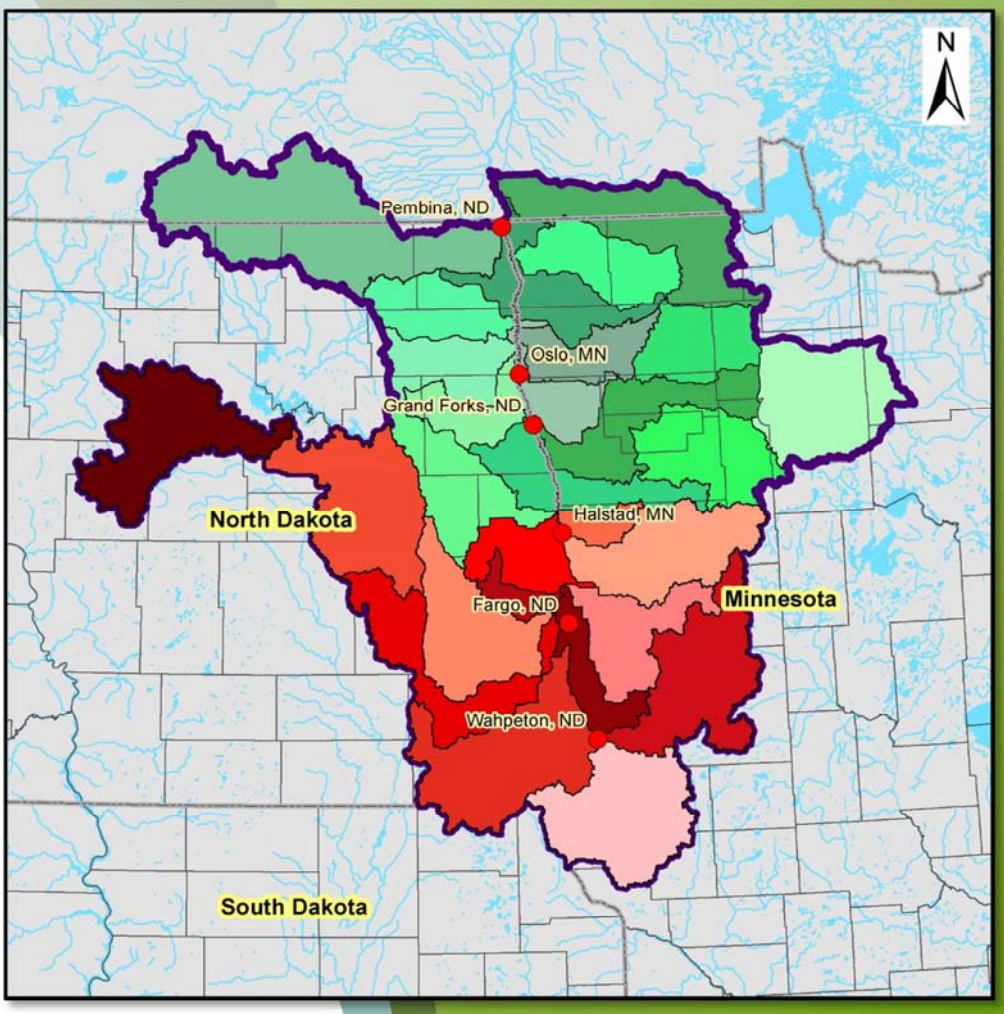
RED RIVER BASIN COMMISSION
HALSTAD UPSTREAM RETENTION STUDY



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March 10, 2014

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EXECUTIVE SUMMARY

Flooding is a persistent problem for residents of the Red River Basin. Recently, severe flooding occurring almost annually has resulted in a regional demand for solutions to alleviate flooding. In response to the devastating 1997 spring flood, the Red River Basin Commission (RRBC) began developing the Long Term Flood Solutions (LTFS) Report to outline recommendations for how to attain acceptable levels of flood risk in the basin. Since the 1997 spring flood, four major flood events (2006, 2009, 2010, and 2011) created a heightened sense of awareness throughout the Basin. Upon completion of the LTFS Report in 2011, several jurisdictional authorities had already begun development of projects and practices to reduce their own individual level of flood risk. While these projects accomplish several goals outlined in the RRBC LTFS Report, they failed to incorporate one key component; an integrated approach to achieve a basinwide solution.

One component of the overall LTFS strategy is a concept defined as the Basinwide Flow Reduction Strategy. This Strategy evaluated the impacts of distributed detention on the 1997 spring flood. Working with local Water Resource Districts (ND) and Watershed Districts (MN), the RRBC developed what appeared to be reasonable reductions in flood volume to tributary outflows. These reductions were aimed at reducing peak flows along the Red River by 20% for the simulated 1997 spring flood. While this Strategy was developed using what appeared to be reasonable volume reductions, a lack of detailed basinwide topography data and consistent assessment tools hindered identification and evaluation of potential impoundment locations to assess the practicability of the recommended peak flow and volume reductions.

Since development of the Basinwide Flow Reduction Strategy, additional tools have been made available that assist in evaluating potential impoundment locations. The International Water Institute led the Red River Basin Mapping Initiative to collect a consistent dataset of high resolution LiDAR topography data across the United States portion of the Red River Basin. Completion of this effort quickly led to the development of a consistent set of synthetic hydrologic models for tributaries throughout the Red River Basin. Synthetic hydrologic models were completed for tributaries above Halstad, MN in December 2011, with hydrologic models for remaining tributaries in the United States portion of the basin expected to be complete by the end of 2013. In addition to the enhanced hydrologic modeling capabilities, a detailed hydraulic model of the Red River mainstem was developed to aid in the ongoing analysis of flood control alternatives for the communities of Fargo, ND and Moorhead, MN. This model allows for a detailed assessment of proposed projects that wasn't previously available. Development of this hydraulic model began in 2009, and has since been evolving and improved as the FM Metro project progresses.

The new tributary hydrologic models were used by local Water Resource Districts (ND) and Watershed Districts (MN) to identify potential impoundment locations throughout the United States portion of the Red River Basin. Generally, these planning efforts have indicated that distributed detention can be used to alleviate local flooding concerns while providing enough storage to meet LTFS tributary volume and peak flow reduction goals. The RRBC's Halstad Upstream Retention (HUR) Study utilizes tributary detention planning efforts to evaluate the cumulative regional impact along the Red River mainstem above Halstad, MN. This effort is funded through the Fargo-Moorhead Diversion Authority.

The initial step of the RRBC HUR Study was to develop a consistent method for assessing distributed detention within the project area. This led to development of the Standardized Melt Progression Event, which takes into account how the melt pattern progresses across the landscape during a typical spring snowmelt event. Runoff depths were used consistent with 100-year, 10-day runoff depths used for hydrologic model development.

Parameters for the Standardized Melt Progression Event were further calibrated to result in a modeled synthetic hydrograph that conforms to the US Army Corps of Engineer's wet period 100-year peak flow at Fargo, ND.

After development of the Standardized Melt Progression Event, tributary hydrologic models and the Red River mainstem hydraulic model were used to evaluate distributed detention above Halstad, MN. The modeling approach used the most recent set of hydrologic models from tributary detention planning efforts to develop synthetic inflow hydrographs for the Red River mainstem hydraulic model. Impoundment locations identified by local Water Resource Districts (ND) and Watershed Districts (MN) were used to evaluate impacts along the Red River mainstem. This modeling approach also provides a framework for policy makers to evaluate relative benefit associated with individual detention projects, and if desired, allocate funding based on a performance-based assessment.

Results from the hydraulic model indicated that a 20% peak flow reduction along the Red River mainstem could generally be met upstream of Halstad, MN. The HUR Study assumes implementation of 96 impoundment locations within the study watershed. All storage locations used in the HUR Study were identified locally with a primary objective of addressing a local flooding concern. In total, these locations utilize approximately 559,200 acre-feet of storage during the simulated Standardized Melt Progression Event. Of this, approximately 455,500 acre-feet is gated storage and approximately 103,800 acre-feet is ungated storage. The RRBC HUR Study did not evaluate how the distributed detention could be used to augment other flood control projects in the region. Instead, results from the RRBC HUR Study present one scenario to achieve the RRBC LTFS Basinwide Flow Reduction Strategy.

While results from the HUR Study indicate that the Basinwide Flow Reduction Strategy appears to be attainable, several other considerations should be addressed as distributed detention is further evaluated. The HUR Study illustrates one scenario to attain the 20% Red River peak flow reduction goal. However, differing combinations of impoundments could attain similar results. Generally, impoundment locations used for the HUR Study are conceptual in nature and are likely to change as considerations for each individual location are evaluated, such as additional technical analysis and landowner involvement. These considerations could result in substantial changes to location, storage capacity, and geometry of individual impoundments. Also, a basinwide gated storage release strategy should be evaluated. The RRBC HUR Study does not evaluate the impacts of releasing gated storage. However, as distributed detention is implemented, a systematic approach to releasing gated storage may be required. It's also important to note that the RRBC HUR Study summarizes performance of distributed detention during only the Standardized Melt Progression Runoff Event. Recognizing that no two floods are identical, events varying from the Standardized Melt Progression Event could result in varying levels of benefit.

It is the intent of the RRBC as part of its Long Term Flood Solutions implementation to continue to work with Water Resource Districts (ND) and Watershed Districts (MN) to complete a similar modeling effort for the rest of the Red River Basin.

1 BACKGROUND

The risk of flooding has always been a reality for residents of the Red River Basin. However in recent years significant flooding has occurred on a nearly annual basis, making the need for flood protection more apparent. Recent spring floods have also led to the development of several new tools available to evaluate benefit and associated impacts of proposed flood damage reduction projects. These tools include LiDAR topography information, the Red River Basin Commission's Long Term Flood Solutions Report, and consistent hydrologic and hydraulic modeling capabilities. Local Water Resource Districts (ND) and Watershed Districts (MN) have used this information to identify and evaluate distributed detention within each of their respective jurisdictional areas. The Red River Basin Commission Halstad Upstream Retention (RRBC HUR) Study uses these locally identified impoundment locations to determine the cumulative regional impact of distributed detention above Halstad, MN.

1.1 STUDY AREA AND LOCATION

The RRBC HUR Study evaluates the impacts of distributed detention on the Red River mainstem above Halstad, MN. The area contributing to the Red River Basin above Halstad, MN is approximately 14,600 square miles, and has an adjacent non-contributing area of approximately 3,040 square miles. This area contains portions of Minnesota, North Dakota, and South Dakota. The landscape of the region is generally characterized by rolling hills, lakes, and potholes in upstream portions of the watershed, and extremely flat slopes in lower areas of the watershed. The Red River Basin above Halstad, MN contains several major tributaries that convey runoff from each of their respective watersheds. These major tributaries include the Elm, Rush, Maple, Sheyenne, and Wild Rice Rivers in North Dakota and the Bois De Sioux, Otter Tail, Buffalo, Wild Rice, and Marsh Rivers in Minnesota. The RRBC HUR Study Area is presented in **Figure 1**.

Several impoundments have been constructed within the area, including three dams constructed and operated by the US Army Corps of Engineers. Several other impoundments have been implemented locally across the project watershed. Existing impoundment locations are discussed in tributary detention plans in greater detail (References 8 – 15). The contributing area to existing impoundment locations is illustrated in **Figure 1**. While this area appears significant, it should be noted that many of the existing impoundments provide reduced benefit for larger magnitude events due to limited capacity to store runoff.

1.2 LONG TERM FLOOD SOLUTIONS REPORT

Damages caused by the spring 1997 flood heightened the need for an overall strategy to alleviate flood risk in the Red River Basin. The RRBC led an effort to develop an overall strategy known as the Long Term Flood Solutions (LTFS) Report (Reference 1). This report summarizes existing flood risk, flood plain management strategies, and recommendations for implementation. As part of the LTFS development, the RRBC developed a document titled the Basinwide Flow Reduction Strategy (Reference 2). This strategy analyzed the impacts of distributed detention on the Red River mainstem during the 1997 flood. As part of this effort, the RRBC worked with local Water Resource Districts (ND) and Watershed Districts (MN) to estimate approximate volume reductions for tributaries throughout the Red River Basin. When combined, these tributary volume reductions would have resulted in a 20% peak flow reduction along the Red River mainstem during the 1997 spring flood. Peak flow and volume reduction goals established from the Basinwide Flow Reduction Strategy were then incorporated into the overall flood damage reduction strategy outlined in the RRBC LTFS Report.

1.3 RELATED REPORTS AND STUDIES

The RRBC HUR Study also uses information made available through various other efforts in the region. Additional details about other information used for the RRBC HUR Study can be found as follows, as well as in the References section of this report.

1.3.1 RED RIVER BASIN MAPPING INITIATIVE

The Red River Basin Mapping Initiative (RRBMI), led by the International Water Institute (IWI), developed a publicly available LiDAR elevation dataset for the United States portion of the Red River Basin. The RRBMI LiDAR information was collected to meet US Federal Emergency Management (FEMA) flood plain mapping standards and specifications, and provides vertical accuracy to less than 15 centimeters. Since completion, the RRBMI LiDAR information has been used in a wide range of applications including standardized model development, project evaluation, water quality analysis, and land use management. (Reference 3)

1.3.2 RED RIVER BASINWIDE HYDROLOGIC MODELS

The development of consistent hydrologic models for tributary subwatersheds of the Red River Basin above Halstad, MN was completed in December of 2011. This effort was funded by the communities of Fargo, ND and Moorhead, MN. (Reference 4) RRBMI LiDAR topography data (Section 1.3.1) was hydrologically reconditioned to accurately determine drainage area and flow path characteristics. Tributary HEC-HMS hydrologic models were developed using standardized procedures to derive initial parameters necessary for model development and were then calibrated to rainfall events using NEXRAD data. Calibrated model parameters were used to develop synthetic hydrologic models for each tributary. The hydrologic models developed for the Red River Basin above Halstad, MN was the first phase of developing tributary hydrologic models for the United States portion of the Red River Basin. A second phase was initiated later to develop consistent tributary HEC-HMS hydrologic models for the United States portion of the Red River Basin downstream of Halstad, MN. This second phase was funded through the US Army Corps of Engineer's Basinwide Feasibility Study.

1.3.3 RED RIVER MAINSTEM HYDRAULIC UNSTEADY MODEL

The Red River mainstem HEC-RAS hydraulic model was developed as part of the US Army Corps of Engineers Basinwide Feasibility Study, and has been further developed as part of the FM Metro Flood Control Project. The HEC-RAS hydraulic model uses unsteady flow routing to accurately account for storage occurring within the channel and the adjacent floodplain. The extent of this model includes the US portion of the Red River mainstem, as well as the lower potions of various tributaries. **Figure 2** presents hydraulic model extents for the HUR Study Area (Reference 5).

1.3.4 MINNESOTA WATERSHED DISTRICT DISTRIBUTED DETENTION STRATEGY

In 2012, an effort was undertaken to develop *Expanded Distributed Detention Strategys* for each of the MN Watershed Districts. This planning effort was aimed at identifying sufficient storage volumes to meet tributary peak flow and volume reduction goals outlined in the RRBC LTFS Basinwide Flow Reduction Strategy (Reference 2). This first involved identifying areas that were conducive to storing runoff on the landscape. RRMBI LiDAR topography data, the International Water Institute's Project Planning Tools, and consultation with Watershed District staff were all considered when selecting locations to detain runoff. The primary objective of identified storage locations was to provide benefit to areas of local flooding concern, with secondary consideration for Red River mainstem impacts. Flood water detention locations previously identified and/or under investigation by local Watershed Districts were also included in the plan. Ideal storage locations were generally considered to have a contributing area of twenty or more square miles, and a gated storage capacity of three to four inches of runoff.

Tributary hydrologic models (Section 1.3.2) were used to evaluate benefit provided by the identified impoundment locations. Proposed impoundment locations were typically assumed to begin from an empty starting condition and fill as runoff reached the site. Runoff reaching the impoundment was stored permanently until the gated storage capacity was exceeded. Runoff in excess of the gated capacity was routed through the proposed impoundment and allowed to continue downstream. Impacts associated with releasing gated storage volumes back into the system after downstream flooding had receded was not analyzed as part of this effort. The Initial Standardized Melt Progression Runoff Event (Section 3.1) was used to calculate peak flow and volume reduction benefits. Refer to References 8 - 10 for Expanded Distributed Detention Strategies used in the RRBC HUR Study.

1.3.5 NORTH DAKOTA TRIBUTARY WATERSHED COMPREHENSIVE DETENTION PLANS

In early 2012, an effort was undertaken to develop Comprehensive Detention Plans for each tributaries within the ND portion of the Red River Basin. This first involved identification of locations that appeared to be conducive to store runoff from their contributing areas. Identified locations generally had a contributing area of twenty or more square miles, and topographic characteristics that would allow for enough gated storage capacity to detain three to four inches of runoff. Additional criteria included minimizing structural and infrastructure impacts through review of aerial photography and other GIS information. Identified locations were further optimized after consultation with County Water Resource Districts. The ND Tributary Watershed Comprehensive Detention Planning Effort was focused on identifying a wide array of potentially feasible locations to detain runoff to provide a set of options for County Water Resource Districts to select from when developing solutions to local flooding problems.

Identified impoundment locations were incorporated in the tributary HEC-HMS model (Section 1.3.2) to analyze downstream benefit for several runoff events. These events included both 24-hour and 10-day duration rainfall events for the 25-year, 50-year, and 100-year recurrence intervals, and the Initial Standardized Melt Progression (Section 3.1). The proposed impoundment locations were generally assumed to begin from an empty starting condition, and would begin to fill as runoff reached the impoundment. Runoff is stored within the proposed impoundment until the gated storage capacity was exceeded. Runoff in excess of the gated capacity was then routed through the identified impoundment and continue downstream. Impacts

associated with releasing gated storage volumes back into the system after downstream flooding had receded was not analyzed as part of this effort. Refer to References 11 - 15 for Comprehensive Detention Plans used in the RRBC HUR Study.

2 SCOPE AND PURPOSE

The Red River Basin Commission's Long Term Flood Solutions Report (RRBC LTFS) established a basinwide set of goals to reduce flood risk for residents and industry in the region. One component is to utilize a Basinwide Flow Reduction Strategy to reduce the magnitude of flooding experienced along the Red River and its tributaries. This Strategy sets forth goals to reduce tributary peak flows and volumes to attain a 20% peak flow reduction along the Red River Mainstem during the 1997 spring flood. The Halstad Upstream Retention (HUR) Study builds off the RRBC LTFS to further define the amount and location of storage required to be implemented to achieve this goal for a synthetic modeling scenario. Since completion of the RRBC LTFS, high resolution LiDAR topography data (Section 1.3.1) has been made available and allows for more in depth review of potential storage locations. In addition, tributary distributed detention planning efforts to evaluate benefits from impoundment locations have been completed in Minnesota and North Dakota (Sections 1.3.4 and 1.3.5). Impoundment locations evaluated in these planning efforts were generally selected to provide benefit to local flood concerns, with secondary consideration to the Red River mainstem. The RRBC HUR Study uses these locally preferred impoundment locations to evaluate the cumulative regional impacts of distributed detention to the Red River mainstem above Halstad, MN. The HUR Study is being completed to for the general purpose of satisfying three primary objectives:

- Update the RRBC LTFS Report
- Provide policy assistance for potential future funding considerations.
- Assist Local Water Resource Districts (ND) and Watershed Districts (MN) in developing future projects.

The intent of the RRBC HUR Study is to present one strategy for reducing peak flows in the Red River Basin, and is not intended to provide an alternative for other planning efforts in the region. As defined in the RRBC LTFS Report, distributed detention is just one component integrated into the overall strategy of reducing flood risks for the Red River Basin.

The Red River mainstem 20% peak flow reduction goal was developed based on the 1997 spring flood. This flood represented various return frequencies for different locations along the mainstem of the Red River. Increased modeling capabilities and the development of a balanced 100-year hydrograph by the US Army Corps of Engineers at Fargo, ND led to the RRBC refining the Red River 20% peak flow reduction goal a synthetic modeling scenario resulting in the 100-year balanced hydrograph at Fargo, ND.

3 STANDARDIZED MODELING APPROACH

Establishment of a standardized approach to hydraulic and hydrologic modeling was required to evaluate the impacts of distributed detention on such a large geographic area. This standardized approach included the development of a synthetic runoff event to ensure consistency in project evaluation regardless of location within the watershed. Timing of how runoff is applied within the hydrologic models is consistent with what would be expected during a typical spring snowmelt. These hydrologic considerations led to the development of the Standardized Melt Progression Event. This synthetic runoff event was analyzed with tributary HEC-HMS hydrologic models to determine outflow hydrographs for each tributary within the project area These outflow hydrographs were then input into HEC-RAS hydraulic model to determine resultant flood hydrographs along the Red River mainstem. Details of this standardized modeling approach are discussed in further detail as follows.

3.1 INITIAL STANDARDIZED MELT PROGRESSION EVENT

To better simulate a synthetic spring melt condition across the US portion of the Red River Basin, the Initial Standardized Melt Progression Event was developed. Historic temperature data at observation points was used to estimate when spring snowmelt generally occurs. Using this temperature information, average spring snowmelt dates were determined and used to produce a Virtual Thaw Progression. 100-year, 10-day runoff depths were applied using methods consistent with tributary hydrologic model development. Once initiated by the Virtual Thaw Progression, runoff was applied over a period of 10 days. For further information regarding the Initial Standardized Melt Progression Event, refer to **Appendix A**.

3.2 STANDARDIZED MELT PROGRESSION EVENT SENSITIVITY ANALYSIS

Following development of the Initial Standardized Melt Progression Event, a sensitivity analysis was completed to evaluate how variables influence peak flows experienced along the Red River. Three variables were considered as part of this analysis:

- Runoff Volume
- Melt Onset Timing
- Melt Duration

This sensitivity analysis resulted in the Initial Standardized Melt Progression Event being revised to incorporate a four day duration rather than of the initial 10 day melt duration. The revised scenario produced results similar to the USACE wet period 100-year balanced hydrograph at Fargo, ND. Refer to **Figure 3** for comparison hydrographs. While the synthetic runoff event produces a flood similar to the USACE 100-year balanced hydrograph, it should be recognized that the Standardized Melt Progression Event is likely not the only scenario resulting in 100-year flood at Fargo, ND. Runoff events differing from the Standardized Melt Progression Event could result in a similar flood hydrograph along the Red River mainstem.

3.3 TRIBUTARY HYDROLOGIC MODELING

Tributary HEC-HMS hydrologic models utilized for the RRBC HUR Study were developed by the communities of Fargo, ND and Moorhead, MN (Section 1.3.2) and were further refined to include the proposed detention locations as part of the MN Tributary Expanded Distributed Detention Strategy (Section 1.3.4) and the ND Tributary Comprehensive Detention Plans (Section 1.3.5). In total, nine tributary hydrologic models were used for the RRBC HUR Study:

- Bois De Sioux Watershed
- Otter Tail Watershed
- Upper Red Watershed
- Wild Rice (ND) Watershed
- Sheyenne/Maple/Rush Watershed
- Buffalo Watershed
- Elm Watershed
- Wild Rice (MN) Watershed
- Marsh Watershed

Output hydrographs from tributary hydrologic models were provided to the RRBC my local Water Resource District and Watershed District staff to use for assessment of the Red River mainstem.

3.4 RED RIVER MAINSTEM HYDRAULIC MODELING

Analysis of the Red River mainstem was completed using the Unsteady State HEC-RAS model developed by the US Army Corps of Engineers. This model was developed to analyze flood control alternatives for the communities of Fargo, ND and Moorhead, MN. Output hydrographs developed using the tributary HEC-HMS hydrologic models (Section 3.3) were used as inflow hydrographs for the HEC-RAS hydraulic model. Unsteady flow routing allows for inflow hydrographs to be routed downstream while accounting attenuation that occurs from floodplain storage adjacent to the channel, such as ponding of floodwater that occurs in an agricultural field. The extent of the HEC-RAS hydraulic model utilized is illustrated in **Figure 2**. The Red River mainstem HEC-RAS hydraulic model used for the RRBC HUR Study assesses benefit provided by distributed detention based on the existing river and flood plain condition (2013) without emergency protection measures in place.

4 SCENARIOS ANALYZED AND RESULTS

4.1 EXISTING CONDITIONS

RRBC LTFS goals for peak flow reduction along the Red River mainstem were developed based on conditions that existed during the 1997 spring flood. Therefore, benefit provided by existing impoundment sites that have been constructed after the 1997 spring flood were counted towards meeting RRBC LTFS peak flow reduction goals. The existing condition was analyzed under two landscape conditions within the hydrologic models; the 1997 condition and the present day (2013) condition. **Table 4** summarizes the existing impoundment locations that have been implemented after the 1997 spring flood within the Red River Basin above Halstad, MN.

4.2 RED RIVER MAINSTEM 20% PEAK FLOW REDUCTION

A subset of the impoundments identified as during tributary detention planning efforts (Sections 1.3.4 and 1.3.5) were used to develop the proposed condition. The total volume of storage utilized by this subset of impoundments during the Standardized Melt Progression Event for each of the nine tributaries is illustrated in **Figure 4.1**. This subset of impoundment locations would detain runoff occurring across approximately 2,655 square miles, or 18% of the HUR Study watershed. The extents of this area is illustrated in **Figure 4.2**. The 96 identified impoundment locations utilized approximately 455,500 acre-feet of gated storage and 103,800 acre-feet of ungated storage during the Standardized Melt Progression Event. Detaining this volume of runoff would inundate approximately 107,800 acres. This area defines the approximate impacted area during the analyzed event; however a more in depth review of individual impoundment locations may require additional acreage in order to meet spillway design criteria. Utilized storage and impacted areas are further broken down into subwatersheds and individual sites in **Table 3** and **Table 4**, respectively.

Comparing the existing condition with the proposed condition illustrated that achieving a peak flow reduction of 20% was attainable by implementing distributed detention, with each individual impoundment having a primary objective of alleviating a local flood concern. **Table 5** presents a comparison of the Basinwide Flow Reduction Strategy goals compared to peak flow and volume reductions achieved through the HUR Study. As illustrated in **Figure 5**, peak flow reductions at USGS gaging locations along the Red River generally meet or slightly exceed the goal of 20%. **Table 6** provides a summary of peak flow and volume reductions along the Red River mainstem as a result of the proposed distributed detention strategy. **Figures 6.1-6.4** presents hydrographs comparing the existing condition with the proposed condition at USGS gaging locations along the Red River.

5 FUTURE CONSIDERATIONS

5.1 TECHNICAL

It should be noted that floodwater impoundment locations considered in the HUR Study were conceptual, and require further technical considerations and landowner involvement before implementation. These considerations could lead to a substantial change in the location and number of impoundments necessary to achieve a Red River mainstem 20% peak flow reduction.

Operating procedures to release gated storage volumes should be addressed to consider timing relative to the peak flow and flood durations along the Red River. The rate at which gated storage volumes are released should also be considered to ensure downstream channel capacities are not exceeded. This systematic drawdown procedure should also assess risk associated with a second event before gate volumes are fully released from the proposed impoundment locations.

The RRBC HUR Study evaluated benefit attained from the synthetic Standardized Melt Progression Event. While using this event is advantageous for the comparison of proposed impoundment locations at various locations in the project area, future floods will likely vary from the Standardized Melt Progression Event. Additional evaluation may include an assessment of runoff volumes that are not distributed uniformly over the Red River Basin, varying melt progression and melt duration, and events of greater and lesser magnitude.

5.2 FUNDING POLICY

Outputs from the RRBC HUR Study could potentially assist in determining funding methods for future flood damage reduction projects. Proposed projects can be assessed directly by using the Standardized Modeling Approach developed as a part of the RRBC HUR Study (Section 3). This approach allows for consistent evaluation of a proposed project. Red River mainstem hydrographs can be subjectively reviewed based on the performance of individual proposed projects as compared to the existing condition. Peak flow reduction and volume removal in relation to the RRBC HUR Scenario of the overall distributed detention strategy can be derived from model results.

Peak flow and volume reduction considerations provide a performance based assessment of a proposed project, although they do have limitations. While peak flow reduction provides a direct impact on the peak flow of the Standardized Melt Progression Event, varying events could result in changes in runoff timing and the resultant peak flow on the Red River. An assessment of total volume removed from the existing condition also has its limitations. While volume removal is beneficial to reduce flooding, timing of this volume is critical. Total volume removal fails to assess the timing of volume relative to the peak flow during a flood. A combined approach of volume removal relative to the peak flow helps to appease these limitations. Volume reduction from the existing condition occurring four days before and four days after the peak flow would allow more flexibility to account for variations in the timing of actual events, while still focusing on the peak of the flood. An eight day volume reduction has a higher likelihood of capturing benefit for varying future floods. **Figure 7** illustrates an example of a prioritized volume approach.

REFERENCES

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6. U.S. Department of Agriculture, Natural Resources Conservation Service, *Earth Dams and Reservoirs*, Technical Release No. 60, July 2005.
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12. Southeast Cass Water Resource District, *Lower Sheyenne River Watershed Comprehensive Detention Plan,* October 23, 2013
13. Maple River Water Resource District, *Maple River Watershed Comprehensive Detention Plan,* February 14, 2013
14. Rush River Water Resource District, *Rush River Watershed Comprehensive Detention Plan,* February 18, 2013
15. Traill County Water Resource District & Cass County Joint Water Resource District, *Elm River Watershed Comprehensive Detention Plan,* August 16, 2013

Figures

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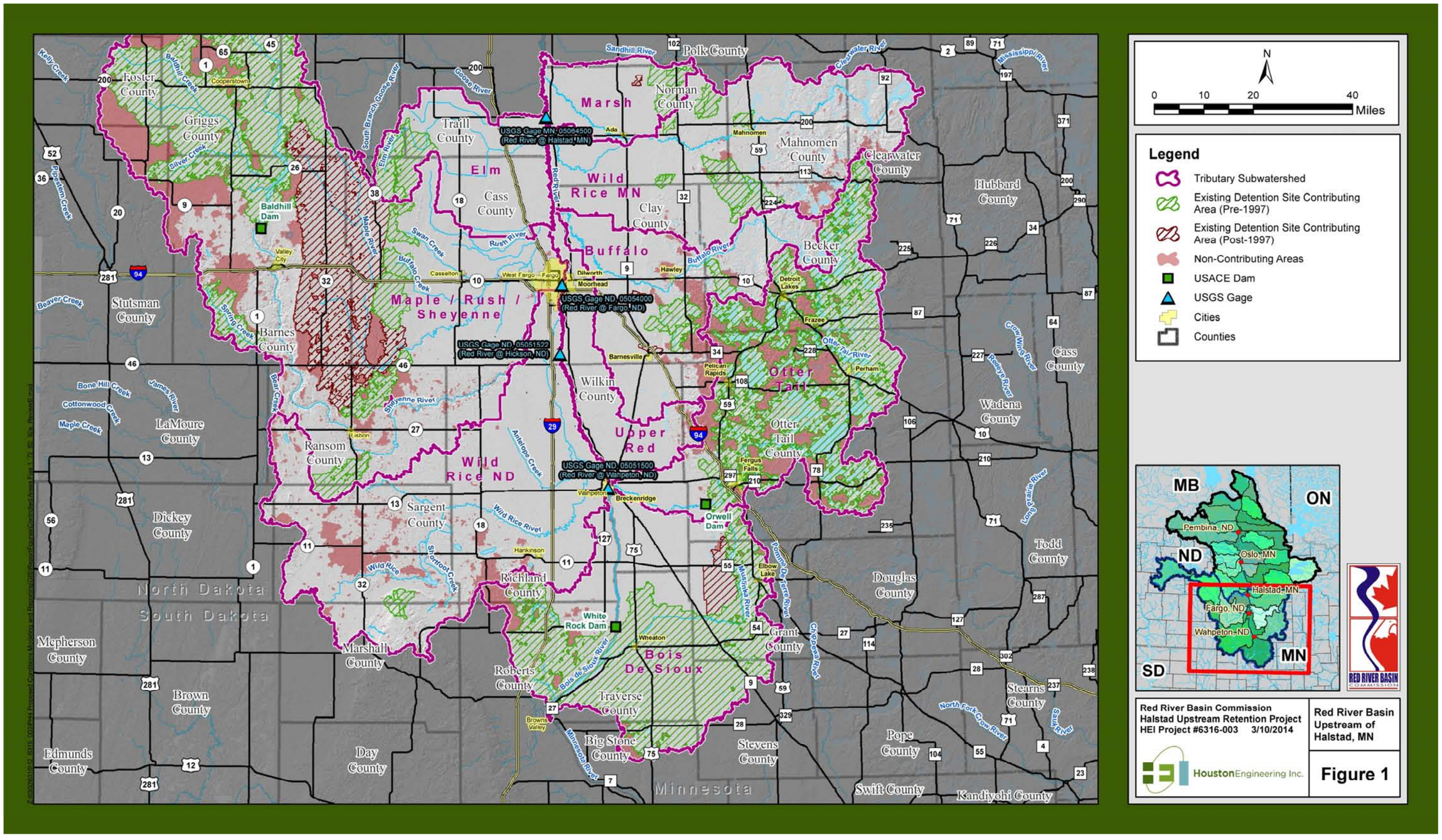
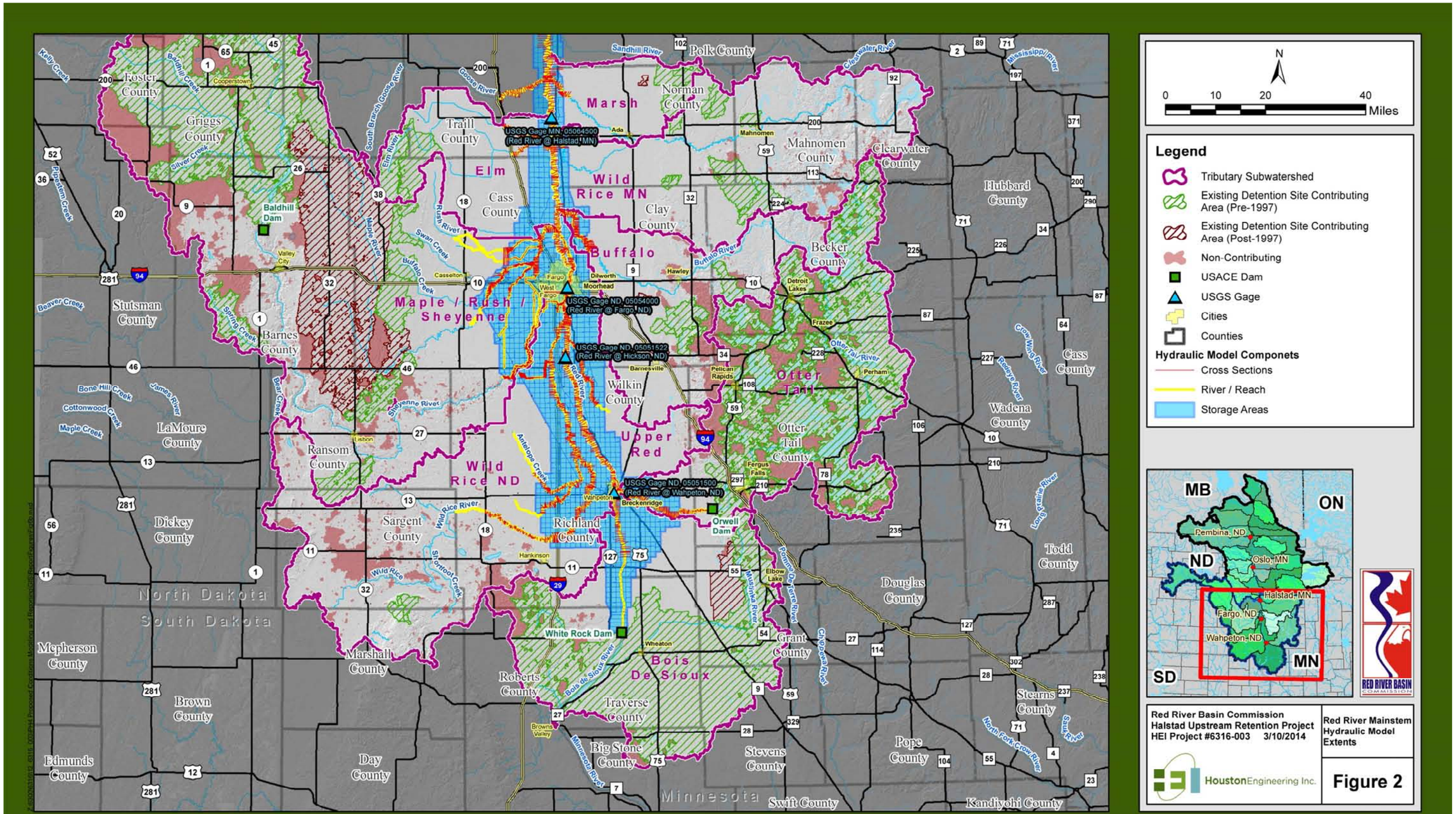
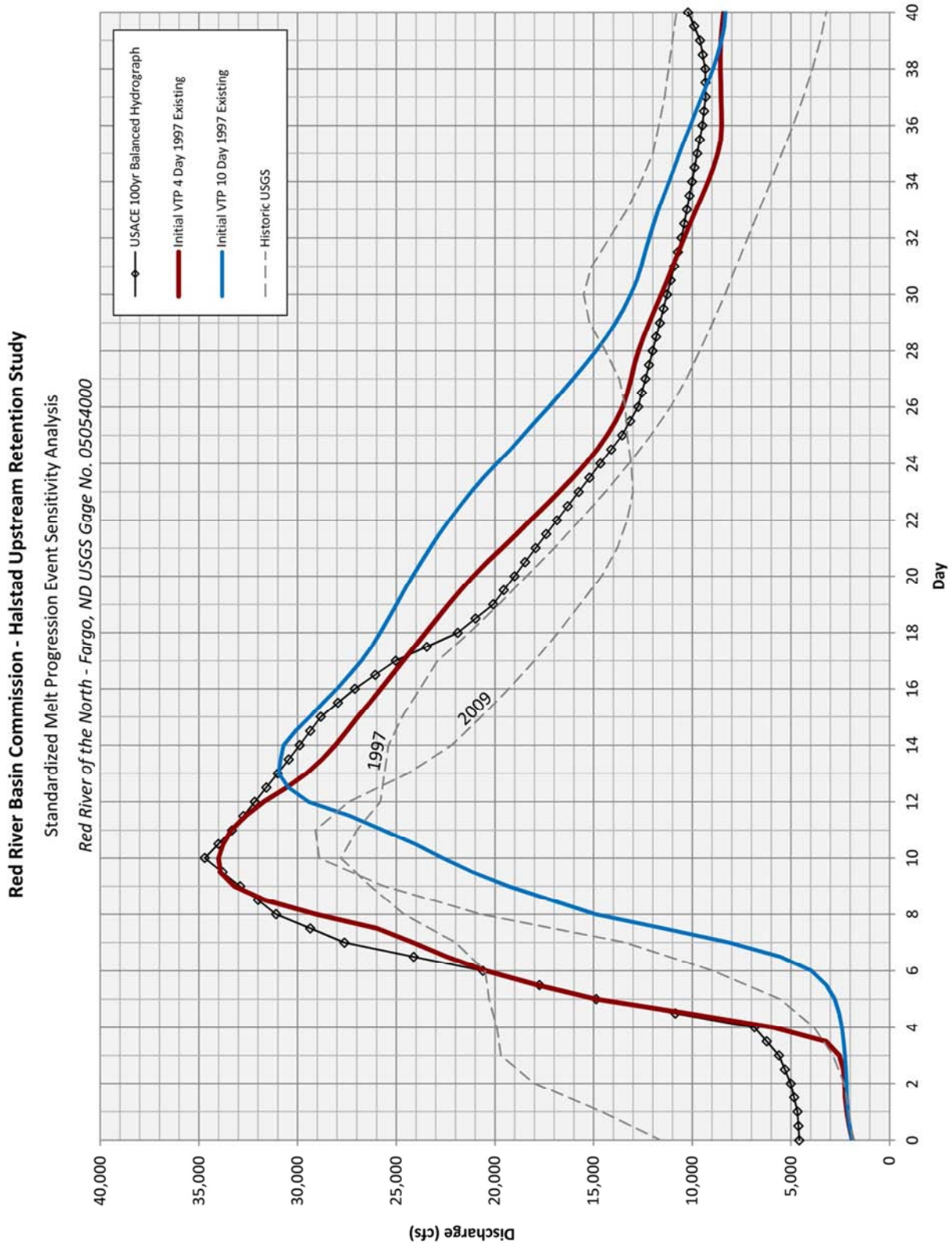
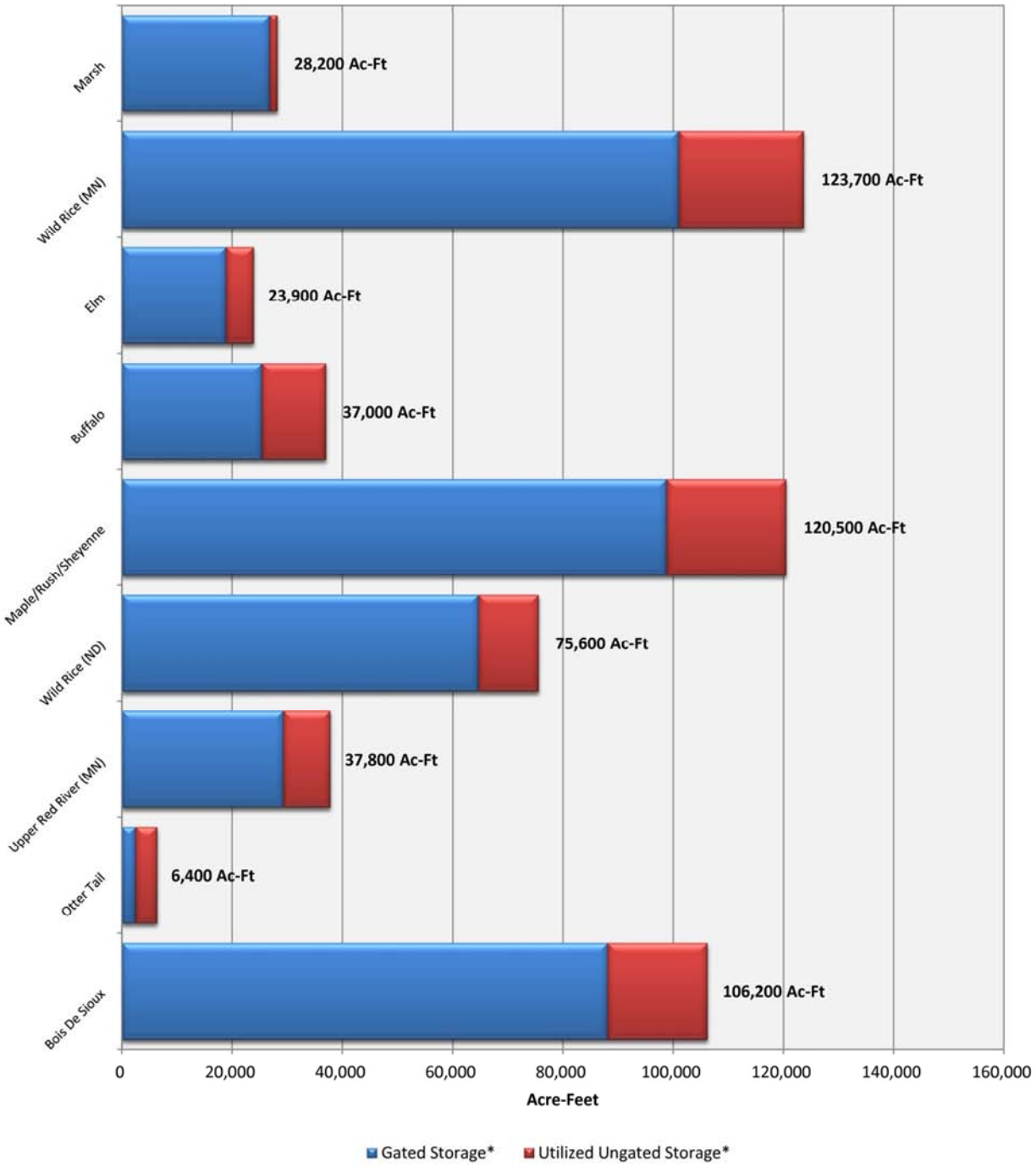

Marsh
Elm
Wild Rice MN
Buffalo
Maple / Rush / Sheyenne
Upper Red
Wild Rice ND
Otter Tail
Bois De Sioux
Polk County
Norman County
Traill County
Mahnomen County
Clearwater County
Hubbard County
Cass County
Becker County
Clay County
Foster County
Griggs County
Stutsman County
Barnes County
Wilkin County
Ransom County
Sargent County
Richland County
Wadena County
Otter Tail County
Todd County
Douglas County
Grant County
Dickey County
LaMoure County
Mcpherson County
Marshall County
Roberts County
Traverse County
Big Stone County
Stevens County
Pope County
Stearns County
Swift County
Kandiyohi County
Brown County
Edmunds County
Day County
North Dakota
South Dakota
Minnesota
USGS Gage MN 05064500 (Red River @ Halstad, MN)
USGS Gage ND 05054000 (Red River @ Fargo, ND)
USGS Gage ND 05051522 (Red River @ Hickson, ND)
USGS Gage ND 05051500 (Red River @ Wahpeton, ND)
Baldhill Dam
Orwell Dam
White Rock Dam
Fargo
West Fargo
Moorhead
Wahpeton
Breckenridge
Fergus Falls
Pelican Rapids
Detroit Lakes
Barnesville
Hawley
Casselton
Valley City
Hankinson
Wheaton
Elbow Lake
Ada
Mahnomen
Frazee
Perham
Lisbon
Browns Valley
Sandhill River
Red River
Buffalo River
Otter Tail River
Rush River
Swan Creek
Maple River
Elm River
Goose River
South Branch Goose River
Silver Creek
Baldhill Creek
Spring Creek
Beaver Creek
Bear Creek
Sheyenne River
Antelope Creek
Wild Rice River
Shortfoot Creek
Bois de Sioux River
Minnesota River
Mustinka River
Pomme De Terre River
Chippewa River
Crow Wing River
Redeye River
Long Prairie River
North Fork Crow River
Swan River
Mississippi River
Clearwater River
Kelly Creek
Pipestem Creek
Bone Hill Creek
Cottonwood Creek
Maple Creek
James River
Cooperstown
Lake Traverse
N
0 10 20 40
Miles
Legend
Tributary Subwatershed
Existing Detention Site Contributing Area (Pre-1997)
Existing Detention Site Contributing Area (Post-1997)
Non-Contributing Areas
USACE Dam
USGS Gage
Cities
Counties
MB
ON
ND
MN
SD
Pembina, ND
Oslo, MN
Halstad, MN
Fargo, ND
Wahpeton, ND
RED RIVER BASIN COMMISSION
Red River Basin Commission
Halstad Upstream Retention Project
HEI Project #6316-003 3/10/2014
HoustonEngineering Inc.
Red River Basin Upstream of Halstad, MN
Figure 1


N
0 10 20 40
Miles
Legend
Tributary Subwatershed
Existing Detention Site Contributing Area (Pre-1997)
Existing Detention Site Contributing Area (Post-1997)
Non-Contributing
USACE Dam
USGS Gage
Cities
Counties
Hydraulic Model Componets
Cross Sections
River / Reach
Storage Areas
Foster County
Griggs County
Stutsman County
Barnes County
LaMoure County
Dickey County
Ransom County
Sargent County
Richland County
Traill County
Cass County
Clay County
Norman County
Polk County
Mahnomen County
Clearwater County
Hubbard County
Becker County
Wilkin County
Otter Tail County
Wadena County
Cass County
Todd County
Douglas County
Grant County
Stevens County
Pope County
Stearns County
Swift County
Kandiyohi County
Big Stone County
Traverse County
Roberts County
Marshall County
Day County
Edmunds County
Brown County
Mcpherson County
Ransom County
Marsh
Elm
Wild Rice MN
Buffalo
Maple / Rush / Sheyenne
Upper Red
Wild Rice ND
Bois De Sioux
North Dakota
South Dakota
Minnesota
Baldhill Dam
White Rock Dam
Orwell Dam
USGS Gage MN 05064500 (Red River @ Halstad, MN)
USGS Gage ND 05064000 (Red River @ Fargo, ND)
USGS Gage ND 05061522 (Red River @ Hickson, ND)
USGS Gage ND 05051500 (Red River @ Wahpeton, ND)
Fargo
West Fargo
Moorhead
Dilworth
Wahpeton
Breckenridge
Fergus Falls
Detroit Lakes
Barnesville
Pelican Rapids
Perham
Frazee
Hawley
Casselton
Valley City
Lisbon
Hankinson
Wheaton
Browns Valley
Elbow Lake
Mahnomen
Ada
Sandhill River
Goose River
South Branch Goose River
Elm River
Rush River
Swan Creek
Buffalo Creek
Maple River
Spring Creek
Beaver Creek
Bear Creek
Sheyenne River
Bone Hill Creek
Cottonwood Creek
Maple Creek
James River
Wild Rice River
Shortfoot Creek
Antelope Creek
Red River
Buffalo River
Otter Tail River
Crow Wing River
Redeye River
Long Prairie River
Mississippi River
Clearwater River
Pipestem Creek
Kelly Creek
Baldhill Creek
Silver Creek
Bois de Sioux River
Minnesota River
Chippewa River
Pomme De Terre River
Minnesota River
North Fork Crow River
Sauk River
MB
ON
ND
SD
MN
Pembina, ND
Oslo, MN
Halstad, MN
Fargo, ND
Wahpeton, ND
Red River Basin Commission
Halstad Upstream Retention Project
HEI Project #6316-003 3/10/2014
Red River Mainstem Hydraulic Model Extents
HoustonEngineering Inc.
Figure 2

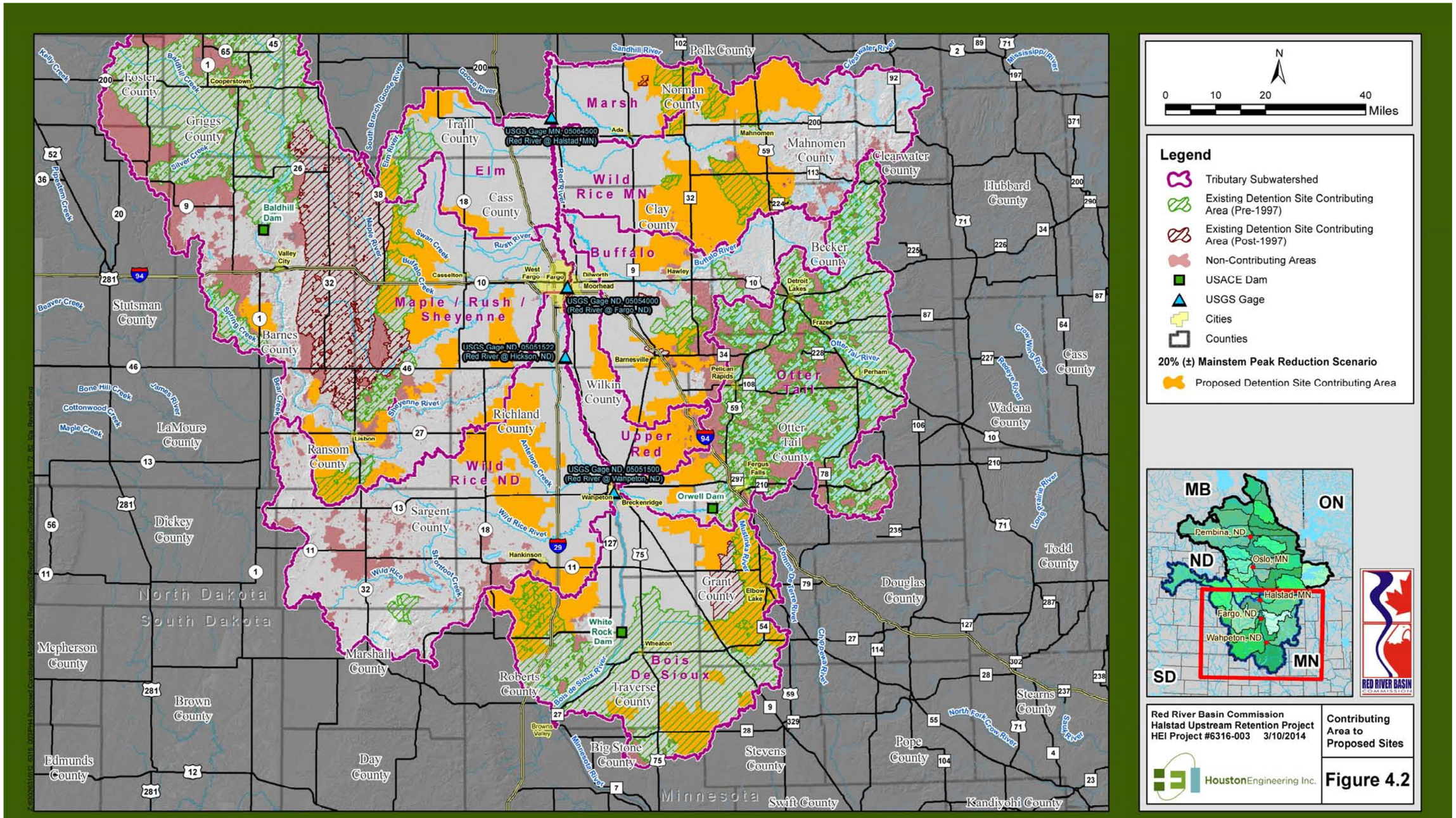

Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Fargo, ND USGS Gage No. 05054000
USACE 100yr Balanced Hydrograph
Initial VTP 4 Day 1997 Existing
Initial VTP 10 Day 1997 Existing
Historic USGS
1997
2009
Discharge (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40

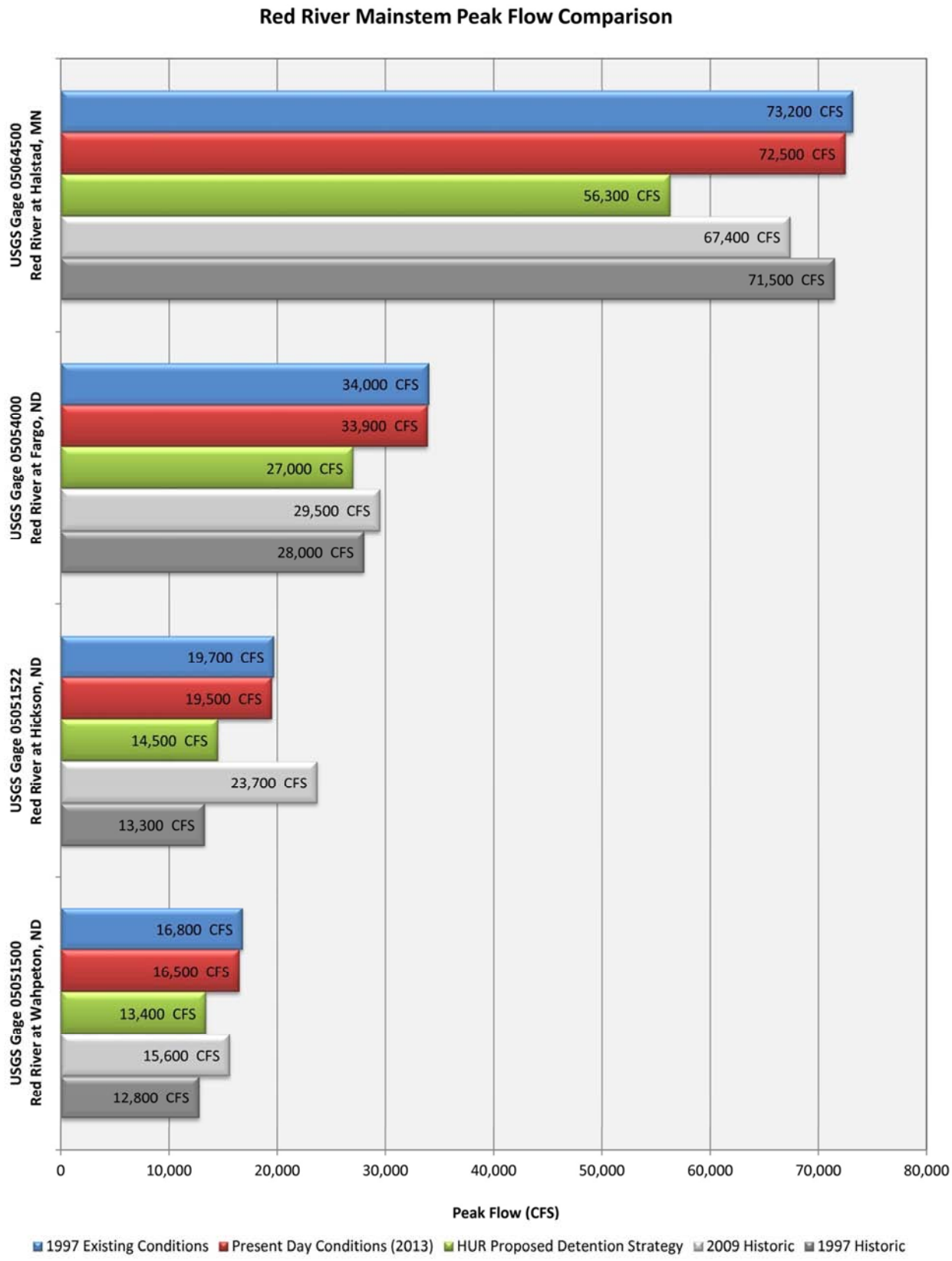
Red River Mainstem 20% (±) Peak Flow Reduction Scenario

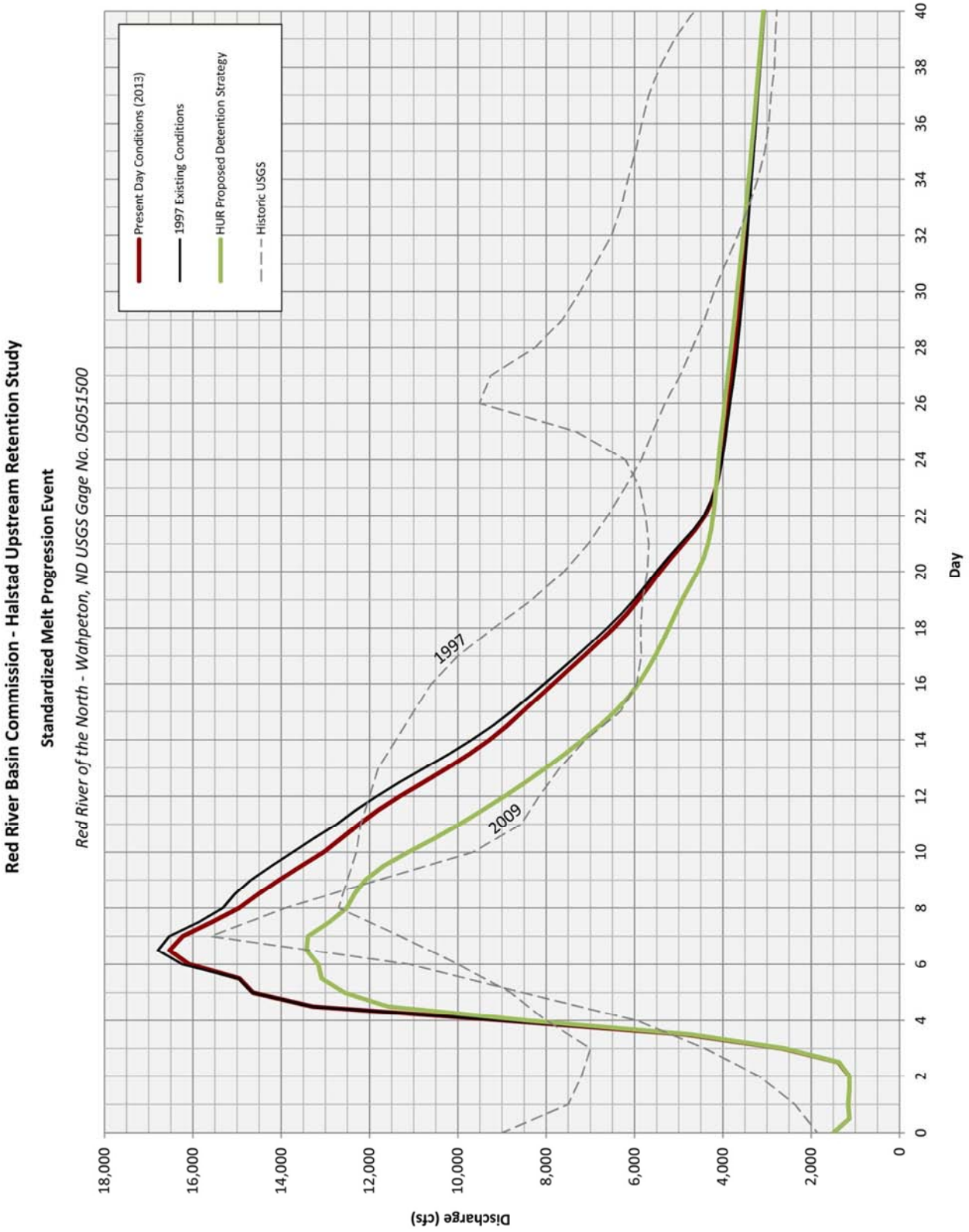
Tributary Utilized Storage



**Presented storage volumes coorelate to runoff volume detained during the analyzed 4-day Initial Melt Progression Event.*


N
0 10 20 40
Miles
Legend
Tributary Subwatershed
Existing Detention Site Contributing Area (Pre-1997)
Existing Detention Site Contributing Area (Post-1997)
Non-Contributing Areas
USACE Dam
USGS Gage
Cities
Counties
20% (±) Mainstem Peak Reduction Scenario
Proposed Detention Site Contributing Area
Marsh
Wild Rice MN
Elm
Buffalo
Maple / Rush / Sheyenne
Upper Red
Wild Rice ND
Bois De Sioux
Otter Tail
Polk County
Norman County
Traill County
Cass County
Clay County
Mahnomen County
Clearwater County
Hubbard County
Becker County
Wilkin County
Richland County
Ransom County
Sargent County
Dickey County
LaMoure County
Barnes County
Stutsman County
Foster County
Griggs County
Baldhill Dam
Orwell Dam
White Rock Dam
USGS Gage MN 05064500 (Red River @ Halstad, MN)
USGS Gage ND 05054000 (Red River @ Fargo, ND)
USGS Gage ND 05051522 (Red River @ Hickson, ND)
USGS Gage ND 05051500 (Red River @ Wahpeton, ND)
Fargo
West Fargo
Moorhead
Dilworth
Wahpeton
Breckenridge
Fergus Falls
Detroit Lakes
Wheaton
Barnesville
Hawley
Casselton
Valley City
Lisbon
Hankinson
Elbow Lake
Browns Valley
Pelican Rapids
Perham
Frazee
Todd County
Wadena County
Cass County
Douglas County
Grant County
Stevens County
Pope County
Stearns County
Big Stone County
Traverse County
Roberts County
Marshall County
Day County
Edmunds County
Brown County
Mcpherson County
North Dakota
South Dakota
Minnesota
Swift County
Kandiyohi County
Red River
Sheyenne River
Maple River
Rush River
Buffalo River
Otter Tail River
Wild Rice River
Bois de Sioux River
Mustinka River
Pomme De Terre River
Chippewa River
Long Prairie River
Crow Wing River
Redeye River
North Fork Crow River
Swan River
Minnesota River
Turtle River
Goose River
Sandhill River
Clearwater River
Mississippi River
Elm River
South Branch Goose River
Nelson River
Swan Creek
Buffalo Creek
Spring Creek
Bear Creek
Antelope Creek
Shortfoot Creek
Wild Rice
Silver Creek
Ripestem Creek
Kelly Creek
Baldhill Creek
Beaver Creek
Bone Hill Creek
Cottonwood Creek
Maple Creek
James River
MB
ON
ND
SD
MN
Rembina, ND
Oslo, MN
Halstad, MN
Fargo, ND
Wahpeton, ND
Red River Basin Commission
Halstad Upstream Retention Project
HEI Project #6316-003 3/10/2014
Houston Engineering Inc.
Contributing Area to Proposed Sites
Figure 4.2


Red River Mainstem Peak Flow Comparison
USGS Gage 05064500 Red River at Halstad, MN
73,200 CFS
72,500 CFS
56,300 CFS
67,400 CFS
71,500 CFS
USGS Gage 05054000 Red River at Fargo, ND
34,000 CFS
33,900 CFS
27,000 CFS
29,500 CFS
28,000 CFS
USGS Gage 05051522 Red River at Hickson, ND
19,700 CFS
19,500 CFS
14,500 CFS
23,700 CFS
13,300 CFS
USGS Gage 05051500 Red River at Wahpeton, ND
16,800 CFS
16,500 CFS
13,400 CFS
15,600 CFS
12,800 CFS
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Peak Flow (CFS)
1997 Existing Conditions
Present Day Conditions (2013)
HUR Proposed Detention Strategy
2009 Historic
1997 Historic


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event
Red River of the North - Wahpeton, ND USGS Gage No. 05051500
Present Day Conditions (2013)
1997 Existing Conditions
HUR Proposed Detention Strategy
Historic USGS
1997
2009
Discharge (cfs)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
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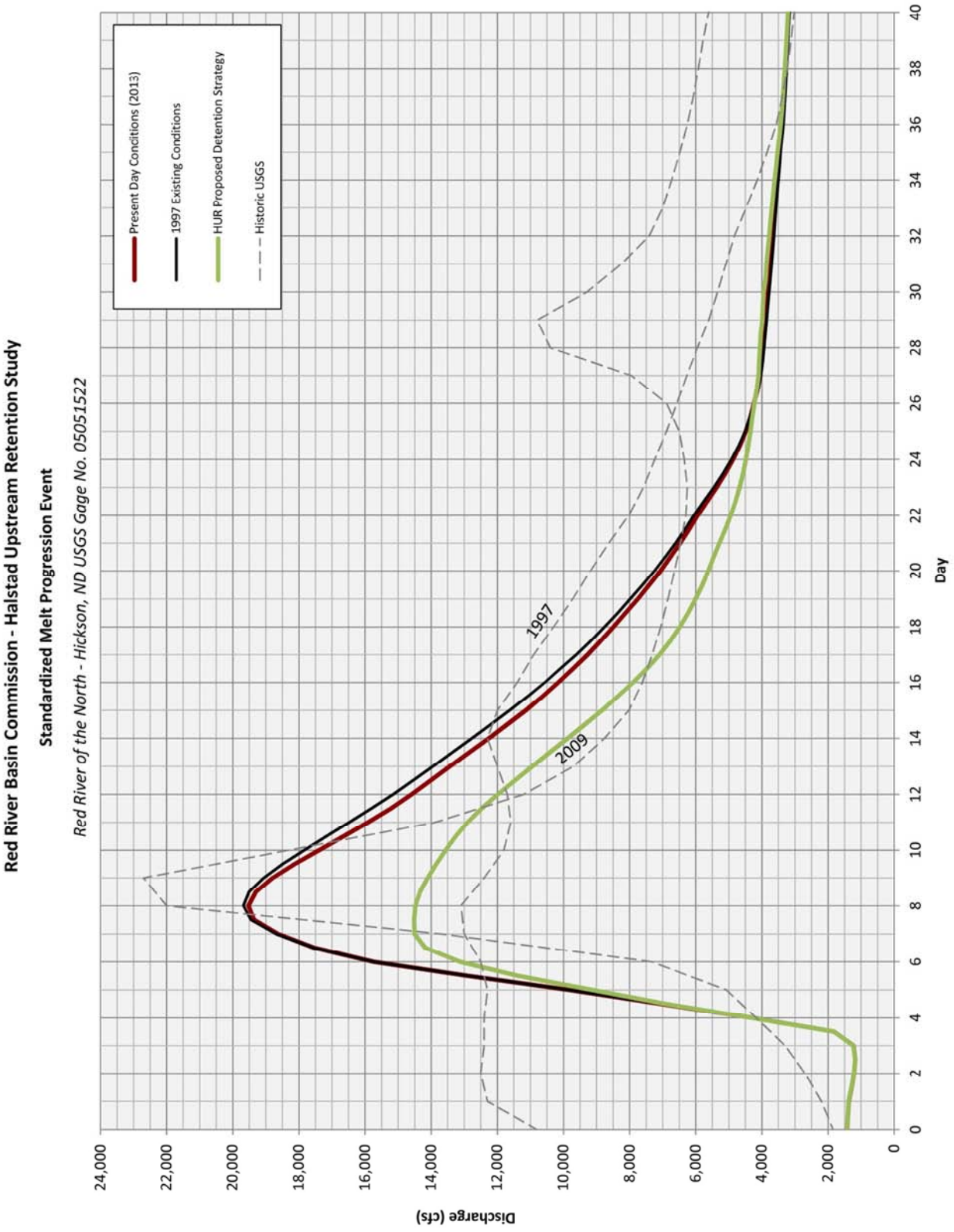
24
26
28
30
32
34
36
38
40


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event
Red River of the North - Hickson, ND USGS Gage No. 05051522
Present Day Conditions (2013)
1997 Existing Conditions
HUR Proposed Detention Strategy
Historic USGS
1997
2009
Discharge (cfs)
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Day
0
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18
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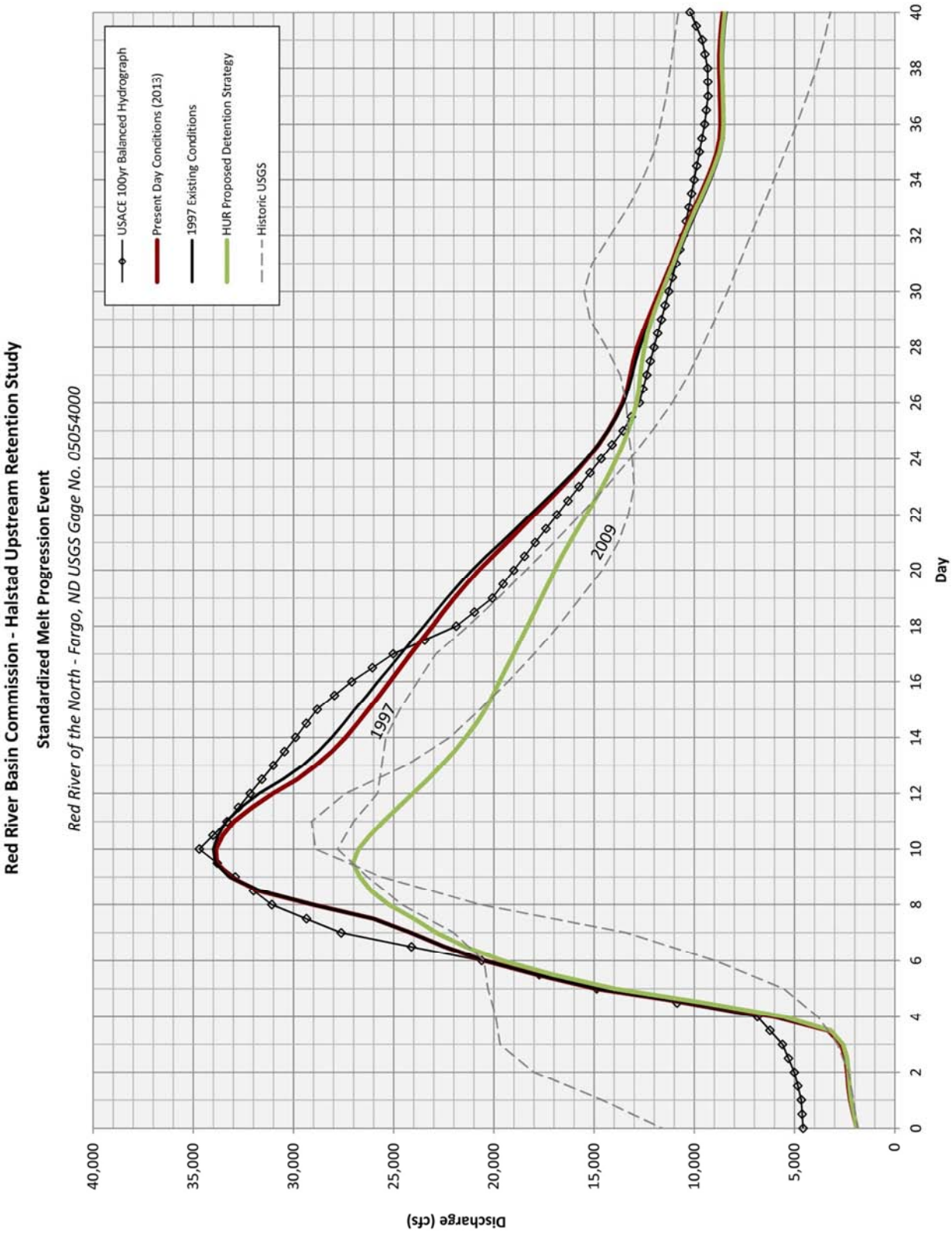
32
34
36
38
40


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event
Red River of the North - Fargo, ND USGS Gage No. 05054000
USACE 100yr Balanced Hydrograph
Present Day Conditions (2013)
1997 Existing Conditions
HUR Proposed Detention Strategy
Historic USGS
1997
2009
Discharge (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day
0
2
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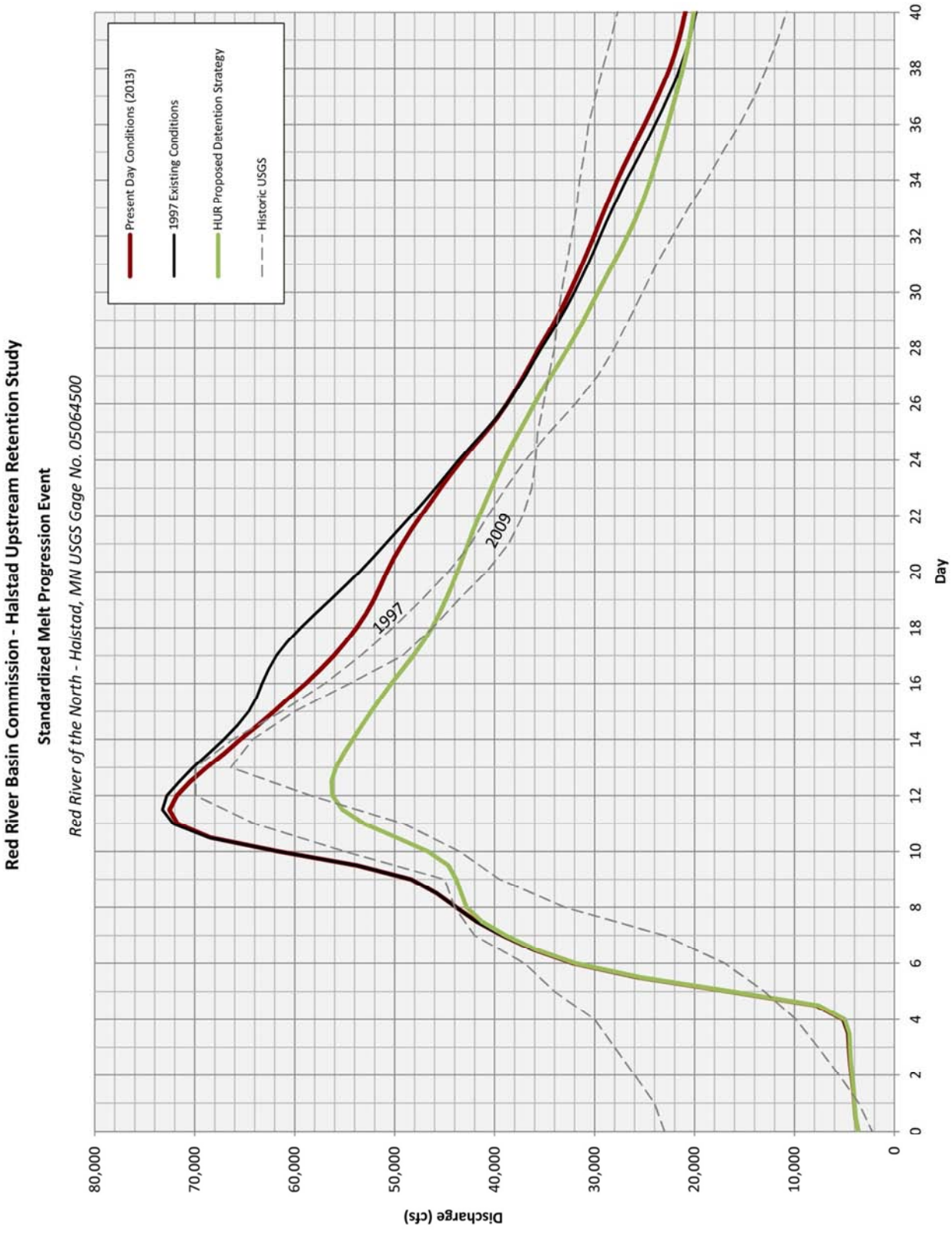
Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event
Red River of the North - Halstad, MN USGS Gage No. 05064500
Present Day Conditions (2013)
1997 Existing Conditions
HUR Proposed Detention Strategy
Historic USGS
1997
2009
Discharge (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
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32
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36
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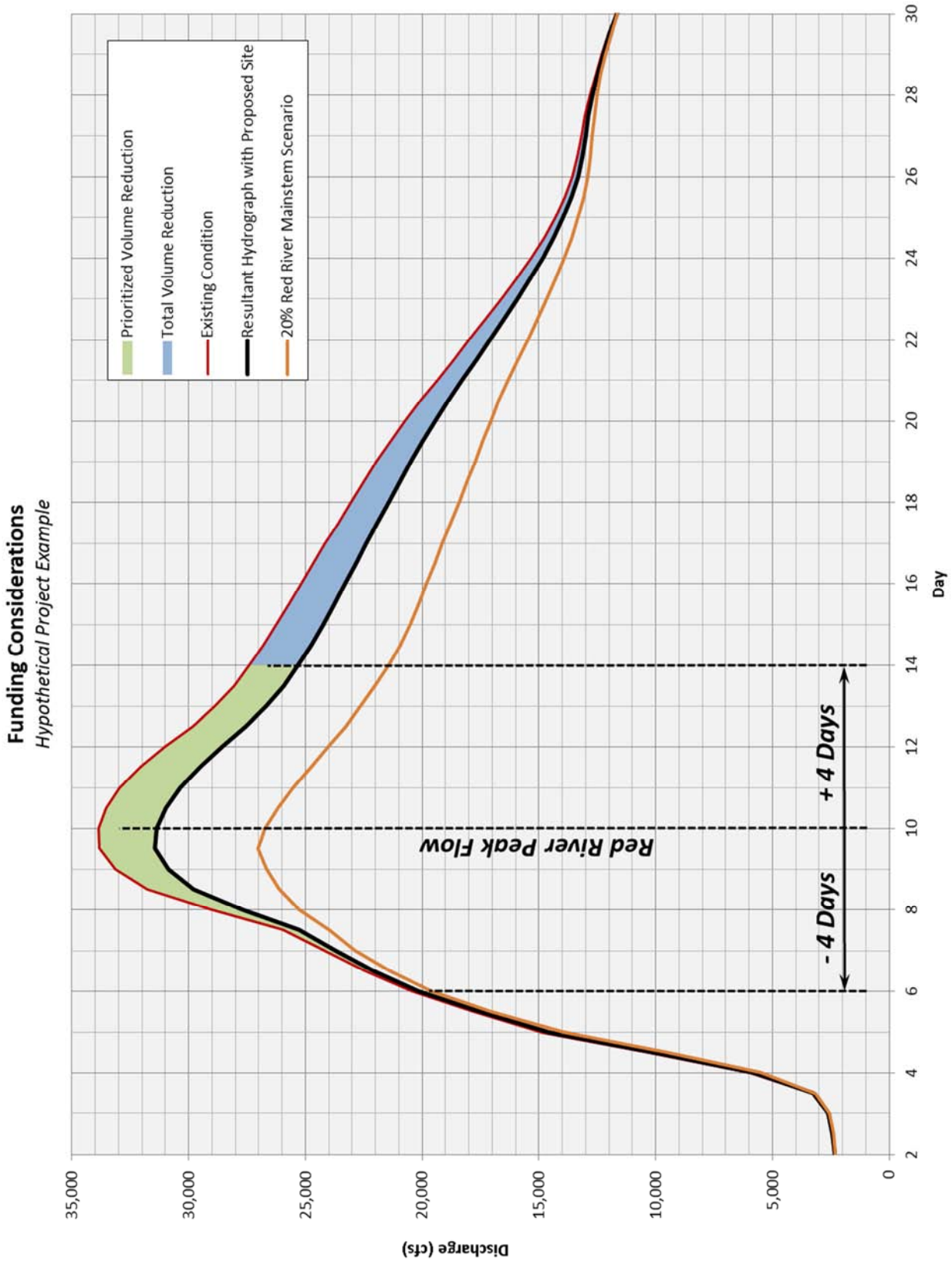
40


Funding Considerations
Hypothetical Project Example
Prioritized Volume Reduction
Total Volume Reduction
Existing Condition
Resultant Hydrograph with Proposed Site
20% Red River Mainstem Scenario
Red River Peak Flow
- 4 Days
+ 4 Days
Discharge (cfs)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Tables

In cooperation with:

Houston Engineering Inc.

moore engineering, inc.

WIDSETH SMITH NOLTING

Table No. 1

Red River Basin Commission Long Term Flood Solutions Report

Tributary Reduction Goals

USGS Gage No.	Location Description	Drainage Area *Square Miles*	Peak Flow Reduction Goal	Volume Reduction Goal	Reduction Focus
05050000	Bois De Sioux River near White Rock, SD (White Rock Outflow)	1,133	20%	20%	Store Early Water
05046000	Otter Tail River below Orwell near Fergus Falls, MN	1,212	0%	0%	No Reduction
05053000	Wild Rice River near Abercombie, ND	1,858	35%	17%	Peak Flow Reduction
05064000	Sheyenne River at Harwood, ND	5,034	23%	11%	Peak Flow Reduction
05060500	Rush River at Amenia, ND	101	35%	13%	Peak Flow Reduction
05062000	Buffalo River near Dilworth, MN	891	35%	17%	Peak Flow Reduction
05064000	Wild Rice River at Hendrum, MN	1,512	35%	20%	Peak Flow Reduction
05067500	Marsh River near Shelly, MN	231	51%	18%	Peak Flow Reduction
Ungaged	Rabbit River at MN State Highway No. 75	300	35%	26%	Peak Flow Reduction
Ungaged	Bois De Sioux River (Ungaged)	417	13%	9%	Peak Flow Reduction
Ungaged	Otter Tail River (Ungaged)	167	13%	12%	Peak Flow Reduction
Ungaged	Red River Local Areas Ungaged Upstream of Fargo (ND)	266	13%	13%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Fargo (MN)	406	13%	13%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Halstad (ND)	852	13%	13%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Halstad (MN)	231	13%	13%	Store late water
Ungaged	Red River Local Areas Upstream of Red Lake River (MN)	224	13%	13%	Store late water

Table 2

Watershed Performance Statistics - HUR Detention Scenario

Standardized Melt Progression Event

Watershed	Contributing Area *Square Miles*	Contributing Area to Proposed Sites *Square Miles*	Number of Sites Included	Total Utilized Storage* *Acre-Feet*	Gated Storage* *Acre-Feet*	Utilized Ungated Storage* *Acre-Feet*	Event Peak Inundation Area *Acres*
Bois De Sioux	1,850	589	22	106,220	88,090	18,110	20,110
Otter Tail	1,380	44	1	6,360	2,480	3,880	1,530
Upper Red River (MN)	486	159	4	37,820	29,330	8,490	9,350
Wild Rice (ND)	2,022	346	13	75,570	64,750	10,880	17,890
Maple/Rush/Sheyenne	5,397	507	26	120,490	98,780	21,740	20,050
Buffalo	995	198	6	36,960	25,380	11,570	11,150
Elm (Red River Ungaged)	478 (255)	109	3	23,870	18,880	5,000	4,780
Wild Rice (MN)	1,685	589	17	123,730	100,980	22,740	18,350
Marsh	398	115	4	28,200	26,790	1,430	4,590
Totals	***14,691***	***2,655***	***96***	**559,220**	***455,460***	***103,840***	***107,800***

**Presented storage volumes utilized during the Standardized Melt Progression Runoff Event (4-day melt duration and Initial Virtual Thaw Progression).*

Table 3
Proposed Storage Site Performance Statistics - HUR Detention Scenario
Standardized Melt Progression Event

Watershed	Storage Site ID	Contributing Area *Square Miles*	Total Utilized Storage* *Acre-Feet*	Gated Storage* *Acre-Feet*	Utilized Ungated Storage* *Acre-Feet*	Event Peak Inundation Area *Acres*
Bois De Sioux	Moonshine 4	6	1,440	1,030	410	380
Bois De Sioux	Moonshine 13	7	1,700	1,360	340	340
Bois De Sioux	Moonshine Lake	7	1,570	780	790	590
Bois De Sioux	Leonardsville 12	30	8,030	6,680	1,350	1,060
Bois De Sioux	Leonardsville 31E	6	1,120	790	330	280
Bois De Sioux	Leonardsville 31W	4	1,050	1,050	0	380
Bois De Sioux	Tara 12	9	2,270	1,890	380	500
Bois De Sioux	Parnell 13	15	4,300	4,300	0	760
Bois De Sioux	Moose Head	8	2,370	1,620	750	960
Bois De Sioux	Eldorado 7	9	2,160	1,700	460	2,160
Bois De Sioux	Dollymount 30	25	6,980	5,270	1,710	870
Bois De Sioux	Big Lake	10	2,040	860	1,180	380
Bois De Sioux	Red Path	203	22,200	19,860	2,330	2,020
Bois De Sioux	Hart 2	18	4,330	3,060	1,270	930
Bois De Sioux	Brandrup 9	9	2,130	1,490	640	430
Bois De Sioux	LaMars 11	46	10,550	8,790	1,760	1,550
Bois De Sioux	Elma 27	27	7,420	7,420	0	2,990
Bois De Sioux	Victor 17	82	9,530	7,050	2,470	940
Bois De Sioux	Lawrence 19	32	5,250	4,420	830	940
Bois De Sioux	Bradford 34	12	3,550	3,410	140	630
Bois De Sioux	Brandrup 23	12	3,460	2,870	590	630
Bois De Sioux	Western 32	12	2,770	2,390	380	390
Bois De Sioux Watershed Summary		**589**	**106,220**	**88,090**	**18,110**	**20,110**
Otter Tail	Foxhome Twp.	44	6,360	2,480	3,880	1,530
Otter Tail Watershed Summary		**44**	**6,360**	**2,480**	**3,880**	**1,530**
Upper Red River (MN)	Meadows Twp. Site 1	31	7,980	6,870	1,120	1,910
Upper Red River (MN)	Meadows Twp. Site 2	32	8,710	7,810	900	1,990
Upper Red River (MN)	Nilsen Twp.	62	16,160	14,420	1,730	2,920
Upper Red River (MN)	Sabin Coulee	34	4,970	230	4,740	2,530
Upper Red River (MN) Watershed Summary		**159**	**37,820**	**29,330**	**8,490**	**9,350**

**Presented storage volumes utilized during the Standardized Melt Progression Runoff Event (4-day melt duration and Initial Virtual Thaw Progression).*

Table 3
Proposed Storage Site Performance Statistics - HUR Detention Scenario
Standardized Melt Progression Event

Watershed	Storage Site ID	Contributing Area *Square Miles*	Total Utilized Storage* *Acre-Feet*	Gated Storage* *Acre-Feet*	Utilized Ungated Storage* *Acre-Feet*	Event Peak Inundation Area *Acres*
Wild Rice (ND)	Site 14	35	8,030	7,870	160	1,370
Wild Rice (ND)	Site 15	28	6,160	4,870	1,290	1,850
Wild Rice (ND)	Site 16	32	6,170	5,230	940	1,680
Wild Rice (ND)	Site 17	37	6,760	6,350	420	1,690
Wild Rice (ND)	Site 18	35	8,160	6,120	2,040	2,070
Wild Rice (ND)	Site 19	24	4,960	4,230	740	980
Wild Rice (ND)	Site 20	20	4,120	3,560	560	820
Wild Rice (ND)	Site 21	29	7,010	5,250	1,770	1,990
Wild Rice (ND)	Site 22	17	4,040	3,530	510	770
Wild Rice (ND)	Site 23	20	6,230	4,950	1,290	1,800
Wild Rice (ND)	Site 24	28	5,290	4,500	800	810
Wild Rice (ND)	Site 25	13	2,940	2,880	60	550
Wild Rice (ND)	Site 26	28	5,700	5,410	300	1,510
Wild Rice (ND) Watershed Summary		**346**	**75,570**	**64,750**	**10,880**	**17,890**
Maple/Rush/Sheyenne	MR Site 23	29	6,180	5,880	300	1,480
Maple/Rush/Sheyenne	MR Site 25	12	3,010	2,790	220	530
Maple/Rush/Sheyenne	MR Site 26	7	1,750	1,630	130	340
Maple/Rush/Sheyenne	MR Site 27	23	4,570	3,840	720	680
Maple/Rush/Sheyenne	MR Site 28	18	5,160	3,750	1,420	560
Maple/Rush/Sheyenne	MR Site 29	11	2,680	2,520	160	500
Maple/Rush/Sheyenne	MR Site 30	17	3,340	2,480	860	1,070
Maple/Rush/Sheyenne	MR Site 31	21	5,200	4,360	830	1,520
Maple/Rush/Sheyenne	MR Site 32	13	3,180	3,010	170	400
Maple/Rush/Sheyenne	MR Site 33	9	1,920	1,740	180	360
Maple/Rush/Sheyenne	MR Site 34	17	4,050	3,790	260	600
Maple/Rush/Sheyenne	MR Site 35	13	2,980	2,590	390	490
Maple/Rush/Sheyenne	MR Site 36	20	4,110	3,410	700	810
Maple/Rush/Sheyenne	MR Site 37	14	4,430	2,800	1,640	730
Maple/Rush/Sheyenne	MR Site 38	45	18,330	7,930	10,410	4,800
Maple/Rush/Sheyenne	SR Site 1	27	5,890	5,370	520	1,350
Maple/Rush/Sheyenne	SR Site 2	13	2,580	2,530	50	270
Maple/Rush/Sheyenne	SR Site 3	24	4,880	3,940	940	950
Maple/Rush/Sheyenne	SR Site 4	23	4,830	4,550	280	770
Maple/Rush/Sheyenne	SR Site 5	43	9,020	8,260	760	910
Maple/Rush/Sheyenne	SR Site 6	45	9,560	9,180	380	400
Maple/Rush/Sheyenne	SR Site 7	11	2,240	2,180	60	90
Maple/Rush/Sheyenne	SR Site 8	9	1,800	1,770	40	60
Maple/Rush/Sheyenne	SR Site 9	10	2,070	2,020	50	80
Maple/Rush/Sheyenne	SR Site 11	13	2,880	2,790	90	130
Maple/Rush/Sheyenne	SR Site 12	20	3,850	3,670	180	170
Maple/Rush/Sheyenne Watershed Summary		**507**	**120,490**	**98,780**	**21,740**	**20,050**

**Presented storage volumes utilized during the Standardized Melt Progression Runoff Event (4-day melt duration and Initial Virtual Thaw Progression).*

Table 3

Proposed Storage Site Performance Statistics - HUR Detention Scenario

Standardized Melt Progression Event

Watershed	Storage Site ID	Contributing Area	Total Utilized Storage*	Gated Storage*	Utilized Ungated Storage*	Event Peak Inundation Area
		Square Miles	*Acre-Feet*	*Acre-Feet*	*Acre-Feet*	*Acres*
Buffalo	Barnesville Twp.	36	8,900	8,480	420	2,200
Buffalo	Deerhorn Creek Site 2A	12	3,940	3,200	750	800
Buffalo	Manston Slough Restoration	28	5,320	590	4,730	3,930
Buffalo	Manston Twp.	26	6,460	5,440	1,010	1,430
Buffalo	Spring Prairie Twp.	60	5,780	1,110	4,660	1,730
Buffalo	Stony Creek Off-Channel	36	6,560	6,560	0	1,060
Buffalo River Watershed Summary		**198**	**36,960**	**25,380**	**11,570**	**11,150**
Elm (Red River Ungaged)	Site 5	30	4,870	3,540	1,330	870
Elm (Red River Ungaged)	Site 6	47	11,130	8,300	2,830	2,300
Elm (Red River Ungaged)	Site 7	32	7,870	7,040	840	1,610
Elm (Red River Ungaged) Watershed Summary		**109**	**23,870**	**18,880**	**5,000**	**4,780**
Wild Rice (MN)	C-1 (Spring Creek)	8	2,300	2,160	140	310
Wild Rice (MN)	C-2 (Spring Creek)	66	1,990	1,520	470	180
Wild Rice (MN)	D-1	50	12,610	10,370	2,240	1,750
Wild Rice (MN)	D-2 (Marsh Creek)	26	4,380	2,750	1,630	1,070
Wild Rice (MN)	D-3 (Marsh Creek)	125	8,240	6,030	2,210	830
Wild Rice (MN)	E-1 (Mossasin Creek)	32	8,680	7,090	1,600	1,790
Wild Rice (MN)	F-1 (Middle Wild Rice)	23	4,300	3,500	790	750
Wild Rice (MN)	G-1 (Mashaug Creek)	23	5,450	4,820	620	720
Wild Rice (MN)	G-2 (Mashaug Creek)	38	9,860	8,340	1,520	1,290
Wild Rice (MN)	H-1 (Coon Creek)	21	4,800	4,400	400	820
Wild Rice (MN)	I-1 (South Branch)	38	9,220	8,550	670	830
Wild Rice (MN)	I-2 (South Branch)	12	2,860	2,520	340	510
Wild Rice (MN)	I-3 (South Branch)	20	5,020	4,280	740	890
Wild Rice (MN)	I-4 (South Branch)	10	1,340	1,090	260	320
Wild Rice (MN)	I-5 (South Branch)	25	6,080	5,340	730	760
Wild Rice (MN)	I-6 (South Branch)	208	22,420	14,810	7,610	2,330
Wild Rice (MN)	J-1 (Felton)	62	14,180	13,410	770	3,200
Wild Rice (MN) Watershed Summary		**589**	**123,730**	**100,980**	**22,740**	**18,350**
Marsh	N-1 (Marsh River)	31	5,680	5,480	200	780
Marsh	N-2 (Marsh River)	50	11,540	11,440	110	1,610
Marsh	N-3 (Marsh River)	30	2,340	1,820	520	320
Marsh	0-1 (Ungaged Marsh River)	34	8,640	8,050	600	1,880
Marsh River Watershed Summary		**115**	**28,200**	**26,790**	**1,430**	**4,590**
Subtotal: U/S of USGS Gage 05051500 (Red River at Wahpeton, ND)**		633	112,580	90,570	21,990	21,640
Subtotal: U/S of USGS Gage 05054000 (Red River at Fargo, ND)**		1,138	225,970	184,650	41,360	48,880
Subtotal: U/S of USGS Gage 05054500 (Red River at Halstad, MN)**		2,541	531,020	428,670	102,410	103,210
Grand Total		**2,655**	**559,220**	**455,460**	**103,840**	**107,800**

**Presented storage volumes utilized during the Standardized Melt Progression Runoff Event (4-day melt duration and Initial Virtual Thaw Progression).*

***Totals do not account for benefit provided to breakout flows from downstream watersheds.*

Table 4

Post 1997 Storage Site Performance Statistics - HUR Detention Scenario

Standardized Melt Progression Event

Watershed	Storage Site ID	Contributing Area *Square Miles*	Total Utilized Storage* *Acre-Feet*	Gated Storage* *Acre-Feet*	Utilized Ungated Storage* *Acre-Feet*
Bois de Sioux	North Ottawa	72	17,341	16,167	1,174
Buffalo	Riverton	6	339	0	339
Buffalo	Whisky Creek Tributary	5	402	0	402
Maple	Maple River Dam	815	77,547	0	77,547
Marsh	Olson - Agassiz**	34	3,303	1,120	2,183
Marsh	Lockhart	2	311	0	311
Subtotal: U/S of USGS Gage No. 05051500 (Red River at Wahpeton, ND)***		72	17,341	16,167	1,174
Subtotal: U/S of USGS Gage No. 05054000 (Red River at Fargo, ND)***		72	17,341	16,167	1,174
Subtotal: U/S of USGS Gage No. 05054500 (Red River at Halstad, MN)***		897	95,629	16,167	79,462
Grand Total		**934**	**99,243**	**17,287**	**81,956**

**Presented storage volumes utilized during the Standardized Melt Progression Runoff Event (4-day melt duration and Initial Virtual Thaw Progression).*

***Operational changes to existing pre-1997 detention sites made after the 1997 spring flood.*

**** Totals do not account for benefit provided to breakout flows from downstream watersheds.*

Table No. 5

Red River Basin Commission Long Term Flood Solutions Report

Tributary Reduction Goals & Halstad Upstream Retention Achieved Reductions

USGS Gage No.	Location Description	Drainage Area *Square Miles*	Peak Flow Reduction Goal	Volume Reduction Goal	Provided Peak Flow Reduction*	Provided Volume Reduction*	Reduction Focus
05050000	Bois De Sioux River near White Rock, SD	1,133	20%	20%	37%	23%	Store Early Water
05046000	Otter Tail River below Orwell near Fergus Falls, MN	1,212	0%	0%	0%	0%	No Reduction
05053000	Wild Rice River near Abercombie, ND	1,858	35%	17%	33%	17%	Peak Flow Reduction
05064000	Sheyenne River at Harwood, ND	5,034	23%	11%	33%	9%	Peak Flow Reduction
05060500	Rush River at Amenia, ND	101	35%	13%	0%	0%	Peak Flow Reduction
05062000	Buffalo River near Dilworth, MN	891	35%	17%	13%	7%	Peak Flow Reduction
05064000	Wild Rice River at Hendrum, MN	1,512	35%	20%	18%	19%	Peak Flow Reduction
05067500	Marsh River near Shelly, MN	231	51%	18%	1%	42%	Peak Flow Reduction
Ungaged	Rabbit River at MN State Highway No. 75	300	35%	26%	35%	34%	Peak Flow Reduction
Ungaged	Bois De Sioux River (Ungaged)	417	13%	9%	--	21%	Peak Flow Reduction
Ungaged	Otter Tail River (Ungaged)	167	13%	12%	--	3%	Peak Flow Reduction
Ungaged	Red River Local Areas Ungaged Upstream of Fargo (ND)	266	13%	13%	--	12%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Fargo (MN)	406	13%	13%	--	20%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Halstad (ND)	852	13%	13%	--	9%	Store late water
Ungaged	Red River Local Areas Ungaged Upstream of Halstad (MN)	231	13%	13%	--	0%	Store late water
Ungaged	Red River Local Areas Upstream of Red Lake River (MN)	224	13%	13%	--	13%	Store late water

**Peak flow and volume reductions provided during the Standardized Melt Progression Runoff Event (4-day melt duration and initial virtual thaw progression).*

Table No. 6
Red River Mainstem Peak Flow and Volume Reductions
Basinwide Flow Reduction Strategy

USGS Gage No.	Location Description	Drainage Area *Square Miles*	Peak Flow Reduction	Volume Reduction
05051500	Red River of the North at Wahpeton, ND	3,229	20%	12%
05051522	Red River of the North at Hickson, ND	3,527	26%	14%
05054000	Red River of the North at Fargo, ND	5,759	21%	12%
05064500	Red River of the North at Halstad, MN	14,604	23%	10%

**Peak flow and volume reductions provided during the Standardized Melt Progression Runoff Event (4-day melt duration and virtual thaw progression).*

Halstad Upstream Retention Project – Appendix A

Red River Basin Standardized Melt Progression Event

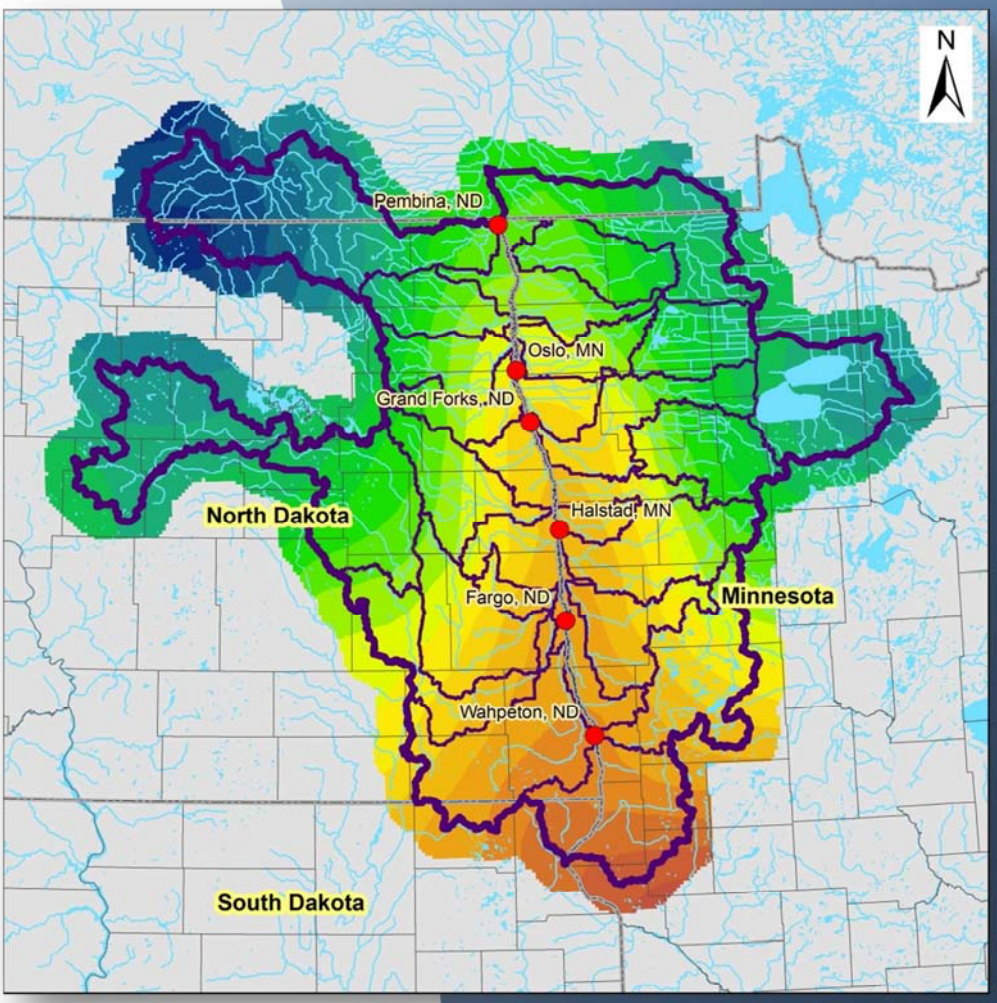
In cooperation with:

Houston Engineering Inc.

moore engineering, inc.

WIDSETH SMITH NOLTING

Red River Basin
Standardized Melt Progression Event Analysis



Prepared for the Red River Basin Commission by:

Houston Engineering, Inc.
1401 21st Avenue North
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4/10/2013

HoustonEngineering Inc.

Red River Basin Standardized Melt Progression Event Analysis

Red River Basin Commission

April 10, 2013

I hereby certify that the attached plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly registered Professional Engineer under the laws of the State of North Dakota.

Jerry Bents P.E.
License No. 4874
Date: 4/10/2013

JERRY D. BENTS REGISTERED PROFESSIONAL PE 4874 ENGINEER NORTH DAKOTA

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FIGURE 7 – Temporal Rainfall Distribution

BACKGROUND & PURPOSE

With both the Phase 1 and Phase 2 HEC-HMS model development nearing completion, a need exists to develop a consistent procedure of application for these models to evaluate potential flood damage reduction projects. This standardized approach would utilize a synthetic runoff event that is applied to HEC-HMS in a manner that depicts typical spring flood conditions within the Red River Basin. During model development, HEC-HMS scenarios were created for a synthetic a 10-day runoff event. This scenario applied runoff depths as defined by the 100-yr 10-day runoff from NRCS's TR-60 publication, and assumed that all runoff begins at the same time within each of the modeled subwatersheds. However in reality, runoff timing varies depending on the timing of the melt of snowpack within each respective modeled subwatershed.

To better simulate this condition, timing characteristics consistent with typical spring snowmelt temperatures will be used to establish a Virtual Thaw Progression (VTP) for the United States portion for the Red River Basin. Historic temperature data from various locations will be analyzed to determine the VTP. This timing analysis will then be applied to the 10-day runoff scenario depths to establish the Red River Basin Standardized Melt Progression Event. This information will be developed in a manner that would allow application via the gridded precipitation meteorological option within HEC-HMS. Gridded precipitation allows for each subbasin to depict a unique temporal distribution and total depth depending on its geographic orientation in relation to the VTP. It is anticipated that this will facilitate a more realistic spring flood condition for project evaluation within HEC-HMS along each tributary, as well as Red River main stem evaluation using the HEC-RAS Unsteady model.

1 VIRTUAL THAW PROGRESSION

1.1 METHODOLOGY

The Virtual Thaw Progression (VTP) is intended to better simulate typical spatial variation of the spring snowmelt within the Red River Basin. Establishment of this pattern allows for a better understanding of how timing of runoff in various subwatersheds relates to the spring flood hydrograph experienced on the Red River main stem. A similar analysis had been completed by the National Weather Service in 2005. This previous analysis established a VTP by determining the first date of three consecutive days at which the minimum daily temperature exceeded freezing (32 degrees Fahrenheit). The analysis derived an average value for each observation location for a period of time ranging from 1970-2005. Refer to **Figure 1** for a map illustrating this previous VTP Analysis.

The updated VTP from this analysis utilizes the same criteria from the previous VTP analysis. Annual thaw dates are established by determining the first date at which three consecutive days that exhibit minimum daily temperature values greater than 32 degrees Fahrenheit. In the updated VTP analysis, time period has been updated to include 1970-2012 spring temperatures. Only temperature observation locations that contained 10 years or more of temperature data was utilized in the analysis. **Figure 2** illustrates the temperature observation points utilized in the VTP analysis.

In order to ensure data was not skewed by short periods of abnormally warm late winter conditions, only dates from March 1 to May 31 were considered. Further precautions were taken to avoid any skewing of data by considering the earliest and latest dates for each observation location as outliers. After abnormal values were removed from the dataset, the remaining dates were averaged to determine the VTP date for each observation location. Refer to **Table 1** for a list of thaw dates at each observation location for years where data was available, as well as the VTP dates for each location. VTP dates are also are illustrated in **Figure 3**.

1.2 ANALYSIS SUMMARY

VTP dates were interpolated between each of the observation points using Kriging methods to determine a VTP trend for the Red River Basin. The Kriging interpolation was completed using the GeoStatistical Analysis Toolset within ArcGIS. Metadata summarizing Kriging assumptions and inputs can be found in **Appendix A**.

In general, VTP across the Red River Basin occurs in a south to north progression, with the earliest thaw dates occurring in the southern end of the Bois De Souix Watershed, and a gradual progression north to the Red River confluence at Lake Winnipeg. For a given latitude, there is a general trend of earlier warming in the lake plain region and increasing delay in warming for areas further removed from the lake plain region. A visual representation of VTP across the Red River Basin is illustrated in **Figure 4**.

1.3 SOURCE DATA

Observed temperature data was obtained the National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA NCDC). Data for both the United States and Canadian portions of the Red River Basin are made available to download via http://www.ncdc.noaa.gov. National Weather Service staff in the Grand Forks, ND office was also collaborated with on determining methodology consistent with previous VTP analyses.

2 RUNOFF VOLUME AND DISTRIBUTION

2.1 RUNOFF DEPTH AND EQUIVALENT PRECIPITATION

Runoff depths utilized to develop the Red River Basin Standardized Event are from *NRCS TR-60: Earth Dams and Reservoirs*, which specifies a runoff depth correlating to a 10-day duration, 100-year event. This event is commonly utilized in design of small dams. In general, depths vary from 4.5 inches to 6.5 inches of runoff across the Red River Basin with volume increasing in a west to east direction (**Figure 5**).

The FM Metro/USACE developed HEC-HMS models for the Red River Basin apply the equivalent rainfall based on the Red River Basin average 24-hr NRCS Curve Number (73.3). This methodology preserves spatial variation of runoff depths due to variations in soils and land use. For further information on development of the TR-60 Equivalent Rainfall development, refer to *Fargo-Moorhead Metro Basin-Wide Modeling Approach: HEC-HMS Model Development of Various Tributaries above the Red River of the North at Halstad, MN, December 23, 2011.* **Figure 6** illustrates the TR-60 100-yr, 10-day Equivalent Rainfall.

2.2 TEMPORAL DISTRIBUTION

Development of the Red River Basin Standardized Melt Progression Event required a timing distribution to be applied to the TR-60 100-yr, 10-day Equivalent Rainfall depth described above. In order to remain consistent with development of the FM Metro/USACE HEC-HMS Models, the same temporal distribution is utilized in this analysis. This distribution correlates to the MN Principal Spillway Rainfall Distribution (Hydrology Guide for Minnesota, USDA SCS), as illustrated in **Figure 7**. This distribution is applied at a uniform intensity for four hour time segments in order to minimize deviations in rainfall volume based on rounding error.

3 STANDARDIZED MELT PROGRESSION EVENT DEVELOPMENT

3.1 METHODOLOGY

Results from the VTP analysis were combined with runoff volumes and temporal distributions described above to develop the Red River Basin Standardized Melt Progression Event. This standardized event results in a synthetic modeling scenario with volumes applied at varying times that reflect spatial variations in melt timing typically experienced in the Red River Basin. Data for the Standardized Melt Progression Event for the Red River Basin was archived in HEC-DSS as gridded precipitation. The system allows for direct input into the FM Metro/USACE HEC-HMS models developed for the Red River Basin.

3.2 GRIDDED PRECIPITATION

Runoff and VTP timing across the Red River Basin is generalized into a two kilometer by two kilometer grid configuration referred to as the Standard Hydrologic Grid (SHG), as defined in HEC-HMS documentation (HEC-GeoHMS User's Manual Version 5, October 2010). VTP timing correlates to the time at which precipitation begins for each SHG cell. Rainfall is applied to each SHG cell consistent with the MN Principal Spillway Temporal Distribution beginning at the VTP thaw date. Incremental precipitation depths are applied to facilitate total rainfall depths within each SHG cell consistent with TR-60 equivalent rainfall total depth

Rainfall data is applied as gridded precipitation within the FM Metro/USACE HEC-HMS models, and requires gridded precipitation to be provided in HEC-DSS format. Gridded precipitation is converted from a GIS platform to HEC-DSS through development of a python-based script within ArcGIS. This scripting effort utilized scripts developed for converting NEXRAD radar data to HEC-DSS gridded precipitation files from Phase I HEC-HMS model development (Fargo-Moorhead Metro Basin-Wide Modeling Approach: HEC-HMS Model Development of Various Tributaries above the Red River of the North at Halstad, MN, December 23, 2011). These scripts were modified as necessary to develop the Standardized Melt Progression Event for the Red River Basin. Further information on ArcGIS based tools utilized in this analysis is available in **Appendix B**. The development of these tools will allow future users to create additional scenarios by varying the VTP, runoff depth, and/or temporal distribution.

3.3 HEC-DSS QUALITY CONTROL

The resultant HEC-DSS file derived from the TR-60 equivalent rainfall depths and VTP timing information was reviewed with the aid of several completed HEC-HMS models developed as part of the FM Metro/USACE HEC-HMS Phase I and Phase II effort. Quality control procedures included reviewing rainfall volume applied to the HEC-HMS model with rainfall volumes from the TR-60 equivalent rainfall depth within GIS. In general, these depths varied within (+/-) 2%. Precipitation start times for each model subbasin were compared to start times derived from the VTP timing data within ArcGIS. In general, the HEC-HMS model was applying rainfall starting at times consistent with the VTP timing data. Variations were noted when the start time interval, as derived from the VTP timing data, consisted of an area small enough to produce incremental rainfall volumes rounded to zero within the HEC-HMS model. In these instances, rainfall began the next four hour time step.

REFERENCES

1. U.S. Department of Agriculture, Natural Resources Conservation Service, *Earth Dams and Reservoirs*, Technical Release No. 60, July 2005.

2. Fargo-Moorhead Metro Basin-Wide Modeling Approach – Hydrologic Modeling, *HEC-HMS Model Development for Various Tributaries above the Red River of the North at Halstad, MN*, December 23, 2011.

3. National Oceanic and Atmospheric Administration, National Climatic Data Center, http://www.ncdc.noaa.gov/

4. U.S. Department of Agriculture, Natural Resources Conservation Service, *Hydrology Guide for Minnesota.*

Tables

HoustonEngineering Inc.

						First Annual Date Cooresponding to Tmin > 32° F for Three Consecutive Days (March - May)																																										
Observation Location	Code	Latitude	Longitude	Average VTP	Years With Data	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
FERTILE CA	CA004012485	49.33	-101.45	04/16	43	04/27	04/18	04/25	05/03	04/24	04/25	04/08	04/17	04/27	04/23	04/16	04/27	04/12	04/19	03/23	04/17	03/27	03/20	04/30	04/13	04/19	04/05	04/15	05/03	04/22	03/12	05/05	04/17	04/12	04/09	04/21	04/09	04/13	04/12	05/07	04/07	04/19	04/15	04/14	04/12	04/12	05/03	03/16
LANGENBURG CA	CA004014145	50.9	-101.72	04/21	36	04/25	05/04	04/20	05/04	04/24	04/22	04/12	-	-	04/17	-	-	-	-	-	04/19	04/05	04/05	04/29	04/20	04/19	04/25	04/15	04/26	04/11	05/01	05/14	05/04	04/12	03/26	04/23	04/25	04/11	04/12	05/26	04/07	04/09	04/15	05/14	05/11	04/28	04/27	03/29
MARYFIELD CA	CA004015045	49.83	-101.52	04/17	35	-	04/18	04/28	05/03	04/24	04/22	04/12	04/09	04/25	05/12	04/16	04/27	04/12	04/18	03/24	04/10	04/05	04/05	04/29	04/20	04/19	04/25	04/15	04/26	04/11	05/02	05/06	04/17	04/10	04/09	04/21	04/18	04/11	04/09	04/05	04/04	-	-	-	-	-	-	-
MOOSOMIN CA	CA004015360	50.13	-101.67	04/15	31	04/25	04/18	04/28	05/03	04/24	04/22	04/12	04/09	04/25	05/12	04/16	03/28	04/12	04/19	03/23	04/10	03/27	04/04	04/02	04/20	04/19	04/01	04/15	03/23	04/11	05/02	05/03	05/04	04/10	04/07	04/20	-	-	-	-	-	-	-	-	-	-	-	-
REDVERS CA	CA004016521	49.6	-101.72	04/16	24	04/27	04/19	04/26	05/03	05/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/20	04/19	04/02	04/14	04/05	04/11	04/20	05/04	04/17	04/12	04/09	04/21	04/18	04/11	04/09	04/05	04/04	04/10	04/15	-	-	-	-	-
ROCANVILLE CA	CA004016842	50.47	-101.55	04/12	43	04/25	04/18	04/21	05/04	04/24	04/14	04/12	04/09	04/25	04/23	04/16	04/25	04/12	04/18	03/23	04/13	03/27	03/20	04/03	04/20	04/19	04/02	04/16	04/26	04/11	04/20	04/16	04/24	04/12	04/06	03/22	04/07	04/11	04/12	05/07	04/04	04/09	03/24	04/18	04/11	03/29	04/24	03/16
BALDUR CA	CA005010140	49.3	-99.33	04/17	43	04/25	04/15	04/26	03/22	04/25	04/16	04/12	04/14	04/23	05/16	04/17	04/28	04/22	04/24	03/25	03/23	03/28	03/20	04/03	05/02	04/20	04/26	04/15	04/26	05/08	05/02	05/06	04/18	04/04	04/25	04/22	04/26	04/14	04/21	05/19	04/07	04/10	04/19	05/13	04/12	03/09	04/09	04/23
BINSCARTH CA	CA005010216	50.58	-101.27	04/19	33	-	-	-	05/17	04/18	04/22	04/12	04/09	04/25	05/15	04/18	05/02	04/28	04/18	04/05	04/18	04/05	04/05	04/03	04/20	04/18	04/25	04/15	04/26	04/11	04/14	05/14	05/04	04/12	04/08	04/23	04/25	04/13	04/12	05/17	04/04	-	-	-	-	-	-	-
BIRTLE CA	CA005010240	50.43	-101.05	04/20	29	05/02	04/18	04/28	05/04	04/24	04/22	04/12	04/09	04/25	04/17	04/18	04/25	05/02	04/24	04/05	04/18	04/05	04/05	04/02	04/20	04/19	04/02	04/15	04/26	05/07	05/02	-	05/04	05/12	-	04/21	-	-	-	-	-	-	-	-	-	-	-	-
BRANDON AIRPORT CA	CA005010480	49.917	-99.95	04/19	43	04/25	04/18	04/19	05/04	04/24	04/21	04/12	04/09	04/25	05/16	04/18	05/02	04/14	04/24	03/24	04/18	04/17	03/19	04/29	04/22	04/19	04/05	04/15	04/27	05/07	04/30	05/14	04/20	04/23	04/09	04/24	04/25	04/13	04/21	05/18	04/07	04/11	04/26	05/12	04/12	03/09	04/25	03/17
BRANDON CDA CA	CA005010485	49.87	-99.98	04/21	38	04/25	04/18	04/26	04/19	04/19	04/22	04/22	04/09	04/25	05/16	04/28	05/02	04/14	04/24	03/24	05/01	04/17	03/19	04/29	04/22	04/19	05/06	03/05	05/05	05/07	04/30	05/14	04/23	04/23	04/25	05/02	04/07	04/13	04/22	05/07	04/07	04/09	04/24	-	-	-	-	-
CAMERON CA	CA005010538	49.47	-100.47	04/12	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/18	03/27	04/04	04/01	04/22	04/18	04/10	04/16	03/23	04/11	04/14	05/06	05/04	04/04	04/09	04/21	-	-	-	-	-	-	-	-	-	-	-	-
CARBERRY CS CA	CA005010547	49.9	-99.35	04/22	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/08	05/14	05/22	04/22	04/25	05/02	04/25	04/13	04/12	05/18	04/07	04/09	04/26	04/18	04/12	03/29	04/25	03/16
CARBERRY CA	CA005010548	49.87	-99.35	04/22	23	04/24	04/18	04/19	05/04	04/24	04/21	04/12	04/14	04/22	04/18	04/27	04/27	04/14	04/18	03/23	04/17	05/04	-	-	-	-	-	-	-	04/11	04/14	05/14	05/22	04/27	04/24	-	-	-	-	-	-	-	-	-	-	-	-	-
CYPRESS RIVER CA	CA005010640	49.55	-99.08	04/09	43	04/23	04/13	04/11	03/22	04/18	04/25	04/12	04/25	04/22	04/18	04/18	04/21	04/14	04/18	03/25	03/23	03/27	03/19	04/29	04/22	03/11	04/02	04/15	03/24	04/11	04/14	05/05	03/31	04/10	04/13	03/23	04/07	04/11	04/12	04/18	04/07	04/09	04/19	04/14	04/12	03/09	04/21	03/16
DELORAINE CA	CA005010760	49.18	-100.5	04/13	24	04/24	04/06	04/19	03/21	04/18	04/22	04/06	04/12	04/16	05/15	04/18	04/27	04/14	04/19	03/24	04/20	04/17	03/19	04/02	04/20	04/18	04/02	04/30	04/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ELKHORN 2 EAST CA	CA005010QFQ	49.93	-101.2	04/16	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/22	04/19	04/02	04/15	04/27	04/11	05/02	05/14	05/04	04/12	04/07	04/24	04/24	04/11	04/12	04/05	04/13	04/11	04/18	04/18	04/15	03/29	04/27	03/16
GLENBORO CA	CA005011051	49.57	-99.33	04/10	22	-	04/18	04/26	03/22	04/17	04/14	04/08	04/20	04/21	04/23	04/18	04/27	04/22	04/24	03/25	03/23	03/27	03/19	04/02	04/22	03/11	04/02	04/15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HAMIOTA CA	CA005011240	50.18	-100.62	04/19	21	04/25	04/18	04/25	04/19	04/18	04/22	04/08	04/09	04/21	05/16	04/18	-	04/28	04/22	03/24	04/18	05/08	04/15	04/03	04/22	04/19	04/27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HAMIOTA 2 CA	CA005011241	50.18	-100.6	04/22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/26	04/16	05/02	05/14	04/24	04/23	03/26	04/21	04/25	04/13	-	-	-	-	-	-	-	-	-	-
HARDING CA	CA005011275	50.03	-100.5	04/23	14	04/27	04/18	04/26	04/19	04/24	04/22	04/12	04/09	04/22	05/16	04/29	05/02	04/28	04/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MINNEDOSA CA	CA005011760	50.27	-99.83	04/26	30	05/06	04/18	04/29	04/19	05/07	04/21	05/11	05/03	04/27	04/18	04/20	05/02	04/23	05/21	03/25	05/03	03/28	04/15	04/30	04/22	04/21	04/25	04/28	04/27	05/13	05/07	05/14	04/24	04/23	04/25	-	-	-	-	-	-	-	-	-	-	-	-	-
OAKNER CA	CA005012054	50.1	-100.63	04/20	38	04/24	04/18	04/29	05/04	04/18	04/22	04/12	04/14	04/25	05/16	04/17	05/02	04/28	04/23	03/24	04/18	04/17	03/19	04/03	04/22	04/19	04/25	04/27	05/05	05/08	05/06	05/05	04/24	04/23	04/25	04/23	04/25	04/13	04/12	04/05	04/07	04/11	04/18	-	-	-	-	-
PIERSON CA	CA005012080	49.18	-101.27	04/16	37	04/25	04/18	04/25	03/21	04/19	04/22	04/08	04/14	04/22	04/17	04/16	04/27	04/23	04/23	03/24	04/17	04/17	04/05	04/29	04/20	04/19	04/05	04/15	05/03	04/22	03/12	04/23	04/17	04/23	04/07	04/21	04/09	04/13	04/12	05/01	04/07	04/11	-	-	-	-	-	-
PORTAGE LA PRAIRIE 2 CA	CA005012322	49.98	-98.32	04/08	27	04/25	04/07	04/12	03/21	04/18	04/22	04/06	04/10	04/25	04/18	04/16	03/28	04/14	04/19	03/24	03/23	04/06	04/05	04/02	04/14	04/24	04/03	03/05	03/25	04/12	03/23	04/16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PORTAGE SOUTHPORT A CA	CA005012324	49.9	-98.267	04/11	36	04/13	04/18	04/26	03/22	-	-	-	-	04/25	04/18	04/16	05/02	04/22	04/19	04/05	03/22	03/27	04/04	04/04	04/22	04/18	04/02	04/27	-	-	-	05/05	04/18	03/25	04/24	03/24	04/07	04/13	04/09	04/18	04/06	04/10	04/20	04/14	04/12	03/09	04/09	03/12
RESTON CA	CA005012400	49.55	-101.1	04/21	18	04/24	04/18	04/28	03/22	04/18	05/14	04/12	04/17	04/08	05/16	04/20	04/25	04/23	04/23	04/06	-	-	-	05/06	04/22	04/19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	
RIDING MOUNTAIN AUDY CA	CA005012423	50.72	-100.23	04/23	13	-	-	-	-	-	-	-	-	04/27	04/17	04/20	05/02	04/28	05/08	03/25	04/27	04/17	04/14	04/29	04/21	04/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROBLIN CA	CA005012469	51.183	-101.367	04/13	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/07	04/22	04/08	03/22	04/10	04/13	04/12	05/17	04/07	04/11	04/15	04/18	04/11	04/13	04/24	03/16
ROSSBURN CA	CA005012500	50.67	-100.82	04/22	21	05/02	04/18	04/21	05/04	04/24	04/22	04/07	04/09	04/25	04/17	04/18	04/25	04/22	04/23	04/09	05/01	05/08	04/07	05/06	05/07	04/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RUSSELL CA	CA005012520	50.77	-101.28	04/20	21	04/25	04/18	04/26	05/08	04/24	04/22	05/08	04/09	04/25	04/17	04/16	04/25	04/22	04/18	04/05	04/17	05/03	04/05	04/02	04/20	04/19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ST ALPHONSE CA	CA005012545	49.45	-99.02	04/07	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/19	04/02	04/20	03/11	04/27	04/14	04/05	04/11	04/13	05/05	05/17	03/25	04/13	03/23	04/07	04/11	03/22	05/07	04/07	04/09	04/15	04/14	04/12	03/09	04/08	03/14
SANDY LAKE CA	CA005012620	50.5	-100.1	04/28	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/25	04/15	05/05	04/12	05/07	05/14	05/21	04/23	04/24	04/23	04/28	04/13	04/23	05/18	-	-	-	-	-	-	-	-
SHOAL LAKE CS CA	CA005012654	50.45	-100.6	04/22	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/26	05/14	05/05	04/22	04/24	04/23	04/09	04/13	04/12	05/21	04/07	04/11	04/15	04/18	05/04	04/23	04/26	03/16
SOMERSET CA	CA005012710	49.45	-98.62	04/18	27	05/22	04/15	04/13	05/04	04/23	04/21	04/12	04/14	04/22	04/18	04/17	04/24	04/14	04/18	04/04	04/17	03/27	04/04	04/28	04/20	03/11	04/02	04/15	04/27	04/12	05/06	-	05/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOURIS CA	CA005012719	49.65	-100.25	04/18	24	-	-	-	-	-	-	-	-	-	-	-	-	-	04/24	03/23	04/18	03/27	04/04	04/01	04/20	04/19	04/05	04/15	04/26	04/11	05/02	05/06	05/10	04/12	04/06	04/21	04/25	04/13	04/12	05/07	05/07	05/13	-	-	-	-	-	-
STRATHCLAIR CA	CA005012796	50.4	-100.4	04/19	43	04/25	04/18	04/28	05/04	04/24	04/22	04/07	04/14	04/16	05/15	04/18	05/11	04/12	04/19	03/24	04/18	05/08	03/20	04/02	04/22	04/19	04/02	04/15	05/01	04/11	05/02	05/06	05/22	04/21	04/08	04/23	04/25	04/13	04/19	05/21	04/08	04/10	04/15	05/12	04/13	04/12	04/24	03/17
TURTLE MOUNTAIN 6 CA	CA005012941	49.3	-100.32	04/17	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/24	04/10	05/03	04/05	04/02	04/22	04/19	04/05	04/16	05/03	04/11	05/02	05/05	05/04	04/10	04/07	04/24	04/25	04/11	04/09	05/07	04/07	04/09	04/18	-	-	-	-	-
VIRDEN CA	CA005012960	49.83	-100.95	04/16	34	04/24	04/18	04/21	05/04	04/19	04/22	04/12	04/09	04/26	05/16	04/17	04/27	04/14	04/18	03/24	04/18	03/28	03/20	04/29	04/20	04/19	04/05	04/15	04/26	04/13	04/14	05/13	04/17	04/12	-	04/21	04/09	04/13	04/12	04/05	-	-	-	-	-	-	-	-
WASAGAMING CA	CA005013117	50.65	-99.933	04/30	37	05/06	05/14	04/30	05/09	05/07	05/03	05/11	04/14	04/27	04/18	04/20	05/02	05/02	05/26	04/06	05/08	05/08	04/15	04/29	04/22	-	-	-	-	-	-	05/14	05/22	04/24	04/26	05/02	04/27	04/13	04/23	05/21	04/08	04/15	04/30	05/23	05/04	04/28	05/06	04/27
WASKADA CA	CA005013120	49.03	-100.75	04/12	12	-	-	-	-	04/16	04/22	04/06	04/08	04/08	04/16	04/18	04/15	04/23	04/24	03/24	-	-	03/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MELITA AUTO8 CA	CA00501A7AR	49.283	-100.983	04/17	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/05	05/04	04/22	04/09	04/24	04/25	04/13	04/12	05/07	04/07	04/11	04/15	04/18	04/11	03/29	05/03	03/16
ALTONA CA	CA005020040	49.1	-97.55	04/06	39	04/24	04/15	04/12	03/22	04/17	04/14	04/06	04/09	04/22	04/18	04/06	04/21	03/15	04/18	03/26	03/22	03/28	04/05	04/03	04/22	03/11	04/02	04/05	03/25	04/11	03/24	04/17	04/18	04/04	03/26	03/24	04/04	04/11	04/09	04/01	04/04	03/29	04/18	04/16	-	-	-	-
BOISSEVAIN CA	CA005020320	49.23	-100.05	04/13	12	04/25	04/06	04/19	03/22	04/18	04/22	04/08	04/09	04/22	04/18	04/16	03/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CARMAN CA	CA005020551	49.43	-98.15	04/05	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/03	03/04	03/24	04/11	03/23	04/17	04/18	03/26	04/08	03/24	04/07	04/14	04/09	04/05	04/02	04/09	04/20	05/13	04/14	03/09	05/03	03/14
CARTWRIGHT CA	CA00502055E	49.05	-99.42	04/17	18	-	04/18	04/25	04/18	04/24	04/15	04/12	-	-	-	04/16	04/27	04/14	05/21	04/07	04/18	03/27	04/07	04/28	04/22	04/19	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	
DEERWOOD CA	CA005020720	49.4	-98.32	04/08	26	04/24	04/08	03/14	05/04	04/16	04/15	04/08	04/10	04/23	04/18	04/25	03/27	04/14	04/24	04/04	03/23	03/28	04/05	04/02	04/13	04/22	04/25	03/04	04/21	03/03	03/23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DUGALD CA	CA005020810	49.87	-96.82	04/12	17	04/13	04/18	04/12	03/22	04/19	04/14	04/12	03/27	04/27	04/18	04/16	05/14	04/14	04/24	04/19	03/24	-	03/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ELM CREEK CA	CA005020870	49.72	-98.02	04/10	21	-	-	-	03/22	04/25	04/14	04/13	04/15	04/24	04/19	04/16	04/21	04/14	05/09	04/07	03/22	03/28	04/05	04/04	04/22	04/19	04/05	03/04	03/26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EMERSON CA	CA005020880	49.07	-97.2	04/09	26	04/13	04/07	04/12	04/18	04/11	04/14	04/13	04/14	04/22	-	04/06	04/21	04/14	04/18	03/26	03/23	04/17	03/18	04/29	04/22	03/11	04/02	03/05	03/27	05/07	03/12	05/14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GLENLEA CA	CA005021054	49.65	-97.12	04/07	33	04/14	04/18	04/12	03/22	04/17	04/14	04/07	03/27	04/23	04/18	04/17	04/21	04/14	03/04	03/26	04/19	03/28	03/19	04/02	04/22	04/19	04/02	03/05	03/25	04/11	03/24	04/29	04/22	03/26	04/08	03/24	04/07	04/14	-	-	-	-	-	-	-	-	-	-
GRAYSVILLE CA	CA005021160	49.5	-98.17	04/18	19	04/26	04/09	04/25	03/22	04/16	04/14	04/13	04/15	04/23	05/21	04/17	04/27	04/14	04/23	03/26	04/29	03/28	05/04	04/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRETNA AUT CA	CA005021220	49.03	-97.57	04/07	18	-	-	-	03/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/17	04/23	03/25	03/26	03/24	04/07	04/13	04/23	04/18	04/04	04/09	04/20	05/12	04/15	03/09	04/09	03/14
GUNTON HATCHERY CA	CA005021227	50.28	-97.17	04/11	16	-	-	-	-	-	-	-	-	-	-	04/17	05/13	04/14	04/24	03/26	04/18	03/28	04/05	04/29	04/22	04/19	04/03	03/05	03/24	04/11	04/15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KILLARNEY CA	CA005021480	49.18	-99.65	04/15	18	04/24	04/18	04/19	03/22	04/18	04/15	04/12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/06	-	04/10	04/09	04/24	04/25	04/11	04/21	04/05	04/07	04/09	04/15	-	-	-	-	-
LANDMARK CA	CA005021529	49.67	-96.88	04/18	12	-	-	-	-	-	-	-	-	-	-	-	04/21	05/09	03/04	04/07	03/23	04/17	05/05	05/17	04/20	04/24	04/03	04/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MANITOU CA	CA005021688	49.27	-98.48	04/21	11	05/21	04/18	-	03/22	04/24	04/15	04/08	04/14	04/22	05/16	04/18	04/25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARQUETTE CA	CA005021695	50.02	-97.8	04/08	43	04/25	04/18	04/21	04/19	04/23	04/17	04/12	04/14	04/21	04/12	04/16	03/26	04/21	04/23	03/25	04/17	03/28	04/04	04/29	04/22	04/19	04/02	03/04	03/24	04/11	03/24	04/17	04/23	03/25	04/08	03/20	04/10	04/13	03/23	04/05	04/04	03/29	04/18	04/14	04/12	03/09	04/09	03/16
MIAMI THIESSEN CA	CA005021737	49.45	-98.25	04/06	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/14	05/05	04/18	03/25	03/26	03/04	04/07	04/13	04/08	04/01	04/04	04/09	04/20	04/14	04/15	03/09	04/08	03/12
MORDEN CDA CA	CA005021848	49.183	-98.083	04/09	33	04/25	04/08	03/14	03/22	04/17	04/14	04/13	04/09	04/23	04/18	04/16	04/21	04/14	04/18	03/26	03/21	03/28	04/04	04/04	04/22	04/18	04/02	03/04	03/24	04/08	03/23	05/05	04/18	03/25	-	-	-	-	04/09	05/16	-	-	04/22	-	-	04/27	-	-
MORRIS CA	CA005021920	49.35	-97.37	04/10	15	04/13	04/10	04/13	03/22	04/18	04/13	04/12	04/14	04/22	-	04/16	03/28	04/14	04/23	03/26	-	-	04/05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRTLE CA	CA005021975	49.4	-97.78	04/10	34	04/24	04/09	04/13	03/22	04/17	04/14	04/13	04/15	04/23	04/18	05/01	04/27	04/14	04/24	03/26	03/23	03/28	03/18	04/30	04/22	04/19	04/04	03/04	03/24	05/16	03/23	04/17	04/18	03/25	03/26	03/24	04/07	04/13	04/23	-	-	-	-	-	-	-	-	-
NIVERVILLE CA	CA005022043	49.6	-97.05	04/09	22	04/13	04/18	04/13	03/22	04/17	04/14	04/12	03/27	04/22	04/17	04/06	04/21	04/23	03/04	04/06	03/23	03/28	04/05	04/02	04/22	04/21	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PEACE GARDENS CA	CA005022065	49	-100.05	04/21	30	04/26	04/07	04/27	03/22	04/25	04/24	04/07	04/14	04/22	04/17	04/18	04/25	04/22	04/24	04/07	04/18	04/17	04/06	04/28	04/21	05/05	04/05	04/15	05/03	05/10	05/02	05/05	05/04	04/22	-	04/24	-	-	-	-	-	-	-	-	-	-	-	-
NINETTE 1 NW CA	CA0050220M0	49.42	-99.65	04/12	20	-	-	-	-	-	-	-	04/09	04/22	05/15	04/18	04/27	04/22	04/23	04/04	04/18	03/27	03/19	04/01	04/20	03/11	04/02	04/15	03/24	04/11	04/14	05/16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PILOT MOUND AUT CA	CA005022125	49.183	-98.9	04/18	40	04/25	04/18	04/21	04/18	04/24	04/15	04/12	04/09	04/22	05/16	04/16	04/27	04/22	04/18	03/25	04/18	03/28	04/26	05/27	-	-	04/03	05/08	04/28	05/15	-	05/14	04/24	04/10	04/25	03/24	04/18	04/13	04/12	05/07	04/07	04/09	04/19	05/12	04/12	03/29	04/09	03/16
PINEY CA	CA005022171	49.03	-96.02	04/09	32	-	-	-	-	-	-	-	-	-	-	-	04/21	03/15	04/20	04/08	04/17	03/28	03/18	04/30	04/22	04/21	04/03	03/05	03/25	04/23	03/12	05/13	04/26	03/25	04/26	03/20	04/07	04/13	04/12	05/08	04/04	04/09	03/24	05/29	04/12	03/08	05/07	03/19
PLUM COULEE CA	CA005022245	49.05	-97.8	04/05	34	04/25	04/15	04/12	03/22	04/19	04/14	04/12	04/15	04/22	04/12	04/06	04/21	04/14	03/03	03/26	03/22	03/28	04/03	04/04	04/22	04/19	04/02	03/04	03/25	04/11	03/12	04/17	04/18	03/25	03/26	03/24	04/04	04/11	04/09	-	-	-	-	-	-	-	-	-
RATHWELL CA	CA005022335	49.68	-98.55	04/08	31	04/25	04/07	05/07	03/22	04/17	04/21	04/06	03/27	04/23	04/13	04/16	03/27	04/14	04/18	04/04	03/23	03/28	04/04	04/02	04/22	04/18	04/02	04/15	03/24	04/11	03/23	05/06	04/17	03/25	03/26	03/24	-	-	-	-	-	-	-	-	-	-	-	-
ROLAND CA	CA005022480	49.42	-98	04/16	10	04/25	04/08	04/12	05/04	04/24	04/14	04/13	04/12	-	04/18	04/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STE ANNE CA	CA00502254Q	49.67	-96.63	04/03	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/19	04/02	04/21	-	04/05	04/15	03/24	05/13	03/22	04/09	04/23	03/26	03/26	03/05	-	-	-	-	-	-	-	-	-	-	-	-
SAINT ANDREWS CA	CA0050225DP	50.05	-97.033	04/19	10	-	-	-	-	-	-	04/08	05/04	05/14	04/17	04/18	04/21	04/14	04/23	04/07	04/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ST PIERRE JOLYS CA	CA005022606	49.47	-97.02	04/01	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/23	04/17	03/31	03/25	03/26	03/05	04/07	04/11	03/22	05/07	04/04	-	-	-	-	-	-	-
SELKIRK CA	CA005022630	50.17	-96.87	04/09	37	04/13	04/18	04/12	04/19	04/19	04/14	04/12	04/09	04/22	04/12	04/16	-	04/14	04/23	04/04	04/17	03/28	03/18	04/02	04/20	04/18	04/02	03/05	03/24	04/11	03/24	05/05	04/23	04/22	04/13	03/05	04/07	04/14	04/12	04/05	04/04	03/29	04/18	-	-	-	-	-
SNOWFLAKE CA	CA005022703	49.07	-98.65	04/09	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/04	03/26	04/12	04/14	05/05	04/24	04/04	04/13	03/24	04/07	04/13	04/12	05/17	04/07	04/09	04/18	04/14	04/12	03/08	04/08	-
SPRAGUE AUTO8 CA	CA005022760	49.017	-95.6	04/15	28	04/25	04/18	04/21	04/18	04/11	04/14	05/19	04/15	04/27	03/17	04/06	04/21	03/15	05/09	04/07	04/17	04/05	03/22	04/30	04/22	04/21	04/03	03/05	04/27	05/13	03/12	05/13	04/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STARBUCK CA	CA005022770	49.73	-97.62	04/17	35	04/25	04/16	04/15	05/08	04/18	04/14	04/08	05/03	04/23	04/19	04/18	03/31	04/14	04/24	03/26	04/18	05/04	04/15	04/29	04/22	04/19	04/03	04/15	04/27	05/16	03/24	04/17	04/22	04/23	04/26	03/24	04/07	04/14	04/19	04/18	-	-	-	-	-	-	-	-
STEINBACH CA	CA005022780	49.53	-96.77	04/11	34	04/14	04/18	04/12	03/22	04/11	04/14	04/08	04/14	-	04/18	04/16	05/13	04/14	03/03	04/06	04/19	04/05	03/18	04/29	04/22	04/19	04/02	03/05	03/25	04/11	05/07	05/14	05/22	04/25	03/26	03/05	04/07	04/13	03/23	05/18	-	-	-	-	-	-	-	-
STONEWALL CA	CA005022788	50.12	-97.33	04/19	22	04/25	04/18	04/13	05/17	04/24	04/20	04/12	04/09	04/23	04/13	04/18	05/13	04/23	04/20	04/06	04/17	04/17	04/12	04/29	04/22	04/19	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STONY MOUNTAIN CA	CA005022791	50.12	-97.17	04/10	41	-	-	04/26	05/04	04/24	04/14	04/12	04/15	04/25	04/12	04/16	04/21	04/14	04/20	04/06	04/18	03/28	04/04	04/29	04/20	04/19	05/04	03/04	03/24	04/11	03/25	05/05	04/23	03/25	03/26	03/05	04/07	04/13	04/12	04/05	04/04	04/09	04/18	04/18	04/15	03/12	04/08	03/16
TURTLE MOUNTAIN 11 CA	CA005022946	49.13	-100.12	04/12	24	-	-	-	-	-	-	-	-	-	-	-	04/15	04/22	04/19	03/24	04/17	04/05	03/20	04/02	04/20	04/19	04/26	04/15	04/05	04/11	03/11	05/14	05/04	04/22	04/07	03/03	04/24	04/11	03/22	05/07	-	-	-	-	-	-	-	-
WINNEPEG CA	CA005023222	49.917	-97.233	04/11	39	04/12	04/18	04/12	03/21	04/18	04/14	04/12	04/14	04/25	04/12	04/16	05/14	04/22	04/24	04/06	04/17	03/28	03/18	04/02	04/20	03/11	04/02	03/04	03/25	04/11	03/24	05/06	04/23	03/25	04/24	03/24	04/08	04/14	04/12	05/18	04/07	04/09	04/18	05/12	-	-	-	-
WINNIPEG STP CA	CA005023261	49.95	-97.1	04/10	19	04/12	04/15	04/12	03/21	04/18	04/13	04/08	03/26	-	04/12	04/17	05/02	04/14	04/24	04/06	04/19	03/29	03/18	04/02	04/20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ZHODA CA	CA005023370	49.25	-96.52	04/04	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/18	04/12	03/28	03/18	04/29	04/22	04/21	04/03	03/04	03/25	05/13	03/12	04/17	04/23	03/25	04/25	03/20	-	-	-	-	-	-	-	-	-	-	-	-
CARMAN U OF M CS CA	CA00502I001	49.5	-98.033	04/10	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/14	04/18	03/25	04/25	03/24	04/07	04/14	04/19	04/18	04/04	04/09	04/20	04/14	04/12	03/29	04/08	03/16
WINNIPEG A CS CA	CA00502S001	49.92	-97.25	04/13	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/23	03/25	04/24	04/23	04/08	04/14	04/12	05/18	04/07	-	04/19	04/18	04/12	03/09	05/03	03/16
ARBORG CA	CA005030080	50.93	-97.08	04/13	43	04/25	04/18	04/21	03/22	04/19	04/21	04/13	04/09	04/25	04/12	04/17	04/25	04/22	04/24	04/06	04/19	03/28	03/18	04/28	04/22	04/21	04/03	03/05	03/26	05/13	03/25	05/06	04/18	04/09	04/13	03/20	04/28	05/13	04/24	05/22	04/08	04/10	04/26	04/14	04/12	03/09	04/09	03/16
BEAUSEJOUR CA	CA005030160	50.067	-96.517	04/12	24	-	-	-	-	-	-	-	-	-	-	04/16	04/21	04/14	04/24	04/06	04/17	03/28	04/08	04/29	-	04/21	04/02	03/05	03/24	04/11	04/15	05/06	04/25	03/25	04/24	03/20	03/29	04/13	04/23	05/07	-	-	-	-	-	-	-	-
BISSETT CA	CA005030282	51.03	-95.7	04/23	28	05/06	04/18	04/12	05/05	05/07	04/15	05/08	04/09	05/02	03/17	04/18	05/19	04/22	05/17	04/06	04/19	04/17	03/17	04/29	04/22	04/19	04/14	04/28	03/24	05/16	04/29	05/14	05/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BROAD VALLEY CA	CA005030510	50.98	-97.47	04/13	21	-	04/18	04/19	03/22	04/24	04/21	04/12	04/09	04/25	04/12	04/17	04/25	04/14	04/23	03/25	04/19	03/28	04/05	04/03	04/22	04/19	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ELMA CA	CA005030869	49.77	-95.93	04/21	12	-	-	-	-	-	-	-	-	-	03/17	05/26	03/25	05/04	05/09	04/08	05/07	04/17	03/18	05/01	04/22	-	05/13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FALCON LAKE TCPL 45 CA	CA005030912	49.68	-95.37	04/17	27	04/14	04/08	04/12	04/18	05/07	04/15	04/16	04/09	04/27	03/17	04/17	04/21	04/14	-	04/08	04/19	04/17	05/04	05/09	04/22	04/24	04/03	04/29	03/25	04/23	03/24	04/17	05/16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISHER BRANCH CA	CA005030916	51.083	-97.55	04/22	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/12	04/07	04/29	-	05/20	05/22	-	-	05/20	-	05/14	04/23	04/10	04/13	03/20	04/25	04/14	04/12	05/15	04/07	04/15	04/28	04/19	04/13	03/10	-	-
FISHER BRANCH SOUTH CA	CA005030917	51.05	-97.52	04/15	31	-	-	-	-	-	-	-	-	04/23	04/12	04/18	04/28	04/14	04/24	03/26	04/19	03/28	03/19	04/03	04/22	04/21	04/02	04/15	05/03	04/11	03/25	05/06	05/22	04/04	04/13	03/30	04/25	04/14	04/23	05/18	04/07	04/09	04/18	04/14	-	-	-	-
FRASERWOOD CA	CA005030982	50.63	-97.22	04/15	20	04/25	04/18	04/12	04/19	05/07	04/21	04/12	04/09	04/24	04/12	04/18	05/14	04/14	04/24	03/25	04/17	03/28	03/19	04/02	04/22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GIMLI CA	CA005031038	50.63	-97.02	04/16	20	-	-	04/12	05/05	04/24	04/21	04/13	04/09	04/23	04/12	04/17	05/14	04/22	04/20	04/08	04/18	03/28	03/18	04/28	04/22	04/19	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GIMLI INDUSTRIAL CA	CA005031039	50.617	-97.033	04/19	28	-	-	-	-	-	-	-	-	-	-	04/18	04/22	05/03	-	04/12	04/29	03/30	04/16	04/29	05/14	04/20	05/05	04/30	03/26	04/11	03/24	05/13	05/22	04/22	04/13	03/20	04/08	04/14	05/03	04/05	04/07	04/10	04/20	-	05/04	-	-	-
GIMLI INDUSTRIAL PARK CA	CA0050310D0	50.63	-97.05	04/25	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/13	05/22	04/22	04/25	04/24	04/25	04/14	05/03	04/18	04/08	04/13	04/26	05/15	04/12	-	-	-
GREAT FALLS CA	CA005031200	50.47	-96	04/07	33	04/14	04/18	04/12	03/21	04/19	04/14	04/13	04/09	04/22	03/17	04/06	03/28	04/14	04/24	04/06	04/17	03/28	03/18	04/02	04/22	03/12	05/04	03/04	03/25	04/11	03/24	05/06	05/05	03/25	04/13	03/20	04/06	04/13	-	-	-	-	-	-	-	-	-	-
HODGSON 2 CA	CA005031301	51.18	-97.45	04/21	43	04/28	04/18	04/25	04/19	04/24	04/25	04/29	05/03	05/01	04/13	04/18	04/25	04/23	04/24	03/25	05/03	03/29	04/06	04/29	04/22	04/20	04/25	04/15	05/06	05/18	04/29	05/06	05/27	04/25	04/25	03/24	04/28	04/14	05/03	05/22	04/08	04/10	04/19	04/18	04/14	03/10	05/07	03/17
INDIAN BAY CA	CA005031320	49.62	-95.2	04/17	43	04/13	04/18	04/21	04/19	04/19	04/15	04/16	03/11	05/03	03/18	04/18	05/02	04/23	05/09	04/08	04/18	04/05	03/22	04/30	04/23	04/22	04/03	04/28	04/27	05/13	03/24	05/15	05/17	04/23	04/25	04/22	04/08	05/28	04/12	05/02	03/28	03/29	04/19	04/14	04/15	03/10	05/07	03/17
PINAWA CA	CA005032162	50.183	-96.067	04/13	37	04/14	04/18	04/12	04/19	04/19	04/14	04/13	04/09	04/27	03/17	04/17	04/21	04/14	04/25	04/06	04/17	03/28	03/18	04/29	04/22	03/12	04/03	03/05	03/25	05/07	03/25	05/06	05/17	03/26	04/30	03/20	04/10	04/14	04/12	-	-	-	05/03	05/14	-	05/29	-	-
PINE FALLS CA	CA005032164	50.57	-96.22	04/13	24	04/14	04/19	04/12	03/22	04/19	04/14	04/13	04/09	04/22	04/18	04/19	04/06	03/28	04/25	04/06	04/17	04/17	03/19	04/29	05/07	04/21	04/03	03/05	-	05/13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Observation Location	Code	Latitude	Longitude	Average VTP	Years With Data	First Annual Date Cooresponding to Tmin > 32° F for Three Consecutive Days (March - May)																																										
						1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
RENNIE CA	CA005032360	49.85	-95.53	04/26	27	-	-	-	-	-	-	-	-	-	-	04/29	05/13	05/04	-	-	-	-	-	05/09	04/22	04/21	04/05	04/28	03/25	05/13	05/07	05/06	05/18	04/23	04/25	03/24	04/07	04/13	04/23	05/18	05/07	03/27	05/07	05/15	04/15	-	05/10	04/30
SPRUCE TCPL 43 CA	CA005032764	49.65	-96.17	04/10	13	04/13	04/15	04/12	04/18	04/19	04/14	04/13	03/13	04/25	03/18	04/17	05/13	03/15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VICTORIA BEACH AUT CA	CA005032951	50.7	-96.567	04/16	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/18	03/25	04/24	04/21	04/28	04/14	04/22	05/08	04/08	04/09	04/18	04/18	04/12	03/09	05/03	03/16
OSTENFELD CA	CA00503B0NE	49.82	-96.48	04/09	23	-	-	-	-	-	-	-	-	-	-	-	-	03/28	04/24	04/08	04/19	03/29	03/18	05/06	04/22	04/21	04/02	03/04	03/25	04/11	03/24	05/06	04/23	03/25	03/26	03/20	04/07	04/13	04/24	05/08	-	-	-	-	-	-	-	-
ASHERN CA	CA005040120	51.13	-98.37	04/20	21	05/07	05/06	04/28	05/09	04/24	04/22	04/12	04/14	04/23	04/18	04/18	05/11	04/22	04/24	03/25	04/19	04/17	03/19	04/03	04/22	04/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAUPHIN AIRPORT CA	CA005040680	51.1	-100.05	04/18	39	05/06	04/14	04/19	05/04	04/24	04/25	04/13	04/11	05/02	04/18	04/16	03/28	04/22	04/23	03/23	04/19	03/27	04/04	04/28	04/22	04/21	04/25	04/27	04/27	04/11	-	05/14	-	04/25	04/24	03/24	04/10	04/14	03/22	05/17	04/06	04/09	04/25	05/12	04/11	04/28	-	-
DELTA MARSH CS CA	CA005040764	50.183	-98.383	04/19	42	04/25	04/18	04/25	05/04	04/24	04/25	04/13	04/09	04/25	04/18	04/17	04/30	04/22	04/24	04/06	05/03	03/31	04/15	04/29	04/22	04/21	04/04	03/05	03/26	05/07	03/23	05/13	05/17	05/03	04/25	03/24	04/25	04/14	04/22	04/18	04/07	04/09	04/26	05/12	04/12	04/13	04/24	-
ERIKSDALE 1 CA	CA005040896	50.87	-98.13	04/20	10	-	-	-	-	-	-	-	-	-	04/18	04/18	05/11	04/22	04/24	04/06	04/19	04/17	04/14	04/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GILBERT PLAINS CA	CA005040985	51.1	-100.47	04/19	43	05/06	05/12	04/20	05/04	04/24	04/21	04/14	04/09	05/02	04/18	04/20	05/02	04/22	04/24	03/24	04/19	03/28	04/05	04/04	04/22	04/21	04/02	04/27	04/27	04/12	05/02	05/14	05/07	04/22	04/09	03/24	04/25	04/14	04/23	04/05	04/07	04/11	04/25	05/24	04/12	04/28	04/27	03/16
GLADSTONE SOUTH CA	CA0050410N0	50.18	-99.02	04/13	18	-	-	-	05/06	04/24	04/21	04/12	04/10	04/23	04/18	04/16	04/21	04/14	04/23	03/25	03/23	03/27	04/07	04/03	04/22	04/19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRASS RIVER CA	CA005041140	50.52	-98.97	04/18	28	04/25	04/18	04/25	03/22	04/24	04/21	04/21	04/10	04/23	04/18	04/16	04/21	04/22	04/23	04/06	04/18	04/17	04/07	04/03	04/22	04/19	04/03	04/27	04/27	04/12	04/15	05/05	05/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LANGRUTH CA	CA005041530	50.4	-98.55	04/14	31	-	04/18	04/25	05/04	04/24	04/21	04/12	04/09	04/23	04/12	04/16	04/21	04/22	04/18	03/25	03/23	03/28	04/04	04/03	04/22	04/19	04/03	04/28	04/27	04/11	03/23	05/05	04/24	03/25	04/08	04/21	04/25	-	-	-	-	-	-	-	-	-	-	-
LUNDAR CA	CA005041587	50.75	-97.93	04/10	17	-	-	-	-	-	-	-	-	-	-	-	-	-	04/24	03/25	04/17	04/05	03/19	04/03	04/22	04/19	04/02	03/05	03/26	04/11	03/24	05/06	05/21	04/22	04/24	-	-	-	-	-	-	-	-	-	-	-	-	-
LUNDAR 4 SW CA	CA005041588	50.65	-98.1	04/20	17	-	04/18	04/21	05/08	04/24	-	04/13	04/14	04/22	04/18	04/18	05/11	05/02	04/24	03/26	04/19	04/25	03/19	04/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MACGREGOR CA	CA005041684	49.9	-98.7	04/19	24	-	-	-	05/05	04/18	04/25	04/13	03/07	04/09	04/16	04/16	04/15	04/22	05/08	05/13	04/17	03/28	03/20	04/28	04/22	03/12	05/06	05/07	03/25	05/11	05/11	05/27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEEPAWA MURRAY 6 SOUTHWEST CA	CA005042004	50.15	-99.57	04/17	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/29	-	04/19	04/02	04/27	04/27	04/11	03/23	05/14	04/18	04/22	04/25	03/05	04/25	04/13	04/18	04/05	04/07	04/09	04/19	05/21	-	-	-	-
NEEPAWA WATER CA	CA005042005	50.22	-99.47	04/15	38	05/06	04/18	03/14	04/19	04/24	04/21	04/13	04/15	04/23	04/18	04/16	04/27	04/22	04/23	03/25	04/18	03/28	03/19	04/28	04/22	04/19	04/04	04/27	04/27	04/11	03/23	05/13	04/23	04/21	04/24	03/24	04/25	04/14	04/12	04/05	04/07	04/10	04/20	-	-	-	-	-
OCHRE RIVER CA	CA0050420E5	51.07	-99.78	04/14	34	-	04/14	04/12	04/18	05/04	04/21	04/04	04/12	05/03	04/16	04/16	-	03/28	04/24	03/23	04/19	04/22	03/19	04/28	04/20	04/18	04/14	04/27	04/26	04/11	03/23	04/08	04/17	04/25	03/26	04/23	04/10	05/12	04/10	03/30	03/29	-	-	-	-	-	-	-
PLUMAS CA	CA005042241	50.45	-99	04/13	19	04/25	04/18	04/25	03/22	04/24	04/25	04/12	04/10	04/25	04/18	04/16	03/27	04/21	04/18	04/06	04/18	03/28	04/04	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VOGAR CA	CA005043020	50.92	-98.75	04/18	37	04/26	04/18	04/28	04/19	04/25	04/25	04/13	04/14	04/23	04/18	04/16	04/25	04/23	04/24	03/25	04/28	04/23	03/19	04/03	05/08	04/19	04/26	04/27	04/27	04/12	03/24	05/06	05/07	-	04/13	03/24	04/25	04/14	04/12	05/07	04/07	04/10	04/18	-	-	-	-	-
MC CREARY CA	CA005043158	50.717	-99.533	04/12	42	-	05/19	04/21	05/04	04/24	04/21	03/29	04/09	04/23	04/18	04/16	04/27	04/14	04/23	03/24	04/27	03/28	04/15	04/03	04/21	04/19	04/02	04/28	03/23	04/12	03/24	05/12	04/02	03/26	03/26	03/24	04/25	05/12	03/22	05/17	03/29	04/09	03/23	04/14	04/12	03/29	04/25	03/16
OAKPOINT MARINE CA	CA00504K0NM	50.633	-98.033	04/16	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/23	-	04/24	03/23	04/25	04/14	04/12	04/18	04/07	04/09	04/18	04/18	04/12	03/09	04/25	05/10
EAR FALLS AUT CA	CA006012198	50.633	-93.217	04/22	36	04/28	04/18	05/10	04/19	05/09	04/16	04/13	04/15	04/25	03/18	04/19	05/02	04/22	04/25	04/10	04/19	04/05	03/20	04/29	05/10	04/19	04/03	05/01	05/02	05/13	03/12	04/17	-	-	04/25	-	-	-	-	-	04/08	04/14	05/02	05/21	05/26	05/14	05/09	04/30
RED LAKE CA	CA006016975	51.067	-93.8	04/22	42	05/06	04/16	04/14	04/19	05/08	04/15	04/13	04/10	05/02	03/18	-	05/19	04/22	05/09	04/08	04/19	04/05	04/15	04/29	04/22	04/21	04/25	05/06	03/24	05/17	04/29	05/14	05/22	04/28	04/24	04/22	04/28	04/13	05/03	05/22	04/08	04/14	04/20	05/15	04/12	03/29	05/03	03/17
BARWICK MN US	CA006020559	48.63	-93.97	04/07	33	-	-	-	-	-	-	-	-	-	-	04/19	04/21	04/12	03/05	04/09	04/17	03/30	03/19	04/30	04/22	03/11	04/03	03/05	04/27	04/23	03/12	05/07	04/01	03/25	03/27	04/22	03/29	04/13	04/13	04/18	04/04	03/28	05/21	05/15	04/14	03/14	04/01	03/17
FORT FRANCES CA	CA006022475	48.62	-93.42	04/05	26	04/15	04/10	04/21	04/18	04/25	04/14	04/13	03/11	04/26	03/17	04/19	03/30	04/12	03/05	04/09	04/17	03/30	03/22	04/03	04/22	03/11	04/03	04/05	03/25	04/23	03/12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORT FRANCES A CA	CA006022476	48.65	-93.43	04/10	35	-	-	-	-	-	-	-	03/12	04/23	03/17	05/01	04/22	04/12	03/05	04/09	05/02	03/30	03/23	04/30	04/22	03/12	04/03	03/05	04/27	04/23	03/12	05/07	04/01	04/06	04/30	04/25	04/05	04/13	04/13	05/08	04/04	04/10	04/20	05/20	04/17	03/14	04/08	-
RAINY RIVER CA	CA006026852	48.72	-94.53	04/07	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/23	03/12	05/13	04/02	04/23	03/27	03/21	03/29	04/13	04/13	-	-	-	-	-	-	-	-	-
SLEEMAN CA	CA006027825	48.72	-94.42	04/10	22	04/15	04/18	04/21	04/19	04/11	04/14	04/13	03/11	04/26	03/17	04/17	03/25	04/12	04/25	04/09	04/17	03/30	03/22	04/03	04/22	04/21	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRATTON CA	CA006028125	48.78	-94.05	04/11	16	-	04/18	04/21	04/18	04/25	04/16	04/13	03/11	04/23	03/17	04/17	04/21	04/12	03/05	04/09	05/01	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EMO RADBOURNE CA	CA00602K300	48.68	-93.83	04/09	23	-	-	-	-	-	-	-	-	-	-	05/01	05/02	04/23	03/05	04/09	04/19	04/05	03/22	04/30	04/22	03/12	04/03	03/05	04/27	04/23	03/12	05/07	04/01	04/06	03/27	04/25	03/29	04/13	-	-	-	-	-	-	-	-	-	-
KENORA AIRPORT CA	CA006034075	49.783	-94.367	04/08	43	04/25	04/15	04/14	04/19	04/25	04/14	04/13	04/09	04/22	03/17	04/17	04/21	04/23	04/24	04/03	04/17	03/28	03/19	04/27	04/21	04/19	04/03	03/05	03/25	04/11	03/24	04/17	04/23	03/25	04/09	03/05	04/07	04/12	04/09	04/18	04/04	03/28	03/24	04/18	04/12	03/08	04/09	03/16
KENORA TCPL 49 CA	CA006034077	49.78	-94.48	04/16	17	04/28	04/18	04/13	05/18	04/27	04/14	04/13	03/11	-	03/19	05/03	04/21	04/23	04/25	04/07	-	04/05	-	-	04/22	-	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RAWSON LAKE CA	CA006036904	49.65	-93.72	04/10	43	04/28	04/18	04/14	04/19	04/25	04/13	04/13	04/09	04/23	04/17	04/17	04/21	04/14	04/24	04/04	04/17	03/28	03/22	04/03	04/21	03/12	04/03	03/05	03/25	04/12	04/29	04/17	04/23	04/11	04/24	03/05	04/24	04/13	04/09	05/16	04/04	03/28	03/24	04/19	05/03	03/08	04/08	03/16
VERMILION BAY TCPL 52 CA	CA006039136	49.83	-93.63	04/28	15	04/22	04/18	05/11	05/18	05/08	05/04	04/14	04/15	05/15	04/13	05/01	04/21	04/23	04/25	05/16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ADA MN US	USC00210018	47.2992	-96.5161	04/02	41	04/13	04/10	04/13	03/22	04/11	04/13	04/12	03/08	04/26	03/17	04/16	04/15	03/14	03/01	03/24	03/21	03/28	03/18	04/02	04/19	04/19	04/01	03/03	-	04/23	03/22	05/05	04/19	03/26	04/09	03/06	04/07	04/11	03/19	04/15	05/05	-	03/28	04/18	03/21	03/07	04/07	03/14
AITKIN MN US	USC00210059	46.5258	-93.6675	04/04	38	04/16	04/08	04/21	03/13	04/11	04/16	04/13	03/12	04/26	03/17	04/17	03/28	04/23	03/31	04/10	03/26	03/29	-	04/03	04/22	03/11	-	03/05	04/07	04/15	05/02	04/18	03/28	03/27	03/31	04/20	04/06	04/10	03/21	03/26	04/04	-	-	-	04/15	03/09	04/25	03/21
AMBOY MN US	USC00210157	43.8836	-94.1664	03/21	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/02	04/06	03/13	03/15	03/12	03/25	03/26	03/27	03/20	-	04/10	03/14	03/24	03/28	03/29	03/12	04/04	03/15	03/11	04/07	03/10
ARGYLE MN US	USC00210252	48.3311	-96.8253	04/06	43	04/14	04/18	04/13	04/18	04/25	04/15	04/13	03/26	04/23	04/17	04/06	04/26	04/22	03/03	04/05	04/12	03/28	03/19	04/03	04/21	03/12	04/02	03/05	04/28	04/24	03/12	05/05	04/22	03/26	04/07	03/06	04/08	04/12	04/13	04/14	04/05	03/28	04/19	04/19	03/22	03/09	04/09	03/15
ARTICHOKE LAKE MN US	USC00210287	45.3783	-96.1542	03/26	43	04/15	04/10	04/12	03/23	04/10	03/19	04/05	03/10	04/05	04/11	04/06	03/25	03/15	03/01	03/26	03/21	03/28	03/16	03/21	03/25	03/11	03/20	03/04	03/25	04/07	03/12	04/17	04/18	03/26	03/30	03/05	04/07	04/10	03/14	03/26	04/04	03/27	03/23	04/15	03/15	03/10	04/07	03/16
BAUDETTE MN US	USC00210515	48.7094	-94.5869	04/08	37	04/15	05/09	04/21	-	04/25	04/14	04/13	03/11	04/26	03/17	04/06	04/15	04/12	03/30	04/09	04/17	03/30	03/18	04/03	04/22	04/21	04/03	03/05	03/26	04/23	03/12	05/05	04/01	04/06	03/27	04/22	03/29	04/13	04/13	05/08	04/04	03/28	03/24	-	-	-	-	-
BAUDETTE 21 SSE MN US	USC00210520	48.4167	-94.5667	04/12	18	04/15	04/18	04/29	04/18	04/11	04/16	04/13	03/11	04/26	03/17	04/06	04/21	04/12	03/31	04/09	-	-	03/21	04/29	04/22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEMIDJI MN US	USC00210643	47.5369	-94.8297	04/18	25	04/25	04/18	04/26	04/18	04/11	04/26	04/13	03/09	04/26	04/12	04/17	03/28	04/23	04/24	04/07	04/12	-	-	04/30	04/23	04/19	-	03/05	04/28	04/14	05/02	-	-	-	-	-	-	05/21	-	05/19	-	-	-	-	-	-	-	-
BENSON MN US	USC00210667	45.3167	-95.6167	03/27	43	04/14	04/08	03/19	03/22	04/10	04/13	03/28	03/10	04/05	04/11	04/06	03/24	03/15	03/01	04/07	03/21	03/28	03/18	03/23	03/23	03/11	03/20	03/04	03/25	04/07	03/12	04/17	04/18	03/26	03/30	03/05	04/04	04/13	03/18	04/05	03/29	03/29	03/25	04/19	04/15	03/08	04/08	03/16
BIG FALLS MN US	USC00210746	48.1969	-93.7994	04/16	43	04/14	04/15	04/21	04/19	04/11	04/16	04/13	03/12	04/26	05/16	04/17	03/30	04/14	05/09	04/10	04/19	04/26	04/09	04/30	04/22	04/21	04/03	04/28	04/22	04/23	05/07	05/13	04/01	03/25	04/26	04/25	04/28	04/15	04/13	05/08	04/08	03/28	03/24	05/15	04/16	03/30	04/08	03/17
BLACKDUCK MN US	USC00210809	47.6714	-94.5175	04/08	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/12	04/03	03/05	03/26	04/17	04/28	-	-	-	-	04/25	04/08	04/13	04/14	04/14	04/09	04/18	04/20	05/19	04/12	03/11	04/22	03/18
BRAINERD MN US	USC00210939	46.3433	-94.2086	04/07	43	04/15	04/08	04/26	03/23	04/26	04/16	04/13	03/11	05/07	04/17	04/17	03/28	04/23	04/25	04/03	04/12	03/29	03/23	04/03	04/20	04/19	04/03	03/04	03/25	04/14	03/18	04/18	04/23	03/26	03/31	04/23	04/06	04/14	04/13	04/15	03/30	03/30	03/26	04/21	03/22	03/09	04/25	03/18
BRECKENRIDGE MN US	USC00210973	46.2681	-96.5914	04/02	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/21	04/10	04/16	03/17	05/26	04/03	03/26	03/24	05/04	03/22	03/07	04/08	-
BROWNS VALLEY MN US	USC00211063	45.5939	-96.8278	03/28	39	-	-	-	-	04/11	04/15	04/13	03/11	04/05	03/17	04/05	03/28	03/15	03/01	03/26	03/22	03/28	03/18	03/06	03/26	03/12	04/02	03/05	03/27	03/19	03/12	04/10	04/18	03/26	03/27	04/18	04/07	04/13	03/19	03/26	03/29	03/28	03/29	04/30	04/13	03/30	04/08	03/27
BUFFALO MN US	USC00211107	45.1969	-93.84	03/27	40	04/15	04/07	04/29	03/01	04/10	04/14	03/28	03/11	04/04	03/17	04/06	03/28	03/29	03/04	04/08	03/21	03/28	03/06	04/02	03/26	03/11	-	03/04	04/15	04/13	03/12	04/18	04/02	03/26	03/27	03/06	04/06	-	-	03/25	03/29	03/29	04/15	04/16	03/15	03/11	04/06	03/16
CAMPBELL MN US	USC00211245	46.0958	-96.4092	04/03	31	04/15	04/18	04/11	03/23	04/10	04/13	04/13	03/10	05/02	05/04	04/07	03/28	03/29	03/01	-	03/25	03/28	03/19	04/02	04/20	04/19	03/20	03/05	04/07	04/14	03/17	-	-	-	-	03/05	04/09	04/13	04/13	04/17	04/03	-	-	-	-	-	-	-
CAMP NORRIS DNR MN US	USC00211250	48.61	-95.1817	04/09	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/12	04/13	05/08	04/04	03/28	04/20	05/15	03/22	03/14	04/22	03/17
CANBY MN US	USC00211263	44.7183	-96.2697	03/23	43	04/06	03/12	04/11	04/01	04/10	05/02	03/18	03/11	04/05	03/17	04/05	03/27	03/15	03/04	04/02	03/22	03/28	03/19	04/03	03/27	03/12	03/17	03/05	03/27	03/03	03/11	03/11	04/01	03/26	03/30	03/05	04/07	04/13	03/15	04/05	03/29	03/27	03/11	04/04	03/15	03/13	04/05	03/11
CASS LAKE MN US	USC00211374	47.3847	-94.6147	04/09	43	04/15	04/18	04/30	04/18	05/07	04/16	05/15	03/10	05/04	04/18	04/06	03/28	04/14	03/04	04/09	04/12	03/30	03/22	04/30	04/22	04/21	04/03	03/05	03/25	04/14	04/30	04/17	05/16	03/26	03/31	04/22	04/06	04/12	04/12	04/13	04/03	03/28	03/27	05/15	03/22	03/09	04/09	03/17
CHASKA MN US	USC00211465	44.8	-93.5833	03/25	30	04/11	04/20	03/19	03/01	03/28	04/17	03/26	03/11	-	-	04/06	03/24	03/29	03/01	04/07	03/26	03/13	03/18	03/23	03/24	03/12	03/20	03/03	04/07	04/12	03/12	03/12	04/17	03/25	03/31	03/04	-	-	-	05/06	-	-	-	-	-	-	-	-
CHASKA 2 NW MN US	USC00211468	44.8131	-93.6311	03/29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/03	03/25	04/04	03/30	03/24	04/09	03/23	03/09	04/09	03/15
COLLEGEVILLE ST JOHN MN US	USC00211691	45.5794	-94.3919	03/26	43	04/15	04/07	04/12	03/13	04/11	04/14	03/28	03/11	04/06	03/17	04/05	03/25	03/29	03/03	04/07	03/21	03/28	03/06	04/03	03/26	04/19	03/17	03/04	04/07	03/04	03/12	04/17	04/18	03/25	03/27	03/06	03/29	04/10	03/15	03/25	03/29	03/29	03/12	04/15	03/15	03/07	04/09	03/14
CROOKSTON MN US	USC00211886	47.7833	-96.6167	04/01	13	-	-	-	-	-	-	04/06	-	04/08	03/17	05/03	03/28	03/28	03/02	03/24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/17	03/28	-	03/22	05/01	-	03/20
CROOKSTON NW EXPERIMENTAL STATION MN US	USC00211891	47.8014	-96.6028	04/01	43	04/13	04/06	04/12	03/22	04/10	04/21	04/12	03/25	04/22	03/17	04/06	03/28	03/15	03/03	04/07	03/21	03/27	03/17	04/01	04/21	03/12	04/02	03/05	04/22	04/23	03/13	04/17	04/23	03/26	03/27	03/20	04/07	04/10	03/19	04/17	04/08	03/28	03/28	04/19	05/05	03/09	04/08	03/16
DEEP PORTAGE MN US	USC00212050	46.8997	-94.3872	04/11	29	-	-	-	-	-	-	-	-	-	-	-	-	-	03/03	04/09	03/22	04/05	04/14	05/03	05/09	04/19	04/03	03/05	04/27	04/15	04/30	05/07	05/05	03/26	04/27	03/06	04/07	05/21	04/22	04/14	03/29	05/09	03/24	04/30	03/21	03/09	04/08	-
DELANO MN US	USC00212088	45.0417	-93.7903	04/04	30	-	-	-	-	-	-	-	-	04/08	03/17	04/17	03/24	04/12	-	-	-	-	03/20	04/01	04/20	04/21	03/20	04/28	04/06	04/12	04/11	04/17	04/01	-	03/31	03/21	04/10	04/10	04/16	03/24	03/29	04/11	03/29	04/09	04/15	03/11	04/07	03/14
DETROIT LAKES 1 NNE MN US	USC00212142	46.8372	-95.8372	04/06	41	04/27	04/06	04/26	04/18	04/11	04/14	04/21	03/09	04/22	03/17	04/06	03/28	04/14	03/02	04/07	03/21	03/28	03/18	04/30	04/20	04/21	04/05	04/27	-	-	04/26	04/16	05/04	03/26	03/27	03/05	04/04	04/10	03/17	04/14	04/04	03/27	03/24	04/30	03/22	03/08	05/04	03/16
ELBOW LAKE MN US	USC00212476	46.0108	-95.8756	04/04	18	04/15	04/18	04/16	04/18	04/10	04/14	04/13	03/10	04/22	03/17	04/17	03/25	04/14	03/01	-	03/26	03/28	03/19	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FERGUS FALLS MN US	USC00212768	46.2919	-96.1172	03/30	36	04/15	04/18	03/19	03/23	04/10	04/14	-	03/11	04/26	04/17	04/06	03/28	04/14	03/01	04/07	03/26	03/28	03/18	04/03	04/20	03/30	04/02	03/05	03/25	04/17	03/16	04/10	04/01	03/25	03/30	03/04	04/08	04/11	03/15	03/25	03/28	03/28	-	-	-	-	-	-
FOSSTON MN US	USC00212916	47.5636	-95.7244	04/13	37	04/13	04/10	04/15	04/18	04/19	04/14	04/13	03/08	04/22	03/17	04/06	03/28	04/23	05/06	04/06	04/17	04/16	-	04/29	04/20	04/21	04/03	03/05	04/28	04/23	04/30	05/07	04/27	-	04/25	03/06	04/07	04/10	04/13	05/08	04/03	03/27	03/29	04/30	-	-	-	-
GAYLORD MN US	USC00213076	44.5564	-94.2208	03/24	43	04/07	04/07	03/19	03/01	04/10	04/13	03/18	03/10	04/04	04/16	04/15	03/23	03/16	03/01	04/02	03/19	03/16	03/18	04/02	03/24	03/11	03/18	03/04	04/06	04/11	03/12	03/12	03/27	03/27	03/28	03/21	03/29	04/10	03/15	03/25	03/28	03/30	03/24	04/05	03/16	03/10	04/01	03/11
GEORGETOWN 1 E MN US	USC00213104	47.0792	-96.7758	03/30	39	04/13	04/08	04/12	03/22	04/10	04/13	04/12	03/09	04/22	04/12	04/05	03/28	04/14	03/02	03/26	03/21	03/28	03/17	03/05	05/02	04/18	03/20	03/05	03/25	03/17	03/16	04/08	04/18	03/25	03/26	03/05	04/07	04/10	03/18	03/27	03/28	03/27	03/28	04/15	-	-	-	-
GLENWOOD 2 WNW MN US	USC00213174	45.6583	-95.4392	03/31	41	04/15	04/10	04/10	03/13	04/10	04/13	03/24	-	-	05/04	04/05	03/28	04/23	03/02	04/08	04/11	04/02	03/19	03/23	03/25	04/20	04/02	03/04	03/27	03/17	03/11	05/08	03/27	03/26	03/30	03/05	04/07	04/14	03/15	03/25	04/04	04/05	03/25	04/19	04/15	03/10	04/21	03/14
GULL LAKE DAM MN US	USC00213411	46.4119	-94.3608	04/05	43	04/15	04/18	04/16	03/13	04/11	04/14	04/13	03/12	04/26	03/17	04/06	03/28	03/29	03/04	04/11	04/12	03/28	03/24	05/01	04/22	04/19	04/03	03/05	04/27	04/15	04/29	05/07	05/05	03/25	03/31	03/23	04/06	04/13	04/11	03/27	03/29	03/28	03/28	04/20	03/23	03/09	04/26	03/18
HALLOCK MN US	USC00213455	48.7714	-96.9406	04/07	32	04/14	04/15	04/12	03/22	04/19	04/13	04/07	04/14	04/22	04/12	04/16	03/24	03/15	03/03	04/05	04/12	03/28	03/19	04/02	04/23	04/19	04/02	03/05	03/25	04/11	03/12	05/05	-	-	-	-	-	-	-	-	-	-	-	04/18	05/03	04/12	05/04	04/13
HAWLEY 3 NE MN US	USC00213587	46.8833	-96.25	04/08	15	04/13	04/10	04/12	03/22	05/07	-	-	05/03	05/02	04/18	04/06	03/23	04/14	03/02	04/07	-	03/28	03/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	
HUTCHINSON 1 N MN US	USC00213962	44.9089	-94.3675	03/25	40	04/14	04/07	03/19	03/01	04/10	04/12	03/23	03/10	03/30	03/17	04/06	03/24	03/29	03/04	04/08	03/20	03/28	03/06	04/02	03/27	03/11	03/20	03/04	03/25	04/12	03/12	03/11	03/26	03/25	03/27	03/03	03/28	04/09	03/13	03/24	03/29	03/29	03/24	04/16	04/15	-	-	-
ITASCA UNIVERSITY OF MINN ND US	USC00214106	47.2256	-97.1919	04/10	43	04/27	04/18	04/30	04/18	04/11	04/25	04/13	03/10	04/17	03/17	04/06	03/28	04/14	03/05	04/07	04/17	03/30	03/22	04/30	04/26	04/21	04/03	03/05	03/26	04/24	05/01	05/13	05/16	04/06	04/27	04/23	04/08	04/13	04/14	04/14	04/09	03/29	04/21	05/15	03/23	03/11	04/09	03/18
JORDAN 2 E MN US	USC00214176	44.65	-93.6356	03/25	41	04/07	04/08	03/19	03/13	04/10	04/14	03/26	03/10	04/06	03/17	04/17	03/28	03/29	03/04	04/08	03/25	03/28	03/23	04/02	04/21	03/12	03/17	03/03	04/07	03/04	03/11	03/11	03/27	03/25	03/30	03/04	04/05	04/08	03/14	03/24	-	03/27	03/27	04/05	-	03/08	04/01	03/11
KARLSTAD MN US	USC00214213	48.5833	-96.5167	04/08	17	04/25	04/18	04/15	04/19	04/26	04/14	04/12	04/09	04/22	03/17	-	04/21	-	03/04	-	-	03/28	03/19	04/10	-	03/11	04/05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KELLIHER MN US	USC00214233	47.9422	-94.4553	04/21	38	04/25	04/10	04/26	04/19	04/26	04/27	05/12	03/09	05/15	04/22	04/17	-	04/12	04/24	04/07	04/17	03/28	03/18	04/29	-	04/24	04/02	04/28	03/25	05/07	04/30	05/05	-	-	04/13	04/25	04/28	05/25	04/23	05/08	04/10	03/28	04/20	-	04/29	04/27	04/28	05/08
LAKE WILSON MN US	USC00214534	43.9981	-95.9572	03/25	39	-	-	-	05/03	04/09	04/13	03/18	03/10	04/04	03/17	04/06	03/28	03/29	03/01	04/07	03/21	03/28	03/18	04/02	04/02	03/11	03/17	03/05	03/28	03/04	03/11	-	04/01	03/26	04/05	03/05	04/04	04/10	03/18	03/25	03/28	03/30	03/12	04/04	04/16	03/09	04/06	03/16
LAMBERTON SW EXPERIMENTAL STATION MN US	USC00214546	44.2394	-95.3153	03/23	43	04/05	04/07	04/11	03/01	04/10	03/18	03/24	03/11	04/04	03/18	04/05	03/28	03/15	03/01	04/07	03/23	03/23	03/16	03/22	04/20	03/12	03/20	03/04	04/12	03/04	03/11	03/11	03/27	03/26	03/31	03/06	04/06	04/11	03/15	03/25	03/28	03/30	03/24	04/04	03/21	03/08	04/07	03/11
LEECH LAKE DAM MN US	USC00214652	47.2467	-94.2228	04/04	43	04/15	04/18	04/30	03/23	04/11	04/16	04/13	03/09	04/26	03/17	04/06	03/28	03/29	03/04	04/08	04/12	03/30	03/22	03/23	04/21	03/12	04/03	03/05	04/22	04/23	03/17	05/06	04/23	03/26	03/31	05/02	04/08	04/13	04/13	04/14	03/29	03/29	03/28	05/01	03/22	03/09	04/02	03/17
LITCHFIELD MN US	USC00214778	45.1278	-94.5347	03/27	43	04/07	04/07	03/19	03/13	04/10	04/14	03/28	03/10	04/03	03/17	04/06	03/25	03/29	03/03	04/07	03/21	03/28	03/17	03/06	03/26	04/19	03/19	03/04	04/06	04/12	03/11	03/11	04/18	03/26	03/27	03/05	03/29	04/11	03/15	05/02	03/29	03/29	03/25	04/16	04/15	03/10	04/06	03/11
LITTLE FALLS 1 N MN US	USC00214793	45.9656	-94.3694	03/30	43	04/15	04/08	04/26	03/13	04/11	04/16	04/13	03/11	04/06	03/17	04/06	03/28	03/29	03/04	04/08	03/21	03/28	03/06	04/03	04/20	04/19	03/20	03/04	03/25	04/13	03/12	04/17	04/18	03/25	04/09	03/06	04/05	04/10	05/03	03/27	03/29	03/29	03/25	04/20	03/15	03/10	03/20	03/14
LITTLEFORK 10 SW MN US	USC00214809	48.3681	-93.7214	04/18	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/23	05/02	05/07	04/02	04/12	05/01	04/25	04/06	04/13	04/13	05/08	04/04	03/30	04/20	05/15	04/16	03/31	04/22	-
LONG PRAIRIE MN US	USC00214861	45.9647	-94.8892	03/31	41	04/15	04/07	04/12	03/13	04/11	04/14	03/28	03/11	04/17	03/17	04/05	03/28	03/29	03/04	04/07	04/12	03/28	03/19	04/03	04/20	03/11	03/17	03/04	04/07	04/14	03/12	04/17	04/18	03/26	03/27	03/06	04/07	04/10	04/13	03/25	03/29	-	-	04/20	04/16	03/09	04/23	03/18
MADISON SEWAGE PLANT MN US	USC00214994	45.0025	-96.1661	03/27	43	04/05	04/07	04/09	03/13	04/10	04/13	04/13	03/24	03/30	03/17	05/02	03/25	03/15	03/01	04/07	03/21	04/02	03/18	03/06	03/25	03/12	03/20	03/04	03/25	03/18	03/12	04/17	04/18	03/26	03/30	03/06	04/06	05/05	03/18	03/25	04/04	03/29	03/24	04/04	04/15	03/08	04/01	03/17
MAHNOMEN 1 W MN US	USC00215012	47.3172	-95.9675	04/02	32	04/25	04/06	04/12	03/13	04/11	04/14	04/12	03/10	04/08	03/17	04/16	03/28	04/22	03/02	04/07	03/21	03/28	03/23	04/03	04/14	03/30	03/20	03/04	04/22	04/23	04/16	05/05	04/21	04/04	-	-	-	-	-	-	-	-	-	-	-	03/07	04/07	03/15
MANKATO MN US	USC00215073	44.1542	-94.0211	03/23	41	04/11	03/12	03/19	03/01	03/28	04/06	03/18	03/10	03/30	03/17	04/06	03/28	03/29	03/01	03/26	04/10	03/28	03/18	03/07	03/11	03/09	03/21	03/04	04/07	04/13	03/12	03/12	03/27	03/26	03/30	03/05	04/04	04/11	03/16	03/25	03/29	03/28	03/24	04/15	03/23	03/08	-	-
MAPLE PLAIN MN US	USC00215136	45	-93.65	04/01	17	04/15	04/07	03/19	03/13	04/20	04/14	04/14	03/10	04/08	04/16	04/06	03/27	03/29	03/03	04/07	03/22	03/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARCELL 5 NE MN US	USC00215175	47.6308	-93.6522	04/17	23	-	-	-	-	-	-	-	-	-	-	-	-	04/13	05/10	04/11	05/07	04/23	-	-	04/23	03/12	04/04	03/05	04/28	04/24	04/30	05/14	04/02	03/26	04/25	04/23	04/29	04/13	04/14	05/08	04/09	04/14	-	-	-	-	-	-
MARSHALL MN US	USC00215204	44.4706	-95.7908	03/23	42	04/05	04/10	03/15	03/13	04/10	03/19	04/13	03/12	04/06	03/17	04/04	03/27	04/30	03/04	-	03/18	03/30	03/19	04/12	03/10	03/11	03/19	03/01	03/25	03/17	03/12	03/11	03/27	03/26	03/27	03/05	04/02	04/10	03/14	03/24	03/27	03/29	03/11	04/30	03/16	03/09	04/08	03/11
MELROSE MN US	USC00215325	45.6775	-94.8022	03/30	43	04/15	04/15	03/19	03/13	04/11	04/15	03/28	03/10	04/17	03/17	04/06	03/28	04/12	03/04	04/08	03/21	04/03	03/18	04/03	04/20	03/11	04/04	03/05	04/17	04/14	03/12	04/17	04/18	03/26	03/27	03/06	04/05	04/10	03/18	03/24	05/04	04/05	03/25	04/19	04/12	03/09	04/09	03/16
MILACA MN US	USC00215392	45.7533	-93.6617	03/29	40	04/24	04/08	04/12	03/13	04/11	04/15	04/13	03/11	05/07	04/12	04/06	03/28	03/29	03/04	04/01	03/21	03/28	03/06	04/03	03/26	03/12	03/18	03/04	04/16	04/12	03/12	05/07	04/04	03/26	04/01	03/06	04/05	04/11	03/15	03/27	-	-	-	04/19	03/23	03/09	04/10	03/15
MILAN 1 NW MN US	USC00215400	45.1219	-95.9269	03/26	43	04/15	04/15	04/12	03/23	04/10	04/13	03/28	03/10	04/05	03/17	04/05	03/28	03/29	03/04	03/26	03/22	03/28	03/14	04/03	04/20	03/12	04/02	03/04	03/25	03/17	03/12	03/11	04/18	03/26	03/26	03/05	03/28	04/13	03/18	04/05	04/04	03/27	03/24	04/19	03/15	03/07	04/07	03/10
MONTEVIDEO 1 SW MN US	USC00215563	44.9342	-95.7461	03/27	43	04/06	04/18	04/09	03/13	04/18	04/13	03/23	03/11	04/07	04/14	04/06	03/29	03/29	03/02	04/07	03/21	03/28	03/18	03/22	03/23	03/11	03/20	03/04	03/25	03/17	03/12	04/17	04/19	03/27	03/31	03/06	04/05	04/11	03/15	03/28	03/30	04/06	03/12	04/21	04/15	03/08	04/01	03/16
MOORHEAD MN US	USC00215586	46.8875	-96.7478	03/29	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/04	03/25	04/07	03/23	04/17	04/01	03/25	03/26	03/05	04/07	05/03	03/18	04/05	04/04	03/27	04/18	04/30	03/22	03/07	04/07	03/16
MORRIS WC EXPERIMENTAL STATION MN US	USC00215638	45.5903	-95.8747	03/29	43	04/15	04/10	03/19	03/23	04/12	04/14	04/13	03/11	04/05	04/12	04/06	03/28	03/29	03/01	04/07	03/22	03/29	03/19	04/03	04/20	03/12	03/20	03/05	03/26	04/14	03/12	04/10	04/02	03/26	03/28	03/06	04/07	04/11	03/18	03/24	04/04	04/10	03/24	04/20	03/16	03/08	04/08	03/15
MOUND MN US	USC00215665	44.95	-93.65	03/27	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/17	03/03	03/25	04/12	03/11	03/11	04/18	03/25	05/03	03/20	-	-	04/11	-	-	-	-	-	-	-	-	-
NEW LONDON MN US	USC00215842	45.305	-94.9392	03/29	35	04/15	-	-	-	-	-	03/28	03/10	04/17	03/17	04/06	03/24	03/29	03/03	04/08	03/26	03/28	03/06	04/03	03/26	04/19	03/20	03/04	03/25	04/14	03/12	04/17	04/18	03/26	03/31	03/05	04/10	04/10	03/15	03/27	03/29	03/29	03/24	04/19	04/16	-	-	-
NEW ULM 2 SE MN US	USC00215887	44.3006	-94.4897	03/21	41	04/05	03/12	03/19	03/01	03/28	04/06	03/26	03/09	03/30	03/17	03/27	03/28	03/15	03/02	03/26	03/23	03/28	03/16	03/06	03/10	03/11	03/20	03/04	04/17	04/11	03/11	03/11	03/27	03/25	03/28	03/04	04/04	04/10	03/14	03/24	03/28	03/29	03/12	04/09	03/15	03/10	-	-
OKLEE MN US	USC00216148	47.8333	-95.85	04/12	26	04/25	04/18	04/15	04/18	04/11	04/16	04/16	03/11	04/22	03/17	05/16	05/11	04/13	03/02	04/09	04/17	03/28	03/22	04/02	04/22	04/19	04/03	03/05	04/30	05/13	04/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OLIVIA 3 E MN US	USC00216152	44.7628	-94.9297	03/25	36	-	-	-	-	-	-	-	03/11	04/05	04/11	03/29	03/28	03/15	03/02	04/07	03/21	03/28	03/06	03/22	03/12	03/11	03/17	03/04	04/07	04/12	03/12	04/10	03/27	03/26	03/27	03/05	04/04	04/10	03/15	04/15	03/28	03/29	03/24	04/16	04/16	03/12	04/07	03/11
ORWELL DAM MN US	USC00216228	46.2147	-96.1783	04/07	35	-	-	04/10	03/31	04/10	-	-	-	-	-	04/06	03/24	03/29	03/04	04/10	04/16	03/28	04/07	05/03	04/19	04/24	03/20	04/15	03/26	05/10	03/16	05/14	05/06	-	03/30	03/21	04/11	05/07	03/18	05/04	03/29	03/28	03/28	04/15	04/14	03/30	04/07	03/20
OTTERTAIL MN US	USC00216276	46.4314	-95.5464	04/03	42	04/25	04/18	04/12	03/23	04/11	04/15	04/01	03/09	04/09	03/17	04/06	03/28	04/12	04/20	04/07	04/17	03/28	03/18	04/03	04/20	03/12	03/20	03/05	03/25	04/14	03/16	04/17	04/25	03/25	03/27	03/05	04/04	04/11	-	05/02	04/09	04/11	04/21	05/05	03/22	03/08	04/11	03/16
PINE RIVER DAM MN US	USC00216547	46.6694	-94.1089	04/08	43	04/15	04/18	04/28	04/18	04/25	04/26	04/13	03/11	04/26	03/17	04/19	04/10	04/23	03/04	04/08	04/15	04/05	04/14	04/30	04/22	04/22	04/03	03/05	03/26	04/14	05/02	04/18	05/05	03/26	03/27	03/05	04/26	04/15	03/21	05/06	03/29	03/29	03/25	04/20	03/23	03/10	04/26	03/18

Observation Location	Code	Latitude	Longitude	Average VTP	Years With Data	First Annual Date Cooresponding to Tmin > 32° F for Three Consecutive Days (March - May)																																										
						1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PIPESTONE MN US	USC00216565	44.0139	-96.3258	03/28	43	04/17	04/15	03/19	03/22	03/02	04/14	04/15	03/10	04/05	03/17	04/06	03/28	04/14	03/02	04/07	04/10	03/28	04/16	04/02	03/10	03/12	03/20	03/05	03/26	04/14	03/12	04/10	04/20	03/26	03/30	03/05	04/05	04/11	03/15	03/24	04/03	03/29	03/24	04/30	04/15	03/11	04/06	03/16
POKEGAMA DAM MN US	USC00216612	47.2508	-93.5861	04/10	40	04/15	04/14	04/27	04/18	04/11	04/16	04/13	03/11	04/17	03/17	04/06	03/28	04/23	03/04	04/07	04/12	03/28	03/21	03/23	04/25	04/18	04/03	04/29	04/22	04/17	05/02	04/18	04/02	-	04/30	04/26	04/28	05/11	04/23	04/14	03/30	-	-	05/01	03/23	03/09	04/02	03/17
RED LAKE FALLS MN US	USC00216787	47.8881	-96.2658	03/30	43	04/13	04/06	04/14	03/22	04/11	04/14	04/02	03/08	04/22	03/17	04/16	03/24	03/15	03/02	04/06	03/25	03/28	03/18	04/03	04/20	03/30	03/19	03/04	03/25	04/22	03/12	04/17	04/25	03/25	03/26	03/05	04/07	04/11	03/18	04/14	04/05	03/28	03/28	04/30	03/22	03/09	04/08	03/16
RED LAKE INDIAN AGCY MN US	USC00216795	47.8769	-95.0161	04/10	40	04/25	04/18	04/15	03/22	04/25	05/04	04/13	03/11	04/17	04/18	04/19	04/21	04/14	03/03	04/07	04/18	03/29	03/20	04/03	04/22	04/21	04/03	04/28	03/25	04/14	04/28	05/15	05/06	04/11	04/09	04/22	04/27	04/12	03/22	04/04	03/29	03/27	03/24	-	-	-	03/20	03/17
ROSEAU MN US	USC00217087	48.8486	-95.7675	04/08	33	04/26	04/18	04/12	04/19	04/19	04/14	04/16	04/09	04/26	03/17	04/19	04/27	04/14	03/05	04/08	04/17	04/23	03/18	-	04/24	04/21	04/03	03/05	03/25	05/13	03/12	-	-	-	03/26	03/05	03/28	04/11	04/08	04/04	05/04	03/27	-	-	-	-	-	-
ROTHSAY MN US	USC00217149	46.4808	-96.2869	03/29	42	04/14	04/10	04/14	03/22	04/10	04/05	04/07	03/10	04/22	04/17	04/05	03/24	04/14	03/01	04/02	03/21	03/29	03/17	04/02	-	03/11	03/20	03/04	03/25	04/13	03/12	04/10	04/18	03/25	03/30	03/05	04/09	04/11	04/12	04/15	03/28	03/28	03/25	05/05	03/21	03/07	03/20	03/15
ST JAMES FILT PLANT MN US	USC00217326	43.9903	-94.6122	03/23	43	04/05	03/12	03/15	03/13	04/09	04/13	03/18	03/09	04/04	04/16	04/05	03/28	03/29	03/01	04/02	03/21	03/22	03/17	03/06	03/10	03/11	03/20	03/02	04/07	03/04	03/12	03/12	03/27	03/27	03/27	03/04	04/06	04/11	03/15	03/24	04/05	03/29	03/24	04/16	04/16	03/11	04/01	03/12
ST PETER MN US	USC00217405	44.3222	-93.9656	03/24	42	04/06	03/13	03/19	03/01	04/10	04/14	03/26	03/09	03/30	03/17	03/28	03/28	03/16	03/01	04/08	03/27	03/28	03/18	04/02	03/26	03/11	03/20	03/03	04/10	04/12	03/12	03/12	04/01	03/26	05/02	03/06	04/06	04/10	03/15	03/24	03/29	-	03/24	04/16	03/22	03/11	04/07	03/15
SANTIAGO 3 E MN US	USC00217502	45.5461	-93.7572	03/31	43	04/15	04/10	04/17	03/01	04/10	04/13	04/01	03/11	04/06	03/17	04/19	03/28	03/29	05/05	04/08	04/10	03/29	03/23	04/03	03/26	04/19	04/03	03/05	04/21	04/13	03/12	04/17	04/18	03/25	03/27	03/05	03/29	04/07	03/15	03/27	03/29	03/29	03/28	04/28	03/15	03/09	03/20	03/14
SPRINGFIELD 1 NW MN US	USC00217907	44.2469	-94.9864	03/22	43	04/05	03/12	03/15	03/01	04/10	04/13	03/26	03/11	03/30	03/18	03/28	03/28	03/15	03/01	03/26	03/18	03/29	03/18	03/23	03/11	03/12	03/20	03/03	03/25	03/04	03/11	04/17	03/27	03/26	03/30	03/06	04/05	04/11	03/15	03/25	03/29	03/29	03/12	04/16	03/22	03/10	04/07	03/17
SPRING PARK MN US	USC00217935	44.9347	-93.6275	03/26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/21	03/24	03/27	03/30	03/22	04/16	04/13	03/09	04/06	03/10
STEWART MN US	USC00218025	44.7344	-94.3425	03/25	33	04/15	03/12	03/19	03/01	04/09	04/13	03/18	03/10	04/03	03/17	04/05	03/27	03/16	03/01	04/07	03/20	03/28	03/18	04/03	03/26	03/12	03/20	-	04/07	04/12	03/12	04/17	03/27	03/25	03/28	03/05	04/05	04/10	03/15	-	-	-	-	-	-	-	-	-
TAMARAC WILDLIFE REF MN US	USC00218191	46.9589	-95.6472	04/09	34	-	-	-	-	-	-	-	-	04/08	03/17	04/06	03/28	04/14	03/03	04/07	-	03/28	03/18	04/03	04/22	04/18	03/20	03/05	04/17	05/10	05/02	05/07	05/06	04/07	03/31	04/25	04/10	04/16	04/23	04/14	04/12	03/29	04/20	05/06	04/18	03/08	04/27	03/20
THIEF RIVER FALLS 2 MN US	USC00218247	48.1331	-96.1667	04/09	38	-	-	-	04/19	05/08	04/15	-	03/10	04/23	03/17	04/06	03/28	04/14	04/22	04/09	04/17	04/17	04/07	04/02	04/20	04/21	03/20	04/15	04/22	04/13	03/12	04/17	04/20	-	04/06	03/05	04/04	04/11	03/18	04/13	04/04	03/28	04/18	04/30	04/14	04/01	05/17	04/23
THORHULT MN US	USC00218254	48.2325	-95.2481	04/08	41	04/26	04/06	04/29	-	04/25	04/14	-	03/09	04/26	04/18	04/30	04/21	04/12	03/02	04/06	04/17	04/05	03/17	04/02	03/26	04/21	04/04	03/05	04/27	04/23	03/12	04/17	05/22	04/05	04/08	04/22	04/07	04/11	04/13	04/19	04/04	03/27	03/24	05/18	03/21	03/11	04/08	03/17
TRACY MN US	USC00218323	44.2394	-95.6308	03/25	43	04/06	04/07	04/10	03/13	04/10	04/14	04/07	03/12	04/04	04/11	04/05	03/28	03/29	03/01	04/07	03/21	03/01	03/19	03/23	03/27	03/12	03/17	03/04	03/25	03/04	03/11	04/10	04/01	03/26	03/30	03/04	04/05	04/09	03/14	03/23	03/26	03/29	03/24	04/04	03/15	03/12	04/06	03/11
TYLER MN US	USC00218429	44.2781	-96.1281	03/27	21	-	-	04/17	03/23	04/10	04/14	03/24	03/10	04/04	04/16	04/06	03/28	03/15	03/01	04/02	05/03	03/28	03/19	04/02	03/26	03/11	03/17	03/04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WADENA 3 S MN US	USC00218579	46.3939	-95.1494	04/07	43	04/25	04/15	04/17	04/18	04/26	04/14	04/13	03/10	04/26	04/18	04/17	03/29	04/14	03/05	04/08	04/12	03/29	03/23	04/30	04/23	03/12	04/03	03/05	04/28	04/15	04/30	05/07	04/19	03/26	03/27	03/06	04/06	04/11	03/17	04/15	04/08	04/10	03/29	04/21	04/24	03/08	04/08	03/14
WALKER AH GWAH CHING MN US	USC00218618	47.0744	-94.57	04/01	39	04/15	04/08	04/16	03/23	04/11	04/16	04/13	03/09	04/26	03/17	04/17	03/28	04/15	03/03	04/08	04/17	03/28	03/22	04/03	04/22	03/11	04/02	03/04	03/25	04/14	03/12	04/17	03/27	03/25	04/06	03/05	04/10	04/10	03/23	04/05	03/29	03/29	03/24	04/21	-	-	-	-
WANNASKA 1 S MN US	USC00218656	48.65	-95.75	04/18	18	04/25	04/18	04/29	04/18	04/19	05/09	04/29	03/09	-	04/18	04/17	04/27	03/28	05/09	04/07	-	03/28	04/15	04/30	-	-	04/03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WARROAD MN US	USC00218679	48.8947	-95.33	04/10	41	04/25	04/18	04/21	04/19	04/19	04/14	04/13	03/11	04/26	03/17	04/17	04/21	04/14	04/24	04/07	04/18	-	03/22	04/03	04/23	04/19	04/03	03/05	04/28	04/23	04/29	04/10	04/03	05/02	03/27	03/20	04/08	04/12	04/13	04/19	04/05	03/29	04/20	-	03/22	03/30	04/08	03/18
WASKISH 4 NE MN US	USC00218700	48.2064	-94.3939	04/17	37	04/15	04/09	04/15	04/18	04/25	05/06	04/13	04/08	04/26	-	04/25	04/27	04/12	04/24	04/09	04/12	04/05	-	-	-	-	-	04/18	04/22	05/11	04/29	05/07	05/22	04/11	04/25	04/22	03/29	04/13	04/13	04/19	04/08	03/28	04/19	05/15	04/13	03/14	04/09	03/17
WHEATON MN US	USC00218907	45.8081	-96.5042	03/28	43	04/17	03/27	04/12	04/17	04/10	04/13	04/13	03/10	04/07	03/17	04/05	03/28	03/29	03/01	04/07	03/21	03/28	03/18	04/03	04/14	03/11	03/19	03/06	04/07	04/07	03/12	04/10	04/01	03/26	03/27	03/05	04/07	04/10	03/15	03/27	04/05	03/28	03/24	05/05	03/22	03/09	04/08	03/11
WHITE ROCK DAM MN US	USC00218947	45.8619	-96.565	04/06	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/18	04/10	04/16	04/23	03/27	04/05	03/28	03/29	04/30	04/12	03/09	04/09	03/16
WILLMAR RTC MN US	USC00219004	45.1078	-95.0358	03/28	41	04/15	04/10	03/19	03/13	04/10	04/14	03/28	03/10	04/05	03/17	04/06	03/25	03/29	03/04	04/07	03/21	03/28	03/19	04/02	04/20	03/12	03/20	03/04	03/25	04/14	03/12	04/18	04/19	03/26	03/27	03/05	04/05	04/11	03/15	03/24	03/29	03/29	03/25	04/16	04/15	03/10	-	-
WINNIBIGOSHISH DAM MN US	USC00219059	47.4306	-94.0586	04/10	26	04/15	04/18	04/27	03/23	04/11	04/16	04/14	03/11	04/26	03/17	04/17	03/28	03/29	03/04	04/10	04/17	04/05	03/21	04/02	04/26	03/13	04/03	05/06	05/03	05/09	05/09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ALMONT ND US	USC00320127	46.7253	-101.505	04/07	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/11	03/28	03/20	04/29	03/27	04/19	03/21	03/04	03/27	04/16	03/15	04/16	04/23	03/25	04/20	04/24	04/25	04/13	04/12	04/14	04/02	04/12	03/25	04/14	04/14	04/12	-	-
ALMONT 7 W ND US	USC00320136	46.7167	-101.65	04/07	14	04/24	04/07	03/14	03/21	04/10	04/22	04/06	04/07	03/26	-	04/18	04/15	03/15	04/24	04/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	
ASHLEY ND US	USC00320382	46.0406	-99.3742	04/06	42	04/26	04/10	04/10	04/17	04/20	04/15	04/12	04/09	04/15	04/16	04/05	04/24	04/14	03/02	04/06	04/11	03/28	04/16	04/30	04/01	03/29	04/02	03/05	03/27	04/16	03/14	04/23	04/18	04/05	03/26	-	04/04	04/10	03/31	04/14	04/02	03/29	03/11	04/29	04/12	03/29	04/08	03/16
BELCOURT KEYA RADIO ND US	USC00320626	48.8411	-99.7508	04/26	40	05/06	04/18	05/01	05/06	04/24	04/27	04/07	04/10	-	-	04/29	04/27	04/14	05/22	03/25	04/23	04/23	-	05/09	04/22	04/21	05/10	04/30	05/04	04/13	05/10	05/21	05/28	04/21	05/16	04/24	04/25	04/13	04/12	05/19	04/09	04/27	04/18	05/20	04/14	05/10	04/26	03/17
BEULAH 1 W ND US	USC00320766	47.2622	-101.7906	04/10	38	04/25	04/19	04/26	03/22	04/18	04/23	04/08	04/09	03/28	04/17	04/18	04/16	04/12	04/20	03/28	04/14	03/28	03/20	04/29	03/27	04/19	03/20	03/05	03/27	04/20	03/24	04/17	04/17	04/11	04/08	04/22	04/26	04/13	04/12	04/14	03/27	04/15	04/18	-	-	-	-	-
BOTTINEAU ND US	USC00320941	48.8217	-100.4525	04/13	43	04/27	04/07	04/26	03/22	04/25	04/22	04/06	04/09	04/16	04/16	04/17	04/24	04/14	04/19	03/25	04/18	04/17	03/20	04/28	04/20	04/22	04/05	04/15	05/03	04/16	03/12	05/05	04/21	03/26	04/20	04/21	04/09	04/11	04/12	05/07	04/05	04/09	04/15	04/14	04/13	03/31	04/08	03/14
BREIEN ND US	USC00321052	46.3797	-100.9408	04/13	35	05/07	04/16	03/15	03/21	04/10	04/21	05/13	04/08	04/15	04/17	04/01	05/01	05/01	05/03	04/06	04/14	04/02	03/20	04/29	04/20	04/18	03/20	03/04	04/26	04/16	03/24	04/17	04/18	04/24	04/20	04/22	04/26	04/13	03/17	04/14	-	-	-	-	-	-	-	-
BUTTE 5 SE ND US	USC00321225	47.7947	-100.5847	04/05	43	04/25	04/15	03/14	03/21	04/10	04/21	04/08	04/07	03/26	04/16	04/05	04/15	04/12	04/24	03/24	04/18	04/17	04/06	04/02	04/01	04/19	04/02	03/05	03/27	03/03	03/11	05/05	04/17	03/25	04/25	04/21	04/24	04/11	03/22	04/19	04/07	04/05	03/11	04/14	04/13	03/29	04/08	03/15
CARRINGTON ND US	USC00321360	47.4494	-99.1294	04/11	35	04/25	04/18	04/13	04/18	04/11	04/21	04/08	03/09	04/16	04/17	04/17	04/26	03/29	04/21	04/06	04/12	03/27	03/19	04/01	04/19	04/19	04/02	03/04	04/26	04/11	03/16	05/04	04/22	04/04	04/07	04/21	04/25	04/11	04/13	04/14	-	-	-	-	-	-	-	-
CARRINGTON 4 N ND US	USC00321362	47.5089	-99.1211	04/10	43	04/24	04/18	04/12	03/20	04/11	04/26	04/12	04/14	04/22	04/18	04/05	04/15	04/14	03/02	04/10	04/12	04/05	03/20	04/30	04/22	04/19	04/05	03/04	03/27	04/16	03/17	04/17	04/18	04/05	04/13	04/25	04/18	04/15	04/18	05/02	04/19	04/11	04/19	04/14	04/12	03/09	04/08	03/14
CARSON ND US	USC00321370	46.425	-101.5742	04/10	35	04/26	04/15	04/11	04/29	04/19	04/22	04/06	04/08	03/27	05/13	04/16	04/15	04/12	04/21	04/07	04/12	03/28	04/04	04/02	04/01	03/30	03/20	04/16	03/24	04/19	03/12	05/04	04/17	04/10	-	-	-	-	-	-	-	-	03/26	04/30	04/15	03/30	04/25	03/11
CASSELTON AGRONOMY FM ND US	USC00321408	46.8769	-97.2328	03/31	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/03	03/22	03/29	03/19	03/05	04/20	04/21	04/04	03/05	03/27	04/23	03/17	03/13	04/20	03/27	03/31	03/05	03/29	04/11	03/19	04/05	03/28	04/09	03/24	04/30	04/12	03/08	04/08	04/05
CAVALIER 7 NW ND US	USC00321435	48.8628	-97.7014	04/09	42	04/25	04/18	04/12	03/21	04/19	04/14	-	03/13	04/22	04/22	04/17	04/26	04/22	04/18	03/26	03/22	03/28	04/05	04/29	04/22	04/19	04/03	03/05	03/25	04/09	04/29	05/06	04/19	03/26	04/13	04/25	04/06	04/13	04/10	04/01	04/05	04/10	04/19	04/19	04/12	03/09	04/09	03/15
CENTER 4 SE ND US	USC00321456	47.0644	-101.2119	04/10	43	04/25	04/18	04/10	03/22	04/10	04/22	04/12	04/08	03/26	04/23	04/18	04/15	05/03	04/21	04/06	04/13	04/18	04/08	04/10	04/14	03/10	04/02	03/04	03/05	04/20	05/06	05/05	04/22	04/10	04/29	04/25	04/26	04/10	04/12	03/26	04/07	04/10	03/11	04/14	04/14	03/29	04/06	03/10
COLGATE ND US	USC00321686	47.2428	-97.6561	04/10	41	04/14	04/18	04/12	04/17	04/19	04/13	04/13	04/10	04/22	04/17	04/06	03/31	04/15	04/21	04/11	04/18	03/27	04/16	04/30	04/19	04/19	04/02	03/04	03/25	04/23	03/12	04/17	04/18	03/26	04/20	03/06	04/07	04/13	04/12	04/14	04/04	04/10	04/14	05/15	04/14	03/30	-	-
COOPERSTOWN ND US	USC00321766	47.405	-98.0381	04/09	43	04/24	04/18	04/26	04/17	04/19	04/21	04/13	03/09	04/22	04/17	04/16	04/15	04/14	04/21	03/26	03/22	03/28	03/19	04/29	04/20	04/19	03/20	03/04	03/28	05/06	03/23	04/17	04/18	04/05	04/09	03/24	04/09	04/13	04/13	04/18	04/04	04/09	04/19	04/29	04/12	03/09	04/08	03/16
DRAKE ND US	USC00322298	47.9167	-100.3667	04/17	13	04/25	04/15	04/26	03/22	04/19	04/22	04/11	04/09	04/16	04/23	04/16	04/24	04/14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DRAKE 9 NE ND US	USC00322304	48.0475	-100.31	04/12	43	04/25	04/18	04/26	04/17	04/10	04/17	04/08	04/09	04/16	04/16	04/16	04/15	04/14	04/23	04/06	04/14	03/27	03/20	04/28	04/19	04/19	04/02	03/05	03/27	04/22	03/25	05/05	04/22	04/11	04/25	04/22	04/25	04/12	04/13	04/14	04/07	04/10	04/19	05/06	04/13	03/09	04/08	03/15
DRAYTON ND US	USC00322312	48.5608	-97.1808	04/08	15	05/06	-	04/13	04/18	04/19	04/15	04/06	-	04/15	-	-	-	-	-	-	-	-	-	-	-	-	04/02	04/15	03/25	04/12	03/17	04/09	-	03/25	03/26	-	-	-	-	-	-	-	-	-	-	-	-	-
EDGELEY 3 WNW ND US	USC00322482	46.3694	-98.7661	04/11	32	04/15	04/10	04/10	03/23	04/10	04/21	04/07	-	-	-	-	-	-	-	-	-	-	-	04/29	04/20	04/20	04/02	03/04	03/28	03/03	03/13	05/05	04/18	03/27	04/08	03/05	04/04	05/22	04/20	05/04	04/06	04/12	04/22	05/18	04/29	04/28	05/06	03/14
EDMORE 1 NW ND US	USC00322525	48.4239	-98.4714	04/15	42	04/25	04/18	04/14	04/18	04/24	04/15	04/07	04/14	05/02	04/18	04/18	04/15	04/22	04/24	04/05	04/18	04/17	04/06	04/30	04/22	04/19	04/05	04/27	03/26	-	03/12	04/17	04/20	04/10	04/13	05/02	04/07	04/13	04/12	05/05	04/07	04/10	05/01	04/19	04/12	04/18	04/09	03/16
ELLENDALE ND US	USC00322605	46.0108	-98.5261	04/03	41	04/25	04/10	04/10	03/22	04/10	04/15	04/13	03/11	04/22	04/16	04/16	03/28	03/28	03/02	04/07	03/25	03/27	03/19	-	03/27	03/11	03/20	03/04	03/27	04/14	03/24	04/17	04/18	03/25	04/05	03/23	-	04/13	04/13	04/14	04/19	04/11	03/27	05/15	04/12	03/30	04/08	03/18
ENDERLIN 2 W ND US	USC00322695	46.6167	-97.6383	04/05	34	04/13	04/09	-	04/05	04/11	04/25	04/09	03/11	04/22	04/18	04/17	03/28	04/14	03/03	-	03/22	03/28	-	-	-	-	-	-	-	04/14	03/17	04/17	04/18	04/05	04/20	03/23	04/09	04/10	04/13	04/17	03/27	04/09	03/24	04/14	04/12	03/08	04/08	03/12
FESSENDEN ND US	USC00322949	47.6456	-99.6219	04/07	40	04/25	04/18	03/14	03/22	04/10	04/15	04/13	03/08	04/15	04/16	04/19	04/25	-	-	-	04/14	03/27	03/20	04/29	04/19	04/19	04/02	03/03	04/26	04/16	03/16	05/05	03/25	03/25	04/09	03/22	04/24	04/10	04/09	04/05	04/04	04/11	04/19	04/14	04/11	03/29	04/07	03/16
FLASHER ND US	USC00323004	46.4581	-101.2	04/17	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/10	04/22	04/26	04/13	04/12	04/18	04/07	05/07	03/25	05/12	04/15	04/13	04/07	03/16
FORMAN 5 SSE ND US	USC00323117	46.0333	-97.595	04/01	43	04/14	04/10	04/10	03/23	04/10	04/14	03/24	03/10	04/22	04/16	04/05	03/28	03/15	03/02	04/06	03/22	03/28	03/20	04/03	04/20	03/30	03/20	03/05	03/29	04/14	03/12	04/18	04/19	03/26	03/30	03/06	04/10	04/11	04/12	04/15	04/08	03/28	03/29	04/30	04/13	03/11	04/08	03/11
FORT YATES 4 SW ND US	USC00323207	46.05	-100.6667	04/03	30	04/24	04/10	04/09	03/21	04/10	04/21	04/05	03/27	04/08	04/16	04/01	03/27	03/15	03/02	05/04	04/10	05/12	03/17	04/03	03/09	03/29	04/05	03/04	03/27	04/15	03/12	04/26	03/24	04/05	04/20	-	-	-	-	-	-	-	-	-	-	-	-	-
FOXHOLM 7 N ND US	USC00323217	48.4583	-101.5697	04/18	43	04/24	04/18	04/29	04/18	04/19	04/25	04/07	04/13	03/29	05/16	04/16	04/26	04/22	05/03	04/05	04/18	03/27	03/04	04/02	04/14	04/19	04/03	04/27	04/27	04/13	03/12	05/05	04/22	04/21	04/27	04/25	04/24	05/14	04/09	05/18	05/17	04/18	04/24	05/13	04/12	03/29	04/08	03/16
FULLERTON 1 ESE ND US	USC00323287	46.1581	-98.4	04/05	43	04/14	04/10	04/10	03/23	04/10	04/16	04/09	04/08	04/22	04/18	04/16	03/28	03/28	03/02	04/06	04/18	03/27	03/20	04/29	04/19	03/11	03/20	03/04	03/27	04/14	04/14	04/17	04/18	04/05	04/07	04/22	04/11	04/13	03/18	04/14	04/04	04/09	03/28	04/30	03/22	03/08	04/07	04/05
GACKLE ND US	USC00323309	46.6275	-99.1383	04/07	32	04/25	04/10	04/13	03/22	04/10	04/21	04/08	04/09	04/15	04/17	04/16	04/15	04/14	04/21	04/06	04/10	04/02	03/20	04/11	04/19	04/19	03/19	03/04	03/28	04/20	03/12	04/17	04/18	04/05	03/26	03/05	-	04/11	-	-	-	-	-	-	-	-	-	-
GARRISON 1 NNW ND US	USC00323376	47.6539	-101.4197	04/12	41	-	04/13	04/25	04/18	04/29	04/22	04/06	04/08	03/28	04/16	04/16	04/24	04/23	04/21	03/24	-	04/17	04/15	04/02	04/14	04/19	04/03	03/06	03/27	04/20	04/14	05/05	03/26	04/11	04/10	04/22	04/25	04/11	04/12	04/19	04/03	04/11	04/18	05/12	04/29	03/30	04/08	03/16
GRAFTON ND US	USC00323594	48.4181	-97.4247	04/02	37	04/13	04/06	04/25	04/18	04/24	04/12	04/01	03/13	04/23	04/12	04/05	04/15	04/14	04/19	04/05	03/21	03/31	03/18	03/22	04/13	03/08	03/17	03/04	03/25	04/08	03/12	04/29	04/02	03/25	03/26	03/04	04/03	04/11	04/09	03/31	03/29	03/29	-	-	-	-	-	-
GRAND FORKS UNIVERSITY ND US	USC00323621	47.9217	-97.0981	03/31	43	04/12	04/06	03/14	03/21	04/11	05/02	03/28	03/09	04/22	04/12	04/05	03/24	03/15	03/02	04/06	03/21	03/28	03/16	04/02	04/13	03/11	03/20	03/04	03/25	05/01	03/12	04/17	04/18	04/04	04/06	03/22	04/04	04/11	04/12	04/18	04/04	04/09	04/18	04/30	03/21	03/08	04/08	03/14
GRANVILLE ND US	USC00323686	48.2675	-100.8439	04/10	32	04/24	04/18	04/29	04/18	04/11	04/15	-	04/13	04/25	05/12	04/18	04/15	05/02	05/02	03/24	04/18	03/27	04/05	04/01	04/13	04/19	04/02	03/05	03/27	04/11	04/14	-	04/23	03/25	03/26	03/02	04/18	04/12	03/22	-	-	-	-	-	-	-	-	-
HANKINSON ND US	USC00323908	46.0667	-96.9	04/02	24	04/24	04/16	04/10	03/22	04/11	04/14	03/24	03/10	04/23	04/16	04/05	04/01	03/29	03/02	04/07	03/26	03/28	03/20	04/03	04/20	04/19	04/03	03/04	03/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HANNAH 2 N ND US	USC00323936	49	-98.6833	04/18	16	04/25	04/18	04/25	03/22	04/24	05/06	04/07	04/14	05/23	04/22	04/18	04/27	04/14	04/19	04/05	04/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HANSBORO 4 NNE ND US	USC00323963	48.9989	-99.3464	04/16	42	04/25	04/18	04/12	05/02	04/24	04/22	04/04	04/21	04/22	04/18	04/16	04/27	03/29	04/20	03/25	04/18	03/27	04/04	04/30	04/13	04/19	04/03	04/15	04/27	05/01	04/20	05/05	03/26	04/12	04/27	04/24	04/25	04/13	04/10	05/07	04/06	04/10	04/20	05/12	04/12	03/30	04/09	-
HARVEY ND US	USC00324013	47.8083	-99.8758	04/11	31	-	-	-	-	-	-	-	-	-	-	05/02	04/25	04/14	04/23	-	04/14	03/27	03/19	04/28	04/12	04/23	-	03/04	03/27	04/10	03/12	04/16	04/18	03/25	04/25	04/21	04/09	04/13	04/12	04/19	05/06	04/10	04/18	05/05	04/11	03/28	04/07	03/15
HAZELTON 4 NW ND US	USC00324083	46.5172	-100.3486	04/07	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/15	03/26	04/20	03/12	05/05	04/19	04/06	04/07	03/03	04/04	04/11	04/09	04/13	-	04/10	04/16	04/30	04/12	03/30	04/08	03/16
HEART BUTTE DAM ND US	USC00324091	46.5917	-101.8075	04/06	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/11	03/28	04/16	04/29	03/27	04/19	04/06	03/05	03/27	04/20	03/13	04/17	04/18	03/25	04/07	04/22	04/25	04/13	03/15	03/24	04/02	04/10	03/25	05/05	04/15	04/13	04/08	03/16
HILLSBORO 3 N ND US	USC00324203	47.4389	-97.0664	03/31	38	04/14	04/08	04/14	03/22	04/10	03/17	03/27	03/09	04/22	04/12	04/05	03/29	-	03/03	-	-	03/27	03/17	04/29	04/19	03/11	03/20	03/04	03/29	04/13	03/24	04/29	04/19	03/26	03/30	03/21	04/04	-	-	04/17	03/27	03/27	03/23	05/06	03/21	03/08	04/07	03/14
HURDSFIELD 8 SW ND US	USC00324343	47.35	-100.0167	04/18	26	04/25	04/15	03/14	-	04/25	04/21	04/15	-	03/26	04/17	04/17	04/26	05/01	05/02	04/08	04/12	04/05	04/08	04/28	04/21	04/20	04/05	04/15	04/27	04/21	04/30	05/05	04/27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JAMESTOWN STATE HOSPITAL ND US	USC00324418	46.8844	-98.685	03/30	43	04/14	03/12	03/14	03/22	04/10	04/21	04/12	03/09	04/22	04/16	04/06	03/28	04/14	03/02	04/07	04/10	03/27	03/20	03/08	04/19	03/30	03/20	03/04	03/27	03/03	03/12	04/17	04/01	03/25	03/26	03/21	04/03	04/10	04/12	04/18	03/27	04/08	03/30	04/30	04/13	03/09	04/08	03/16
LA MOURE ND US	USC00324937	46.3547	-98.2928	04/05	41	04/14	04/10	03/18	03/23	04/10	04/13	04/13	04/14	04/16	04/17	-	03/29	04/14	04/24	04/07	04/11	03/28	03/20	04/29	03/27	03/12	03/20	03/05	03/28	04/15	03/25	04/18	04/22	04/05	03/30	03/23	04/19	04/13	04/13	-	04/04	03/29	03/24	05/04	04/12	03/09	05/04	03/16
LANGDON EXPERIMENT FARM ND US	USC00324958	48.7622	-98.3447	04/16	43	04/25	04/08	04/14	04/18	04/19	04/15	04/06	04/14	04/22	04/18	04/16	04/15	04/23	04/23	04/07	04/18	03/28	04/06	04/29	04/21	04/19	04/05	04/15	05/03	04/11	04/30	05/05	04/24	04/04	04/25	04/24	04/25	04/13	04/12	05/07	04/05	04/10	04/19	04/19	04/15	03/30	04/09	03/15
LARIMORE ND US	USC00325013	47.8742	-97.7106	04/10	31	04/14	04/08	03/15	04/19	04/16	04/14	04/12	04/10	05/01	04/17	04/16	04/26	-	-	-	-	-	03/19	04/28	04/23	04/19	04/02	04/28	03/26	04/13	03/17	05/06	04/01	04/06	03/27	03/22	04/05	04/12	04/09	04/19	-	04/11	-	-	-	-	-	-
LEEDS ND US	USC00325078	48.2881	-99.4317	04/14	37	04/24	04/06	04/14	03/22	04/19	04/16	04/08	04/14	04/23	04/22	04/17	04/26	04/23	04/24	04/05	04/18	03/27	04/13	04/29	04/14	04/20	04/02	03/05	04/27	04/12	04/29	04/10	-	04/11	04/12	04/21	04/11	04/12	04/12	04/18	04/04	04/09	04/20	-	-	-	-	-
LIDGERWOOD ND US	USC00325186	46.0725	-97.1461	03/31	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/08	04/11	03/19	04/14	04/05	03/28	03/12	04/18	04/13	03/08	04/08	03/11
LINTON ND US	USC00325210	46.2667	-100.2306	04/04	34	04/26	04/16	04/11	03/22	04/10	04/06	03/23	03/24	03/27	04/16	04/01	-	03/15	-	-	04/11	04/02	03/20	04/29	03/26	04/19	03/20	03/03	03/27	04/16	03/24	04/17	03/26	04/05	04/06	05/02	-	04/13	04/12	03/24	04/03	04/10	03/27	-	-	-	-	-
LISBON ND US	USC00325220	46.4386	-97.6856	04/04	40	04/13	04/18	03/19	03/23	04/20	04/26	04/13	04/10	04/22	04/18	04/16	03/28	03/28	03/02	03/25	03/23	03/28	03/23	04/30	04/20	-	05/03	03/05	03/28	04/15	03/17	04/18	04/18	03/25	03/26	03/06	04/03	04/13	03/18	04/05	04/04	04/10	03/28	05/04	03/22	-	04/08	-
MANDAN EXPERIMENT STATION ND US	USC00325479	46.8128	-100.9097	04/05	43	04/10	04/19	04/11	03/22	04/10	04/21	04/07	04/08	03/27	04/17	04/16	04/15	03/15	04/24	04/06	04/10	03/28	03/20	04/11	03/27	04/19	03/20	03/05	03/07	04/16	03/12	04/17	03/26	04/05	04/07	04/21	04/25	04/13	04/12	03/25	03/27	04/10	04/15	04/30	04/12	03/29	04/06	03/14
MAX ND US	USC00325638	47.8214	-101.2922	04/11	43	04/26	04/18	04/26	03/22	04/19	04/23	04/09	04/09	03/27	04/17	04/16	04/24	04/14	04/21	04/06	04/12	04/05	03/05	04/28	04/20	04/19	04/05	04/16	03/25	04/21	04/23	04/23	04/18	04/10	03/26	03/29	04/24	04/11	04/10	04/05	04/03	04/09	04/15	04/14	04/13	03/30	04/10	03/14
MAYVILLE ND US	USC00325660	47.4989	-97.3514	04/04	29	04/12	04/06	04/12	03/22	04/10	04/14	04/13	03/09	04/22	04/12	04/16	03/24	04/14	04/22	04/07	03/22	03/30	03/19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/03	03/18	04/05	03/29	04/10	04/19	05/15	03/21	03/09	03/20	03/16
MC CLUSKY ND US	USC00325710	47.4825	-100.4444	04/06	41	04/26	04/18	04/26	03/21	04/19	04/21	04/06	04/08	03/26	04/16	04/16	04/15	04/22	04/20	-	-	03/22	03/21	04/02	04/19	04/19	04/05	03/04	03/24	04/16	03/11	04/17	03/25	03/25	03/26	04/21	04/12	04/10	04/12	04/05	04/02	04/09	04/15	04/14	04/12	03/08	04/06	03/10
MC HENRY 3 W ND US	USC00325730	47.5808	-98.6422	04/12	41	04/25	-	04/14	04/18	04/11	04/22	04/13	04/09	04/22	04/17	04/16	04/25	04/14	04/24	04/07	04/11	04/17	-	04/29	04/19	04/19	04/01	03/04	03/27	04/12	03/24	04/17	04/18	04/05	04/09	03/30	04/25	04/11	04/09	05/05	04/07	04/10	04/19	04/30	04/12	03/29	04/09	03/16
MC LEOD 3 E ND US	USC00325754	46.3911	-97.2392	04/02	43	04/14	04/15	04/10	03/23	04/10	04/14	04/13	03/10	04/16	04/16	04/06	03/29	03/28	03/02	04/06	04/18	03/28	03/18	04/29	04/19	04/19	04/02	03/04	03/27	04/07	03/23	04/17	04/18	03/26	04/05	03/06	04/09	04/10	03/18	04/05	04/04	03/27	03/24	05/05	03/22	03/08	04/07	03/14
MC VILLE ND US	USC00325764	47.7619	-98.1817	04/05	27	04/25	04/18	03/14	03/22	04/14	04/20	04/08	03/09	04/22	04/17	04/06	03/28	03/27	04/21	03/24	03/22	03/28	04/05	04/29	04/19	03/10	04/02	03/04	04/27	04/22	03/23	04/17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MINNEWAUKAN ND US	USC00325848	48.0781	-99.2656	04/09	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/27	04/16	03/12	05/05	04/23	03/26	04/09	04/21	04/25	04/11	04/12	04/18	04/05	04/10	04/20	04/30	04/13	03/30	03/16	03/18
MINOT EXPERIMENT STATION ND US	USC00325993	48.1803	-101.2964	04/10	43	04/25	04/18	04/09	03/22	04/18	04/23	04/08	04/09	03/29	05/12	04/15	04/25	04/14	04/23	05/04	04/18	04/09	03/05	04/02	04/13	04/19	04/02	04/28	03/24	04/11	03/11	05/06	04/18	04/11	04/08	04/22	04/05	04/12	03/22	04/04	03/28	04/10	04/14	04/14	04/12	03/30	04/24	03/14
MOFFIT 3 SE ND US	USC00326015	46.6706	-100.2294	04/12	43	04/26	04/18	04/11	04/17	04/19	04/21	04/12	04/13	04/05	04/17	04/18	04/15	04/14	04/21	04/06	04/17	03/27	03/20	04/28	04/19	04/19	04/05	03/04	03/27	04/16	03/24	04/17	03/26	04/20	04/20	05/01	04/04	04/10	04/22	04/14	04/12	04/11	04/18	04/29	04/14	03/30	04/26	03/14
MOHALL ND US	USC00326025	48.7603	-101.5089	04/16	43	04/25	04/18	04/19	05/04	04/14	04/22	04/08	05/03	04/23	05/12	04/15	04/24	04/22	04/23	04/05	04/12	03/27	04/06	04/02	04/19	04/20	04/02	04/16	05/02	04/12	04/19	05/14	04/18	03/25	04/24	04/21	04/25	04/12	04/13	04/05	03/28	04/11	04/25	05/12	04/16	03/30	04/10	04/01
MUNICH 11 SSW ND US	USC00326195	48.5167	-98.9167	04/16	13	04/15	04/19	04/21	03/22	04/19	04/21	04/06	04/14	04/22	04/18	04/16	04/15	04/22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAPOLEON ND US	USC00326255	46.5067	-99.7692	04/08	43	04/26	04/10	04/11	03/22	04/11	04/22	04/07	04/08	04/22	04/16	04/05	04/25	04/12	04/24	04/06	04/11	03/27	03/20	04/28	04/20	04/19	03/20	03/05	03/27	04/20	03/24	05/04	04/18	04/05	04/20	03/05	04/05	04/11	04/13	04/14	04/07	04/10	03/26	04/30	04/12	03/30	04/07	03/16
NEW SALEM 5 NW ND US	USC00326365	46.8925	-101.4897	04/11	43	04/26	04/16	04/11	04/17	04/17	04/22	04/12	04/08	04/22	04/17	04/16	04/15	04/23	04/24	04/07	04/12	03/27	04/05	04/03	04/13	04/19	04/05	03/05	03/24	04/16	03/12	04/30	04/18	04/11	04/08	04/21	04/24	04/13	04/09	04/18	04/02	04/09	04/18	05/12	04/14	03/30	04/07	03/16
OAKES 2 S ND US	USC00326620	46.1458	-98.0919	04/08	41	04/15	04/10	04/10	04/18	04/11	-	05/08	04/09	04/16	04/17	04/06	03/28	03/28	03/02	04/06	04/11	03/28	04/08	04/03	04/20	04/19	04/03	03/05	03/28	04/15	03/23	05/03	04/19	03/26	04/06	03/23	04/04	04/12	05/03	-	04/03	04/10	03/29	05/05	04/11	03/31	04/23	03/20
PARK RIVER ND US	USC00326857	48.4	-97.75	04/05	25	04/12	04/08	03/14	03/22	04/11	04/12	04/12	04/10	04/09	04/18	04/16	04/21	04/22	03/03	03/26	03/22	03/28	04/06	04/28	04/22	04/19	04/03	03/04	-	04/11	03/12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PETERSBURG 2 N ND US	USC00327027	48.0356	-98.01	04/12	42	04/06	04/08	04/14	04/19	04/12	04/15	04/07	04/09	-	04/18	04/16	04/26	05/01	04/24	04/07	04/13	04/18	04/05	04/29	04/22	04/19	04/05	03/05	03/27	04/11	04/29	05/05	04/20	04/05	04/08	03/23	04/09	04/12	04/14	05/07	04/07	04/13	04/16	04/18	04/12	03/11	04/08	03/14
PETTIBONE ND US	USC00327047	47.1167	-99.5333	04/12	29	04/25	04/18	04/14	03/22	04/10	04/21	04/12	04/11	04/15	04/16	04/16	04/15	04/14	04/24	04/07	04/11	04/17	03/20	04/11	04/19	04/19	04/05	04/15	03/27	04/16	04/14	05/05	04/18	03/25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RIVERDALE ND US	USC00327585	47.4981	-101.375	04/14	24	05/07	04/18	03/17	03/22	04/19	04/22	04/13	04/07	03/26	04/17	04/29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/05	05/02	05/15	-	05/21	03/24	04/20	04/08	03/25	04/14	04/14	04/13	04/06	03/10
ROLETTE 2 SE ND US	USC00327655	48.6297	-99.8069	04/18	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/21	04/26	04/13	04/12	05/07	04/07	04/11	04/21	05/12	04/14	04/13	04/25	03/17
ROLLA 1 NE ND US	USC00327664	48.8811	-99.5861	04/16	39	05/06	04/08	04/25	04/18	04/24	05/03	04/05	04/09	04/22	05/16	04/17	04/26	04/22	04/20	04/03	04/18	05/04	04/05	04/28	04/20	04/20	04/02	04/15	04/21	04/11	03/12	05/05	04/18	03/26	04/08	03/04	04/24	04/12	04/09	05/07	04/04	04/10	04/19	-	04/13	-	-	-
RUGBY ND US	USC00327704	48.3542	-99.9925	04/07	43	04/11	04/06	04/08	03/21	04/10	04/14	04/06	03/08	04/15	04/16	04/16	03/23	04/23	04/24	03/26	04/10	03/26	03/18	04/28	04/19	04/19	04/05	03/04	03/27	04/16	03/12	05/05	04/22	04/10	03/26	03/23	04/18	04/14	04/12	04/18	04/07	04/03	04/18	05/06	04/12	03/09	04/24	03/17
SHARON ND US	USC00327986	47.5983	-97.9	04/11	33	04/24	04/18	04/14	04/18	04/19	04/21	04/12	04/09	04/22	04/18	04/06	04/15	04/23	04/21	04/06	04/12	04/05	03/19	04/29	04/19	04/19	04/05	03/04	04/26	04/12	03/12	05/05	04/17	03/26	04/06	03/05	04/07	04/12	-	-	-	-	-	-	-	-	-	-
SHEYENNE ND US	USC00328057	47.8333	-99.1167	04/16	13	04/25	04/18	04/14	04/17	04/19	04/21	04/08	04/14	04/15	04/17	04/16	04/15	04/14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STEELE ND US	USC00328366	46.8917	-99.9325	04/08	38	05/06	04/10	04/14	03/22	04/10	04/20	04/12	04/07	04/15	04/17	-	04/15	04/14	04/24	03/22	05/03	-	03/20	-	-	-	04/02	03/05	03/27	04/12	03/13	04/17	04/18	03/25	03/26	04/22	04/25	04/11	04/12	04/18	04/07	04/13	04/18	04/14	04/12	03/29	04/06	03/16
STREETER 7 NW ND US	USC00328415	46.7153	-99.4475	04/15	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/29	04/20	04/20	03/20	04/15	03/27	04/21	05/01	05/06	04/20	04/05	04/09	04/22	04/25	04/11	04/13	05/05	04/04	04/10	04/19	05/19	04/12	03/30	04/08	03/16
TOWNER 2 NE ND US	USC00328792	48.3706	-100.3908	04/17	43	04/25	04/18	04/26	04/18	04/16	04/16	04/12	04/14	04/16	05/16	04/18	04/28	04/23	04/24	04/07	04/18	04/23	03/20	04/29	04/20	04/20	04/04	03/05	05/03	04/16	04/14	04/23	04/23	03/26	04/13	04/21	04/26	04/12	04/23	05/05	04/08	04/10	04/19	05/13	04/13	03/30	04/10	04/05

						First Annual Date Cooresponding to Tmin > 32° F for Three Consecutive Days (March - May)																																										
Observation Location	Code	Latitude	Longitude	Average VTP	Years With Data	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TURTLE LAKE ND US	USC00328840	47.5214	-100.8883	04/12	43	04/24	04/18	04/10	03/21	04/19	04/22	03/23	04/09	03/27	04/17	04/18	04/15	04/22	04/21	04/05	04/11	03/27	04/07	04/02	04/21	04/19	04/05	04/28	03/27	04/20	04/14	05/14	04/22	04/10	04/24	04/21	04/25	04/11	04/11	04/05	04/03	04/10	04/18	05/05	04/15	03/30	04/08	03/17
TUTTLE ND US	USC00328850	47.1333	-100	04/13	26	04/25	04/18	04/11	03/22	04/11	04/21	04/12	04/09	04/16	04/17	04/16	04/25	04/14	04/21	04/07	04/12	04/02	03/20	04/29	04/20	04/19	03/21	04/28	03/27	04/20	05/01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TUTTLE 12 NNE ND US	USC00328853	47.3014	-99.9189	04/13	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/08	04/21	04/25	04/11	04/11	04/19	04/05	04/10	03/24	04/30	04/13	03/30	04/27	04/13
UNDERWOOD ND US	USC00328872	47.455	-101.1461	04/11	40	04/25	04/18	04/11	03/22	04/10	04/22	04/06	04/08	03/27	04/17	04/16	04/15	-	-	04/07	04/11	03/28	04/07	04/29	04/19	04/19	04/02	04/14	04/26	04/16	03/12	04/17	04/18	-	04/10	04/22	04/25	04/11	04/10	04/19	04/02	04/10	04/15	05/04	04/12	03/30	04/07	03/15
UPHAM 3 N ND US	USC00328913	48.6147	-100.7264	04/15	43	04/27	04/18	04/21	03/22	04/24	04/25	04/07	04/14	04/16	05/15	04/20	04/15	04/14	04/24	03/25	04/18	04/17	03/19	04/29	04/14	04/20	04/05	04/16	03/27	04/22	04/19	05/14	04/23	04/22	04/09	04/22	04/25	04/13	04/12	05/07	04/08	04/09	04/18	05/06	04/12	03/09	04/09	03/17
VALLEY CITY 3 NNW ND US	USC00328937	46.9558	-98.0203	04/08	42	04/25	04/18	04/15	04/18	04/11	04/29	04/16	03/10	04/27	04/16	04/18	03/29	04/23	03/03	03/26	03/23	03/28	03/19	04/30	04/20	04/20	04/06	03/05	03/26	04/24	03/24	05/05	04/27	03/26	04/20	03/24	04/10	04/14	04/13	04/19	04/09	04/10	03/29	04/30	03/22	03/09	04/08	-
VELVA ND US	USC00328990	48.0797	-100.875	04/15	39	04/24	04/18	04/29	03/22	04/24	04/17	04/08	04/14	04/16	04/16	04/16	04/15	04/14	05/03	04/07	04/19	03/27	-	05/01	04/21	04/19	04/02	04/28	03/27	04/12	03/25	04/17	04/20	04/11	04/09	04/25	04/26	04/14	04/13	04/28	04/08	04/16	04/24	05/12	-	03/29	-	-
WAHPETON 3 N ND US	USC00329100	46.3233	-96.6108	03/28	30	04/14	04/10	04/10	03/22	04/10	04/13	04/07	03/10	04/08	03/17	04/06	03/28	03/29	03/01	03/26	03/25	03/28	03/17	03/22	04/19	03/11	03/19	03/04	04/07	04/07	03/12	04/17	04/01	03/25	03/27	-	-	-	-	-	-	-	-	-	-	-	-	-
WASHBURN ND US	USC00329195	47.2844	-101.0267	04/05	40	04/25	04/18	03/14	03/22	03/11	04/22	03/23	03/07	03/26	04/16	04/16	04/15	03/15	04/20	04/05	04/11	03/27	03/20	04/02	04/20	04/19	04/01	04/14	03/27	-	-	05/12	03/27	03/26	04/07	04/22	04/25	04/12	04/09	04/14	04/03	04/10	03/11	04/15	04/14	03/29	04/07	-
WESTHOPE ND US	USC00329333	48.9097	-101.0192	04/14	43	04/25	04/18	04/21	04/17	04/18	04/22	04/06	04/13	04/16	04/17	04/20	04/15	04/12	04/19	03/24	04/18	04/05	03/20	04/29	04/20	04/19	04/05	04/27	05/03	04/22	03/12	05/05	04/17	04/09	04/08	04/21	04/18	04/13	04/12	04/18	04/07	04/09	04/18	04/29	05/04	03/30	04/08	03/16
WILLOW CITY ND US	USC00329445	48.6061	-100.2911	04/17	43	04/27	04/18	04/25	04/18	04/19	04/17	04/07	04/15	04/16	04/22	04/16	04/25	04/23	04/20	03/26	04/28	04/22	03/20	04/30	04/20	04/19	04/05	04/16	04/26	04/22	04/14	05/05	04/18	04/11	04/08	04/22	04/25	04/13	04/12	05/07	04/07	04/10	04/20	05/23	04/12	03/31	04/09	04/28
WILTON ND US	USC00329455	47.1603	-100.7892	04/12	41	04/24	04/10	04/10	04/17	-	04/22	04/06	04/07	03/27	04/17	04/16	04/25	04/23	04/21	04/10	04/10	03/28	04/05	04/29	04/24	04/19	04/02	04/26	03/25	03/03	03/11	05/05	03/25	04/27	04/10	04/21	04/24	04/10	04/09	04/04	04/02	04/11	04/15	04/16	04/14	03/30	04/24	-
WISHEK ND US	USC00329515	46.2608	-99.56	04/10	39	04/27	04/18	04/27	03/22	04/19	04/15	04/23	04/09	04/22	04/17	04/18	04/24	04/14	04/24	04/08	04/11	03/28	03/20	04/30	04/20	03/30	04/02	03/05	03/27	04/16	04/14	04/16	04/20	04/05	04/20	04/22	04/10	-	-	-	-	04/09	04/19	04/30	03/22	03/30	04/08	04/06
ANDOVER SD US	USC00390198	45.4136	-97.9069	04/04	15	04/25	04/10	04/09	03/22	04/10	04/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/26	03/25	03/30	03/06	04/04	04/10	03/31	04/14	03/28	-	-	-	-	-	-	-
ARLINGTON 1 W SD US	USC00390281	44.3631	-97.1703	03/26	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/24	04/14	03/11	03/11	04/18	03/25	03/30	03/05	04/04	04/10	03/17	03/24	04/04	03/27	03/24	04/15	03/15	03/12	04/07	03/10
ASTORIA 4 S SD US	USC00390422	44.5044	-96.5319	04/01	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/11	05/04	04/19	04/11	04/07	03/04	04/05	04/11	04/11	03/24	03/28	03/29	03/24	04/15	04/15	03/13	04/07	03/11
BRITTON SD US	USC00391049	45.7908	-97.75	03/28	43	04/14	04/10	03/14	04/17	04/10	04/13	03/23	03/10	04/08	04/16	04/05	03/28	04/14	03/04	03/25	03/21	03/28	03/18	04/03	04/19	03/28	03/20	03/04	03/27	04/07	03/22	04/17	03/31	03/26	03/26	03/05	04/03	04/10	03/14	03/27	03/28	04/05	03/12	04/29	03/21	03/08	04/07	03/13
BROOKINGS 2 NE SD US	USC00391076	44.3253	-96.7686	03/28	43	04/16	04/18	04/10	03/11	04/11	04/06	04/13	03/11	04/06	03/18	04/06	03/28	03/15	03/01	04/07	03/24	03/24	03/23	04/03	03/27	03/12	03/20	03/05	03/27	03/18	03/12	04/18	04/19	03/26	03/30	03/22	04/03	04/13	03/18	03/25	04/04	03/27	03/24	04/30	04/15	03/09	04/06	03/14
CASTLEWOOD SD US	USC00391519	44.7269	-97.0261	04/01	42	04/25	04/15	04/10	03/23	04/10	04/13	03/23	03/10	04/05	04/16	04/06	03/28	03/15	03/01	04/01	03/22	03/28	03/19	04/03	03/27	03/11	04/01	03/05	03/28	04/15	03/23	05/05	04/19	03/27	04/07	03/22	04/08	04/12	04/10	03/24	04/04	03/27	03/24	05/05	04/15	04/12	04/09	-
CLARK SD US	USC00391739	44.8817	-97.7325	03/30	43	04/24	04/10	04/10	03/22	04/10	04/14	03/23	03/10	04/05	04/16	04/18	03/28	03/15	03/01	04/07	03/25	03/28	04/07	04/03	04/14	03/12	03/19	03/05	03/27	04/14	03/12	05/05	04/19	03/26	03/30	03/06	04/05	04/11	03/15	03/01	04/04	03/28	03/24	04/19	04/13	03/30	04/08	03/14
CLEAR LAKE SD US	USC00391777	44.7592	-96.6872	03/29	43	04/24	04/10	04/15	03/22	04/10	04/13	04/09	03/10	04/05	04/16	04/06	03/28	03/29	03/02	04/08	03/21	03/28	03/19	04/02	03/26	03/11	03/17	03/04	03/26	03/17	03/11	04/17	04/18	03/25	04/06	03/05	04/09	04/11	03/18	03/25	04/04	03/28	03/25	04/04	04/12	03/13	04/08	03/16
COLUMBIA 8 N SD US	USC00391873	45.725	-98.3	04/03	43	04/14	04/15	03/19	03/05	04/10	04/15	04/12	03/24	04/26	04/16	04/18	03/27	03/28	03/01	04/06	03/24	03/27	03/19	04/02	04/19	04/18	04/01	03/04	03/27	04/13	04/26	04/17	04/18	04/04	03/29	03/21	04/09	04/12	04/11	04/14	04/08	03/28	03/28	04/30	04/12	03/09	04/07	03/17
CONDE SD US	USC00391917	45.1539	-98.1008	04/04	16	-	-	-	-	-	-	-	-	-	04/16	-	-	-	-	-	-	-	-	-	-	-	-	-	03/24	04/20	03/11	05/05	04/19	03/25	04/08	04/22	04/04	04/11	03/18	03/24	04/04	03/27	03/27	-	-	-	-	-
DE SMET SD US	USC00392302	44.3867	-97.5606	03/27	43	04/06	04/10	03/15	03/31	04/10	04/07	03/18	03/10	03/30	04/16	04/16	03/28	03/28	03/01	04/06	03/26	03/28	03/18	04/02	03/26	03/11	04/02	03/03	03/29	04/11	03/11	04/17	04/19	03/26	04/05	03/04	04/04	04/13	03/14	03/24	04/04	03/27	03/12	04/15	03/15	03/07	03/15	03/11
DUPREE SD US	USC00392429	45.0481	-101.5992	04/03	43	04/26	04/10	04/09	04/17	04/10	04/15	03/18	03/24	03/26	04/16	04/16	03/27	03/14	04/24	04/07	04/02	04/02	04/05	04/28	04/19	04/19	04/01	03/04	03/25	04/16	03/11	04/17	03/26	04/05	04/06	04/22	04/04	04/10	03/17	03/24	03/27	03/31	03/11	04/10	04/14	03/28	04/07	03/10
DUPREE 15 SSE SD US	USC00392446	44.8658	-101.4672	03/29	42	04/24	04/10	03/11	04/17	03/28	04/06	03/23	04/09	03/29	04/13	04/01	04/15	04/11	03/30	04/01	-	03/27	03/05	04/03	03/26	04/19	03/20	03/04	03/25	03/03	03/11	04/17	03/27	03/25	04/06	03/04	04/06	04/10	03/15	03/25	04/02	03/30	03/10	04/18	03/21	03/29	04/06	03/10
EUREKA SD US	USC00392797	45.7644	-99.6353	04/06	43	04/24	04/10	04/09	03/22	04/10	04/21	03/23	03/24	04/15	04/23	04/18	04/15	04/11	04/21	04/06	04/11	03/28	03/20	04/29	03/26	04/19	03/24	03/04	03/27	04/16	04/14	04/17	04/18	04/05	04/20	04/21	04/04	04/10	04/10	03/24	04/03	03/29	03/24	04/30	03/20	03/29	04/07	03/11
FAULKTON SD US	USC00392927	45.0364	-99.1342	03/30	43	04/24	04/10	03/15	03/05	04/10	04/06	04/22	04/08	04/05	04/16	04/05	03/27	03/10	05/01	04/07	04/01	03/28	03/19	04/29	03/26	03/11	03/20	03/04	03/27	03/03	03/12	04/17	03/24	03/25	03/30	03/06	04/03	04/10	04/13	03/27	04/04	03/31	03/12	05/04	04/12	03/30	04/07	03/17
FLANDREAU SD US	USC00392984	44.0517	-96.5928	03/28	43	04/15	04/18	04/10	03/12	04/10	04/06	03/18	03/11	04/05	03/18	04/06	03/27	03/15	03/04	04/07	04/11	03/28	03/18	04/03	03/11	03/12	04/03	03/06	03/27	03/18	03/12	04/18	04/19	03/26	03/30	03/06	04/03	04/13	03/18	03/26	04/04	03/28	03/25	05/04	04/16	03/09	04/06	03/17
FORESTBURG 4 NNE SD US	USC00393029	44.0686	-98.0833	03/23	42	04/14	04/10	03/15	03/05	04/10	04/05	03/18	03/10	03/29	03/17	04/05	03/27	03/15	03/01	03/25	04/10	03/28	03/05	04/02	03/08	03/11	04/02	03/04	03/26	03/17	03/25	04/17	03/31	03/25	03/30	03/05	04/03	04/13	03/14	03/25	04/04	03/27	03/12	04/15	03/22	03/06	-	03/11
FORT SULLY 8 NE SD US	USC00393082	44.6333	-100.4333	03/24	12	04/27	03/13	03/15	03/17	04/10	03/19	03/23	04/06	03/19	-	04/17	-	03/10	03/01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GANN VALLEY 4 NW SD US	USC00393217	44.0569	-99.0719	03/30	40	04/25	04/10	03/14	03/22	04/10	04/14	03/18	03/10	04/05	03/20	03/14	03/28	03/15	04/21	04/01	04/02	03/28	03/18	04/03	03/24	04/19	04/01	03/04	03/25	04/15	03/24	05/01	03/31	03/25	03/30	03/21	04/04	04/13	03/17	03/24	04/08	03/29	03/24	04/16	04/12	-	-	-
GETTYSBURG SD US	USC00393294	45.0194	-99.9403	03/31	42	04/24	04/10	03/15	03/22	04/11	04/07	04/06	04/08	04/06	04/16	04/17	04/06	03/15	04/21	04/07	04/10	03/28	04/08	04/03	03/26	03/11	04/01	03/05	03/26	03/03	03/11	04/17	03/19	04/04	03/29	03/04	04/03	04/09	03/18	04/01	-	04/10	03/24	05/06	04/13	03/30	04/08	03/14
GETTYSBURG 13 W SD US	USC00393302	45.0136	-100.2175	04/12	17	-	-	-	-	-	-	-	-	04/14	04/16	04/18	03/27	03/15	04/21	-	-	-	04/24	04/30	-	-	-	-	-	-	-	-	04/17	04/04	04/05	03/19	-	-	-	04/23	04/03	05/05	03/25	05/05	-	-	-	-
GLAD VALLEY 2 W SD US	USC00393316	45.4178	-101.81	04/05	42	04/05	04/15	03/15	03/21	04/10	04/21	04/12	04/07	03/26	04/17	04/16	04/21	04/13	05/02	-	04/02	03/28	04/06	05/21	04/19	04/18	03/19	03/03	03/24	04/20	03/10	04/29	03/26	04/10	04/05	04/22	04/05	04/11	03/15	03/25	04/02	03/30	03/25	05/04	03/20	03/29	04/08	03/14
HARROLD 12 SSW SD US	USC00393608	44.3628	-99.8033	04/02	36	04/27	04/14	03/18	03/21	04/10	-	03/23	03/10	04/15	04/16	05/02	04/10	03/14	03/04	03/25	04/11	03/27	04/16	04/29	03/24	03/11	03/20	03/04	03/27	04/15	03/11	04/09	-	-	-	05/03	-	-	-	03/25	04/04	04/05	03/26	04/30	04/12	03/31	04/21	03/14
HIGHMORE 1 W SD US	USC00393832	44.5222	-99.455	04/02	42	04/24	04/10	03/19	03/21	04/10	04/06	03/18	04/07	04/14	04/15	04/18	04/19	04/13	04/24	03/23	03/21	04/18	03/19	04/03	03/26	04/19	04/01	03/04	03/27	04/15	03/11	04/08	03/26	04/21	04/20	03/05	04/04	04/10	03/14	04/05	03/28	03/29	03/11	04/29	04/12	03/29	-	03/10
HIGHMORE 23 N SD US	USC00393838	44.8444	-99.4894	04/03	42	04/26	04/10	03/15	03/22	04/10	04/06	03/18	04/08	04/05	04/16	04/06	03/27	04/14	03/04	04/07	04/15	03/28	03/18	04/29	03/26	03/11	03/20	03/04	03/27	04/14	03/11	05/02	04/17	04/06	03/22	04/18	04/18	04/10	04/12	03/24	04/03	04/09	03/23	05/04	04/12	03/28	04/06	-
HOPEWELL 1 SE SD US	USC00393987	44.5	-100.8667	03/31	14	04/05	04/07	04/10	03/23	03/28	04/06	03/18	03/24	03/26	04/15	04/05	03/27	03/14	04/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOWARD SD US	USC00394037	44.0122	-97.5242	03/24	43	04/25	04/10	03/14	03/05	04/10	04/06	03/23	03/10	03/29	03/17	04/06	03/27	03/15	03/01	03/25	03/20	03/28	03/17	04/01	03/09	03/11	03/20	03/04	03/25	04/13	03/10	04/09	03/30	03/25	03/29	03/04	04/02	04/09	03/14	03/24	03/28	03/27	03/12	05/05	04/13	03/13	04/06	03/11
IPSWICH SD US	USC00394206	45.4478	-99.0383	04/06	43	04/24	04/10	03/19	03/22	04/10	04/06	04/15	04/09	04/14	04/16	04/15	04/03	04/13	05/05	04/07	04/19	03/28	03/18	04/29	04/20	03/11	03/20	03/04	03/27	04/14	04/23	04/17	04/18	03/27	04/20	03/23	04/04	04/11	04/13	04/05	04/04	03/27	03/12	04/30	04/12	03/11	04/06	03/17
KENNEBEC SD US	USC00394516	43.9072	-99.8628	03/27	43	04/25	04/10	03/14	03/21	03/01	04/06	03/23	03/24	03/20	03/16	04/18	03/27	03/14	04/18	03/24	04/02	03/27	04/08	04/03	03/24	03/11	03/20	03/03	03/27	04/15	03/24	05/01	03/26	03/24	03/30	04/18	04/03	04/10	03/14	03/25	03/28	03/29	03/12	04/15	04/12	03/07	03/18	03/10
KIRLEY 6 N SD US	USC00394596	44.6122	-101.3369	03/25	42	-	03/12	03/15	03/21	03/28	04/07	03/18	03/08	03/26	03/16	04/16	03/27	04/12	03/30	04/01	04/02	03/22	04/05	03/22	03/26	04/18	03/19	03/01	03/26	03/03	03/12	04/17	03/26	03/25	03/26	04/21	04/04	04/06	03/15	03/24	04/04	03/30	03/11	04/10	03/21	03/29	03/15	03/10
LEOLA SD US	USC00394891	45.7192	-98.9439	03/31	38	04/15	04/10	04/16	03/23	04/10	04/14	04/13	03/11	04/15	04/16	04/05	04/25	04/14	03/02	04/07	04/10	03/27	03/19	04/03	03/27	03/11	04/01	03/04	03/28	03/03	03/12	04/18	04/18	03/25	04/05	03/23	04/04	04/13	03/18	04/05	03/27	03/29	03/25	-	-	-	-	-
MADISON 2 SE SD US	USC00395090	43.9906	-97.0925	03/24	40	04/15	04/10	03/15	03/22	04/10	04/06	03/18	03/10	03/29	03/17	04/04	03/28	03/13	03/01	04/01	03/21	03/28	03/05	04/03	03/11	03/12	03/17	03/04	04/07	03/04	03/11	04/10	04/18	03/26	04/05	03/22	04/03	04/13	03/18	03/25	04/04	03/28	03/24	-	-	-	04/06	03/10
MC INTOSH 6 SE SD US	USC00395381	45.8383	-101.2767	04/02	42	04/05	04/10	04/09	03/21	04/10	04/21	04/05	04/07	-	04/17	04/16	04/15	04/12	04/21	04/07	04/10	03/27	04/05	04/03	03/26	03/29	03/20	03/04	03/26	03/03	03/12	03/11	03/26	03/26	04/06	04/22	04/24	04/10	04/12	03/24	03/27	04/09	03/11	04/30	04/14	03/29	04/07	03/14
MC LAUGHLIN SD US	USC00395406	45.8133	-100.8072	04/08	41	04/26	04/16	04/09	03/22	-	04/21	04/06	04/16	04/26	04/16	03/31	04/24	04/22	04/24	04/19	04/11	03/28	04/15	04/29	03/26	04/18	04/02	03/04	03/26	-	04/30	04/16	03/26	04/05	03/25	04/21	04/04	04/13	04/11	03/23	04/04	04/10	03/25	05/05	03/20	03/30	04/08	03/16
MELLETTE 4 W SD US	USC00395456	45.155	-98.5825	04/04	42	04/07	04/10	03/15	03/22	-	04/06	03/24	04/08	04/15	04/16	04/06	03/28	04/12	04/23	04/06	04/14	03/28	03/19	04/30	03/26	04/19	03/20	03/05	03/27	04/15	03/12	05/02	03/31	04/05	03/30	04/18	04/04	04/13	04/14	04/16	04/04	03/28	03/29	04/30	04/13	03/12	04/08	03/15
MIDLAND SD US	USC00395506	44.0667	-101.15	04/02	40	04/25	04/10	03/15	04/17	04/10	04/05	04/09	-	04/07	03/16	04/18	03/27	03/15	03/04	03/25	04/11	03/09	04/16	04/29	03/25	04/18	03/20	03/03	03/26	04/15	03/18	04/17	04/28	03/24	04/22	04/22	04/03	04/06	03/17	03/25	04/04	03/30	03/12	04/29	04/11	03/29	-	-
MILBANK 2 SSW SD US	USC00395536	45.2836	-96.6689	03/30	38	04/14	03/12	04/09	03/23	04/10	04/13	03/24	03/12	04/24	04/17	04/06	03/29	04/14	03/03	04/08	03/25	03/28	03/23	04/04	03/26	03/12	04/22	03/05	03/29	03/18	03/12	04/18	-	-	04/06	03/06	04/05	04/13	03/22	03/27	03/29	03/28	03/12	04/30	04/16	-	-	-
MILESVILLE 5 NE SD US	USC00395544	44.5208	-101.6192	03/29	43	04/25	04/10	03/15	03/31	04/10	03/19	04/07	03/24	03/20	04/15	04/01	03/27	03/12	04/24	03/25	04/02	03/02	04/07	04/29	03/24	04/18	04/01	03/02	03/26	03/17	03/11	04/16	04/17	03/24	03/26	04/22	04/04	04/06	03/15	03/24	03/27	03/30	03/11	04/14	03/20	03/29	03/19	03/11
MILLER SD US	USC00395561	44.5178	-98.9814	03/28	42	04/05	03/12	03/14	03/10	04/10	04/06	03/18	03/10	03/29	04/15	04/16	03/28	04/12	03/04	04/02	04/02	03/27	03/18	04/03	03/25	03/11	03/19	03/03	04/06	03/17	03/10	05/01	03/29	03/25	04/05	03/05	04/04	04/10	04/10	04/14	04/09	04/05	03/12	04/16	04/12	03/30	04/06	-
MOBRIDGE 2 NNW SD US	USC00395691	45.5656	-100.4489	03/29	37	04/24	04/15	04/09	03/21	04/10	03/19	03/23	03/24	03/29	04/16	03/31	03/27	03/14	03/02	04/06	04/02	03/27	03/19	04/24	03/26	04/18	03/20	03/04	03/27	04/14	03/12	04/23	03/26	-	-	-	-	-	-	03/24	03/27	03/29	03/11	04/09	04/11	03/07	04/07	03/14
MURDO SD US	USC00395891	43.8894	-100.7078	03/25	43	04/05	04/10	03/15	03/22	03/28	04/06	04/05	03/24	04/05	04/13	04/06	03/24	03/15	03/03	03/25	04/02	03/09	04/07	04/03	04/18	04/17	03/31	03/01	03/25	03/02	03/10	03/11	03/26	03/25	03/15	03/03	04/05	04/10	03/15	03/23	03/28	03/29	03/09	04/14	03/15	03/29	03/16	03/10
OAHE DAM SD US	USC00396170	44.4419	-100.4175	03/30	42	04/06	04/16	03/15	03/22	03/29	04/07	03/24	03/25	03/30	04/16	04/15	04/05	03/15	03/04	04/01	04/01	03/22	04/04	04/28	03/25	03/10	03/19	03/04	03/06	03/18	03/22	05/07	03/27	-	03/30	03/01	04/11	04/10	03/18	03/17	04/12	04/05	03/27	04/15	04/15	04/13	05/10	04/24
ONIDA 4 NW SD US	USC00396292	44.7317	-100.1447	04/01	42	-	04/10	05/13	03/22	04/10	04/06	03/17	03/08	03/27	04/19	04/16	04/05	03/14	05/01	04/06	04/11	03/27	04/07	04/29	03/25	04/19	03/20	03/05	03/27	03/03	03/12	04/30	03/31	03/26	04/19	04/18	04/04	04/10	03/14	03/24	04/04	04/04	03/11	05/05	03/20	03/29	03/15	03/10
POLLOCK SD US	USC00396712	45.9042	-100.2875	04/06	43	04/24	04/10	04/10	03/22	04/19	04/21	04/12	04/09	04/22	04/22	04/06	03/27	03/15	05/01	04/07	04/11	03/27	03/18	04/29	03/27	03/29	03/20	03/04	03/27	04/15	03/24	04/17	04/18	04/05	04/06	03/23	04/09	04/16	04/12	03/27	04/04	04/05	03/28	04/30	04/12	03/31	04/07	03/17
PRESHO 7 NW SD US	USC00396790	43.9919	-100.1617	04/02	32	-	-	-	-	-	-	04/09	03/24	05/02	04/16	04/18	03/27	04/23	04/30	03/25	04/15	03/22	04/07	04/30	03/25	03/11	03/19	03/01	03/27	04/14	03/10	04/17	03/26	04/05	04/07	03/05	04/04	04/10	03/14	03/25	04/03	05/08	03/23	-	-	-	-	-
REDFIELD SD US	USC00397052	44.8656	-98.5253	03/29	39	04/25	04/10	03/15	03/05	04/19	04/13	03/24	03/11	03/29	03/17	04/06	03/29	03/12	03/04	03/26	04/11	03/27	03/17	04/03	03/24	04/21	03/20	03/04	03/27	04/15	03/25	05/11	03/31	03/26	04/05	-	-	-	03/18	03/18	04/04	03/28	03/25	04/30	04/12	03/09	04/08	-
ROSCOE SD US	USC00397277	45.4525	-99.3358	04/04	26	04/24	04/15	-	03/23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/20	04/02	03/05	03/28	04/17	03/16	05/02	04/19	04/06	04/08	03/06	04/05	04/11	04/11	03/27	04/03	04/10	03/12	04/19	04/12	03/31	04/07	03/15
ROY LAKE SD US	USC00397326	45.7097	-97.4492	04/04	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/23	04/11	04/13	04/12	04/14	04/04	03/28	03/29	04/30	04/13	03/12	04/11	03/17
SELBY SD US	USC00397545	45.51	-100.0356	04/04	43	04/25	04/10	04/09	03/22	04/19	04/21	04/08	03/27	03/29	04/19	04/18	04/15	03/14	04/24	04/05	04/01	03/27	03/19	04/29	03/26	04/19	03/20	03/05	03/27	04/16	03/11	05/02	04/18	04/05	03/26	04/22	04/05	04/11	03/15	03/23	04/02	04/09	03/24	04/18	03/21	04/19	04/08	03/11
SISSETON SD US	USC00397742	45.6656	-97.0392	03/25	43	04/07	04/06	03/15	03/06	04/10	03/17	04/13	03/09	04/04	04/16	04/05	03/24	03/15	03/01	03/26	03/22	03/28	03/19	03/23	04/21	03/11	04/02	03/04	03/28	03/03	03/11	05/04	04/01	03/26	03/27	03/22	04/19	04/10	03/14	04/05	03/29	04/05	03/11	04/03	03/22	03/08	03/15	03/10
STEPHAN 2 NW SD US	USC00397992	44.2661	-99.4431	04/03	40	04/26	04/15	03/19	04/13	04/10	04/16	03/23	03/24	04/07	04/16	04/16	04/24	04/12	05/05	04/07	04/15	04/02	03/17	04/02	03/24	03/11	03/31	03/04	03/27	04/15	03/23	04/17	03/31	03/25	03/30	03/06	04/04	04/11	03/15	03/25	03/28	04/14	03/25	04/30	03/22	-	-	-
SUMMIT 1 W SD US	USC00398116	45.3036	-97.0625	04/03	42	04/25	04/10	04/16	04/17	04/10	04/14	04/07	04/09	04/22	04/16	04/16	03/23	-	03/04	04/07	03/21	03/27	04/07	03/23	04/20	04/19	04/02	03/04	03/27	04/23	03/11	05/07	04/20	03/26	03/30	03/05	04/10	04/13	03/14	03/24	04/04	03/28	03/28	05/05	03/15	03/11	04/25	03/10
TIMBER LAKE SD US	USC00398307	45.4283	-101.0764	03/29	43	04/24	04/10	04/09	03/21	04/10	04/06	03/18	04/08	03/26	04/16	04/01	04/01	03/14	03/03	04/11	04/10	03/27	04/05	04/03	03/26	04/19	03/20	03/04	03/25	03/03	03/12	03/11	03/26	04/05	03/26	04/21	04/04	04/10	03/15	03/24	03/27	03/29	03/11	04/18	04/12	03/29	04/07	03/13
VICTOR 4 NNE SD US	USC00398652	45.9231	-96.7864	03/29	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	03/12	03/20	03/05	03/28	04/14	03/16	04/18	04/19	03/26	03/27	03/05	04/07	04/10	03/19	04/05	04/08	03/28	03/29	04/18	04/13	03/08	04/08	03/15
WATERTOWN 1 W SD US	USC00398930	44.9028	-97.1136	04/11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/03	05/02	-	-	03/25	04/04	03/28	03/25	05/06	05/01	03/12	04/08	-
WAUBAY NATIONAL WILD LIFE REFUGE SD US	USC00398980	45.4247	-97.3269	04/03	43	04/14	04/10	04/16	03/22	04/19	04/14	04/13	04/09	04/08	04/16	04/16	04/06	04/14	03/04	04/07	04/11	03/28	03/19	03/23	04/03	04/18	04/02	03/04	03/27	04/07	03/12	04/17	04/20	03/26	03/30	03/23	04/04	04/13	03/15	03/27	03/28	03/27	04/16	04/30	03/22	03/29	04/28	03/16
WEBSTER SD US	USC00399004	45.3331	-97.5228	03/30	43	04/24	04/10	04/14	03/22	04/10	04/14	04/13	04/09	04/15	04/16	04/05	03/28	03/28	03/04	04/07	03/21	03/28	03/19	03/23	04/19	03/28	04/02	03/04	03/28	04/12	03/12	04/17	04/18	03/25	04/05	03/05	04/04	04/10	03/14	03/24	03/28	03/27	03/23	04/15	03/15	03/11	04/07	03/10
WENTWORTH 2 WNW SD US	USC00399042	44.0083	-97.0042	03/25	37	04/15	04/15	03/15	03/10	04/10	04/07	03/23	03/11	04/03	04/16	04/06	03/27	03/15	03/01	04/07	03/21	03/28	03/18	04/02	03/26	03/11	03/20	03/04	03/27	03/17	03/11	03/11	04/18	03/25	03/30	03/05	04/03	04/13	03/14	03/24	04/04	03/27	-	-	-	-	-	-
WESSINGTON SPRINGS SD US	USC00399070	44.0761	-98.5706	03/20	43	04/23	04/07	03/15	03/10	03/28	03/17	03/18	03/09	03/26	04/15	03/30	03/23	03/12	03/04	04/01	03/26	03/27	03/05	04/03	03/23	03/12	03/19	03/01	03/06	03/02	03/11	03/11	03/25	03/26	03/27	03/03	04/03	04/10	03/15	03/24	03/27	04/04	03/10	04/04	03/15	03/11	03/16	03/11
ALEXANDRIA MUNICIPAL AIRPORT MN US	USW00014910	45.8678	-95.3942	03/30	42	04/15	04/15	04/16	03/23	04/10	04/13	03/28	03/10	04/08	04/12	04/06	03/24	04/14	03/01	04/07	03/21	03/28	03/18	04/03	04/20	04/18	03/17	03/04	03/25	04/14	03/12	-	04/18	03/26	03/31	03/05	04/07	04/13	03/14	03/25	03/29	03/29	03/24	04/19	03/22	03/07	04/08	03/14
DEVILS LAKE KDLR ND US	USW00014912	48.1069	-98.8681	04/07	39	04/24	04/10	04/14	04/18	04/11	04/15	04/13	03/08	-	04/16	04/16	04/15	04/12	04/23	04/07	04/12	04/05	03/19	04/28	04/19	04/19	04/02	03/04	03/27	03/18	03/12	04/17	-	04/05	04/09	03/22	04/09	04/10	04/12	04/18	04/04	04/10	04/18	04/14	-	-	04/08	03/14
FARGO HECTOR INTERNATIONAL AIRPORT ND US	USW00014914	46.9253	-96.8111	03/28	43	04/13	03/12	03/14	03/22	04/10	03/17	04/12	03/08	04/22	04/12	04/06	03/24	03/28	03/01	03/25	03/21	03/27	03/17	04/03	04/22	04/18	03/20	03/04	03/25	03/17	03/23	04/08	04/18	03/25	03/26	03/20	03/28	04/10	03/18	04/14	04/04	03/27	03/28	04/29	04/11	03/07	04/07	03/16
GRAND FORKS INTERNATIONAL AIRPORT ND US	USW00014916	47.9428	-97.1839	03/31	43	04/12	03/12	04/14	03/22	04/19	04/14	04/01	03/09	04/03	04/12	03/31	03/30	03/28	03/02	03/26	03/21	03/28	03/18	04/29	04/22	03/11	04/02	03/04	03/25	04/11	03/23	04/08	04/01	03/25	03/26	04/22	04/04	04/13	03/18	04/18	04/08	04/09	03/28	04/30	03/21	03/08	04/08	03/16
JAMESTOWN MUNICIPAL AIRPORT ND US	USW00014919	46.9258	-98.6692	04/02	43	04/14	04/18	04/12	03/22	04/10	04/21	04/12	03/09	04/22	04/16	04/06	03/31	03/28	03/02	04/06	03/24	03/27	03/19	04/28	04/01	04/19	04/02	03/04	03/25	04/12	03/12	03/11	03/25	03/25	04/07	03/23	04/03	04/13	04/13	04/14	04/04	04/09	03/30	04/29	04/12	03/08	04/07	03/16
PEMBINA ND US	USW00014924	48.9711	-97.2417	04/11	43	04/14	04/07	04/14	04/19	04/17	04/15	04/13	04/15	04/23	04/18	04/06	04/21	04/22	04/24	04/07	04/12	03/28	04/08	04/29	04/21	04/19	04/02	04/16	03/25	05/08	03/24	05/05	04/24	04/05	03/27	03/24	04/07	04/13	03/23	04/18	04/05	04/10	04/19	04/19	04/12	03/09	04/09	03/15
ST CLOUD REGIONAL AIRPORT MN US	USW00014926	45.5433	-94.0514	03/30	43	04/15	04/07	04/12	03/13	04/11	04/14	04/13	03/11	04/06	03/17	04/06	03/28	04/12	03/03	04/08	04/12	03/28	03/23	04/02	04/20	04/19	03/17	03/04	03/25	04/12	03/12	04/17	04/18	03/25	03/31	03/06	04/05	04/10	03/14	04/05	03/29	03/29	03/25	04/18	03/22	03/09	04/08	03/16
ABERDEEN REGIONAL AIRPORT SD US	USW00014929	45.4558	-98.4131	03/28	43	04/18	04/15	03/14	03/10	04/10	04/05	03/23	03/10	04/15	03/17	04/06	03/28	03/29	03/01	03/25	03/25	03/28	03/18	04/03	03/26	03/11	03/20	03/03	03/25	03/17	03/25	05/04	04/18	03/26	04/05	03/23	04/03	04/13	03/18	04/14	04/04	03/27	03/28	04/29	04/12	03/08	04/07	03/17
HURON REGIONAL AIRPORT SD US	USW00014936	44.3981	-98.2231	03/24	43	04/13	04/15	03/14	03/10	03/01	04/06	03/23	03/10	03/29	03/16	03/28	03/27	03/12	03/12	03/25	04/02	03/27	03/16	04/02	03/11	03/11	03/20	03/03	03/25	03/17	03/11	04/17	03/24	03/25	03/30	03/20	04/03	04/10	03/14	04/14	04/04	03/27	03/12	04/29	04/12	03/08	03/31	03/10
WATERTOWN REGIONAL AIRPORT SD US	USW00014946	44.9047	-97.1494	03/31	43	04/15	04/15	04/10	04/17	04/10	04/14	04/13	03/10	04/15	04/16	04/06	03/27	04/14	03/01	04/07	03/26	03/28	03/19	04/02	04/20	03/11	04/02	03/04	03/27	04/07	03/11	04/17	04/20	03/25	03/30	03/05	04/03	04/13	03/14	03/25	04/04	03/27	03/24	04/30	04/14	03/08	04/07	03/10
REDWOOD FALLS MUNICIPAL AIRPORT MN US	USW00014992	44.5483	-95.0803	03/18	43	04/05	03/12	03/19	03/01	03/02	03/19	03/26	03/09	03/19	03/17	03/18	03/25	03/15	03/01	03/26	03/20	03/28	03/18	03/06	03/10	03/11	03/16	03/03	04/07	03/17	03/11	03/11	03/27	03/25	03/27	03/04	04/04	04/10	03/14	03/24	03/29	03/29	03/24	04/04	03/15	03/07	04/06	03/10
BISMARCK MUNICIPAL AIRPORT ND US	USW00024011	46.7708	-100.7603	04/05	43	04/10	03/12	03/14	03/13	04/10	04/06	04/07	04/08	03/27	04/17	04/06	04/15	04/14	03/02	04/06	04/12	03/28	03/18	04/29	04/20	04/19	03/20	03/04	03/27	04/15	03/24	04/17	04/17	04/05	04/13	04/24	04/24	04/13	04/12	04/14	04/04	04/09	04/18	04/29	04/12	03/08	04/06	03/16
MINOT INTERNATIONAL AIRPORT ND US	USW00024013	48.2553	-101.2733	04/02	42	04/24	04/06	03/13	03/21	04/10	04/14	04/12	03/07	03/25	04/16	04/16	04/15	04/12	04/23	04/04	04/10	03/27	03/19	04/01	04/13	-	04/03	03/05	03/23	03/02	04/13	04/17	03/19	03/25	03/26	03/22	04/06	04/11	03/22	04/18	04/04	04/10	04/14	04/14	04/12	03/28	04/08	03/16
PHILIP AIRPORT SD US	USW00024024	44.0511	-101.6011	04/03	40	04/24	04/10	04/10	03/31	03/01	04/06	04/09	03/24	03/20	04/14	04/16	-	05/02	04/25	03/26	-	03/09	04/08	04/20	04/18	04/18	03/20	03/03	03/26	04/15	03/12	05/07	-	03/25	04/26	04/23	04/03	04/10	03/17	03/25	04/04	03/29	03/12	05/05	03/20	03/29	03/19	03/17
PIERRE REGIONAL AIRPORT SD US	USW00024025	44.3814	-100.2856	03/24	43	04/05	04/10	03/14	03/21	03/11	03/19	03/23	03/24	03/29	03/16	04/16	03/27	03/14	04/17	03/25	04/02	03/22	04/07	04/20	03/11	03/11	03/20	03/01	03/06	03/17	03/11	04/30	03/26	03/24	04/05	03/05	04/03	04/10	03/15	03/24	03/28	03/29	03/12	04/14	04/11	03/06	03/15	03/13
GARRISON ND US	USW00094041	47.6458	-101.4394	04/14	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/23	04/09	04/21	04/24	04/10	04/12	04/18	04/07	04/11	04/15	05/12	04/14	03/29	04/08	03/16
MOBRIDGE MUNICIPAL AIRPORT SD US	USW00094052	45.5464	-100.4078	04/01	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/05	04/05	04/22	04/04	04/10	03/17	03/24	04/02	03/29	03/25	04/30	04/11	03/08	04/07	03/14
BRAINERD CROW WING CO AIRPORT MN US	USW00094938	46.4047	-94.1308	03/30	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	05/07	03/25	03/31	04/22	04/05	04/13	03/14	03/25	03/29	03/29	03/24	04/20	03/22	03/09	04/01	03/17
BAUDETTE INTERNATIONAL AIRPORT MN US	USW00094961	48.7167	-94.6	04/03	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/03	04/06	03/27	04/22	04/07	04/13	04/13	04/18	04/04	03/28	03/24	05/12	03/21	03/14	04/08	03/16
PARK RAPIDS MUNICIPAL AIRPORT MN US	USW00094967	46.9006	-95.0678	04/06	43	04/15	04/18	04/27	03/23	04/11	04/16	04/13	03/10	04/17	03/17	04/05	03/28	04/23	03/31	04/11	04/17	04/05	03/18	04/03	04/20	04/19	04/03	03/04	04/27	04/23	04/29	04/17	05/16	03/26	03/31	03/23	04/07	04/13	03/18	04/14	04/04	03/29	03/28	04/30	03/21	03/07	04/08	03/17
SISSETON MUNICIPAL AIRPORT SD US	USW00094993	45.6689	-96.9914	03/27	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	04/05	03/22	04/04	04/10	03/14	04/05	03/29	03/27	03/11	04/30	04/12	03/07	03/15	03/17

Figures

HoustonEngineering Inc.

*Data from NWS/JOR Engineering, Inc.

Virtual Thaw Progression *
(1970-2005 average)

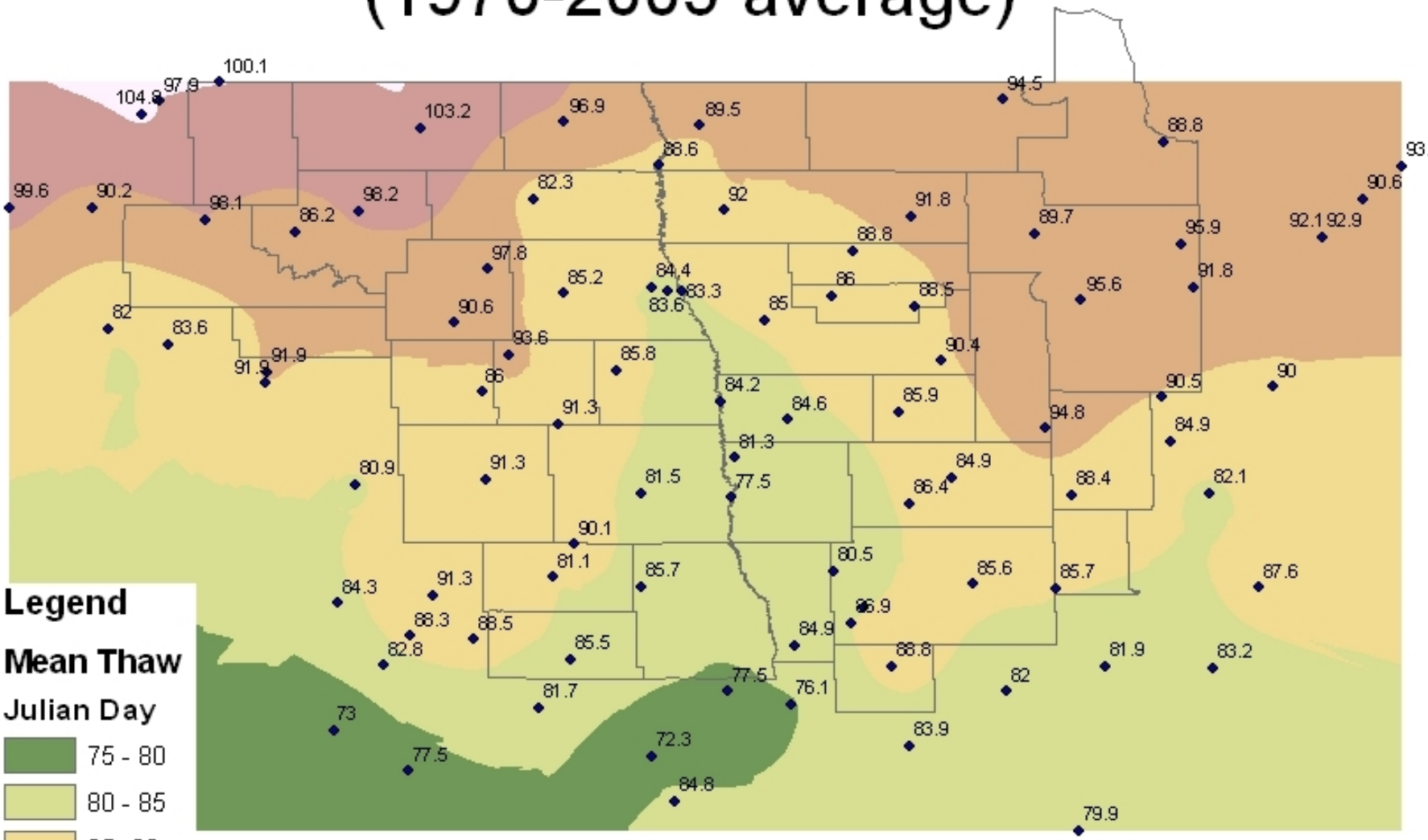


Figure 1

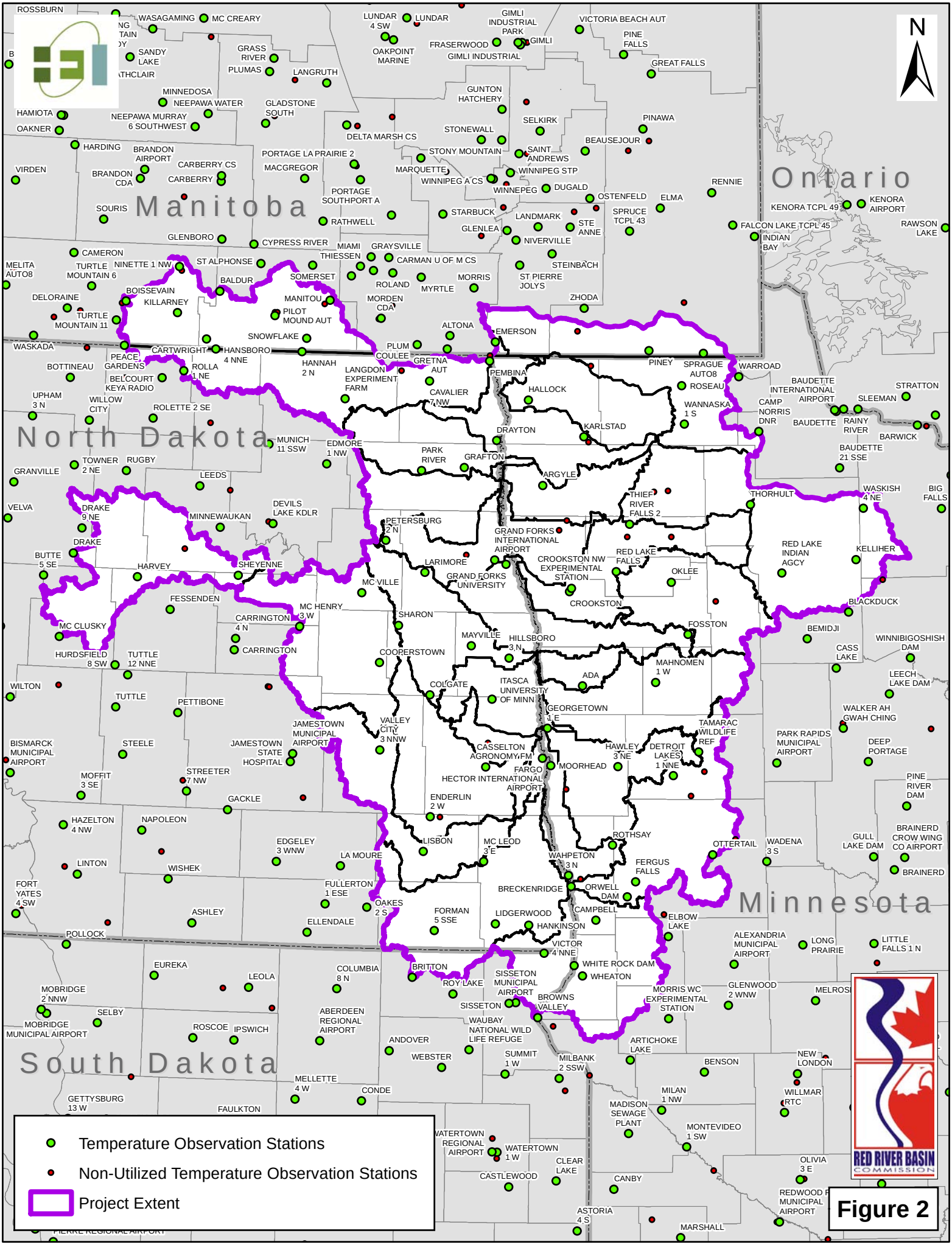

Manitoba
North Dakota
South Dakota
Minnesota
Ontario
N
Temperature Observation Stations
Non-Utilized Temperature Observation Stations
Project Extent
RED RIVER BASIN COMMISSION

Figure 2

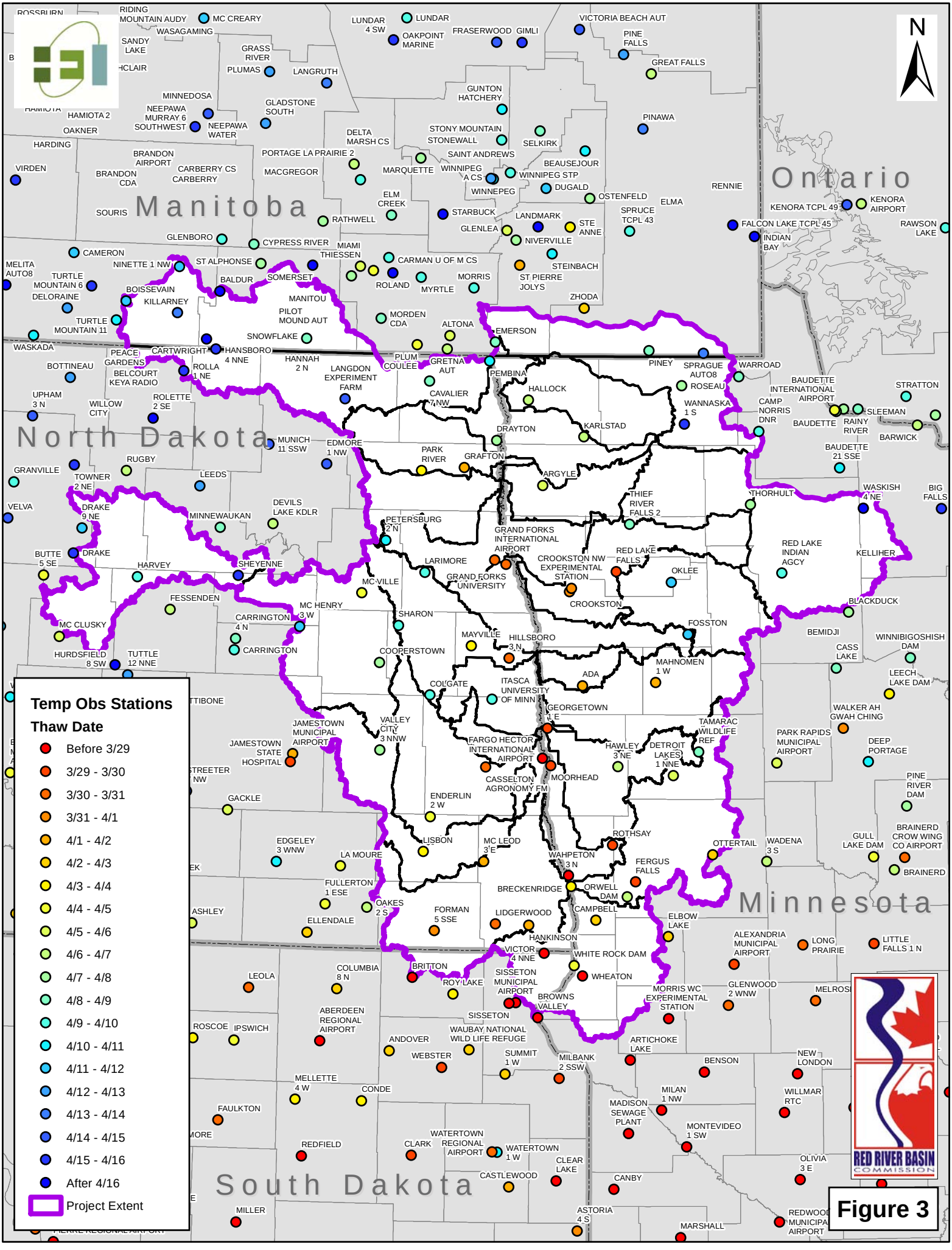

Manitoba
Ontario
North Dakota
Minnesota
South Dakota
N
Temp Obs Stations
Thaw Date
Before 3/29
3/29 - 3/30
3/30 - 3/31
3/31 - 4/1
4/1 - 4/2
4/2 - 4/3
4/3 - 4/4
4/4 - 4/5
4/5 - 4/6
4/6 - 4/7
4/7 - 4/8
4/8 - 4/9
4/9 - 4/10
4/10 - 4/11
4/11 - 4/12
4/12 - 4/13
4/13 - 4/14
4/14 - 4/15
4/15 - 4/16
After 4/16
Project Extent
RED RIVER BASIN COMMISSION

Figure 3

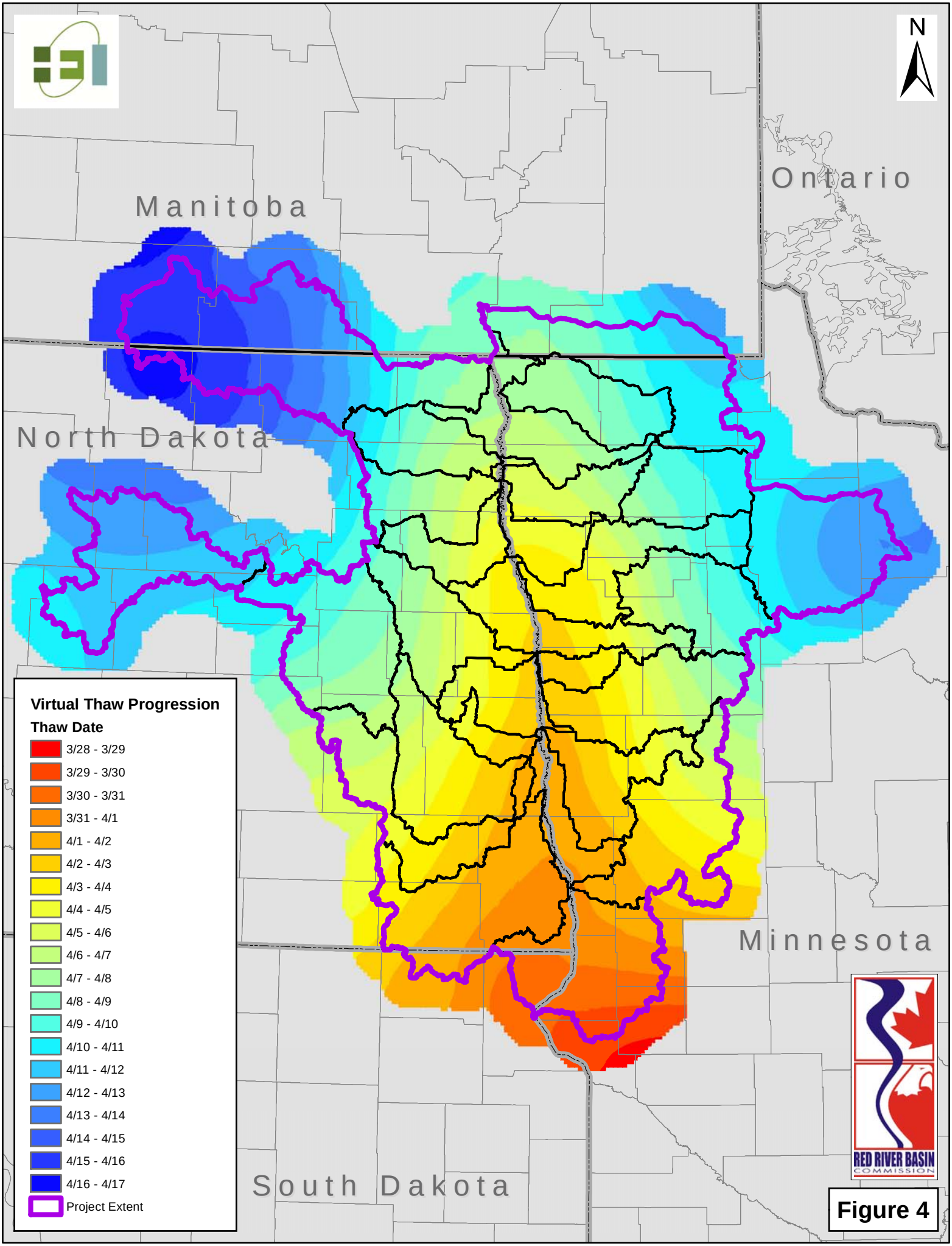

N
Manitoba
Ontario
North Dakota
Minnesota
South Dakota
Virtual Thaw Progression
Thaw Date
3/28 - 3/29
3/29 - 3/30
3/30 - 3/31
3/31 - 4/1
4/1 - 4/2
4/2 - 4/3
4/3 - 4/4
4/4 - 4/5
4/5 - 4/6
4/6 - 4/7
4/7 - 4/8
4/8 - 4/9
4/9 - 4/10
4/10 - 4/11
4/11 - 4/12
4/12 - 4/13
4/13 - 4/14
4/14 - 4/15
4/15 - 4/16
4/16 - 4/17
Project Extent
RED RIVER BASIN COMMISSION

Figure 4

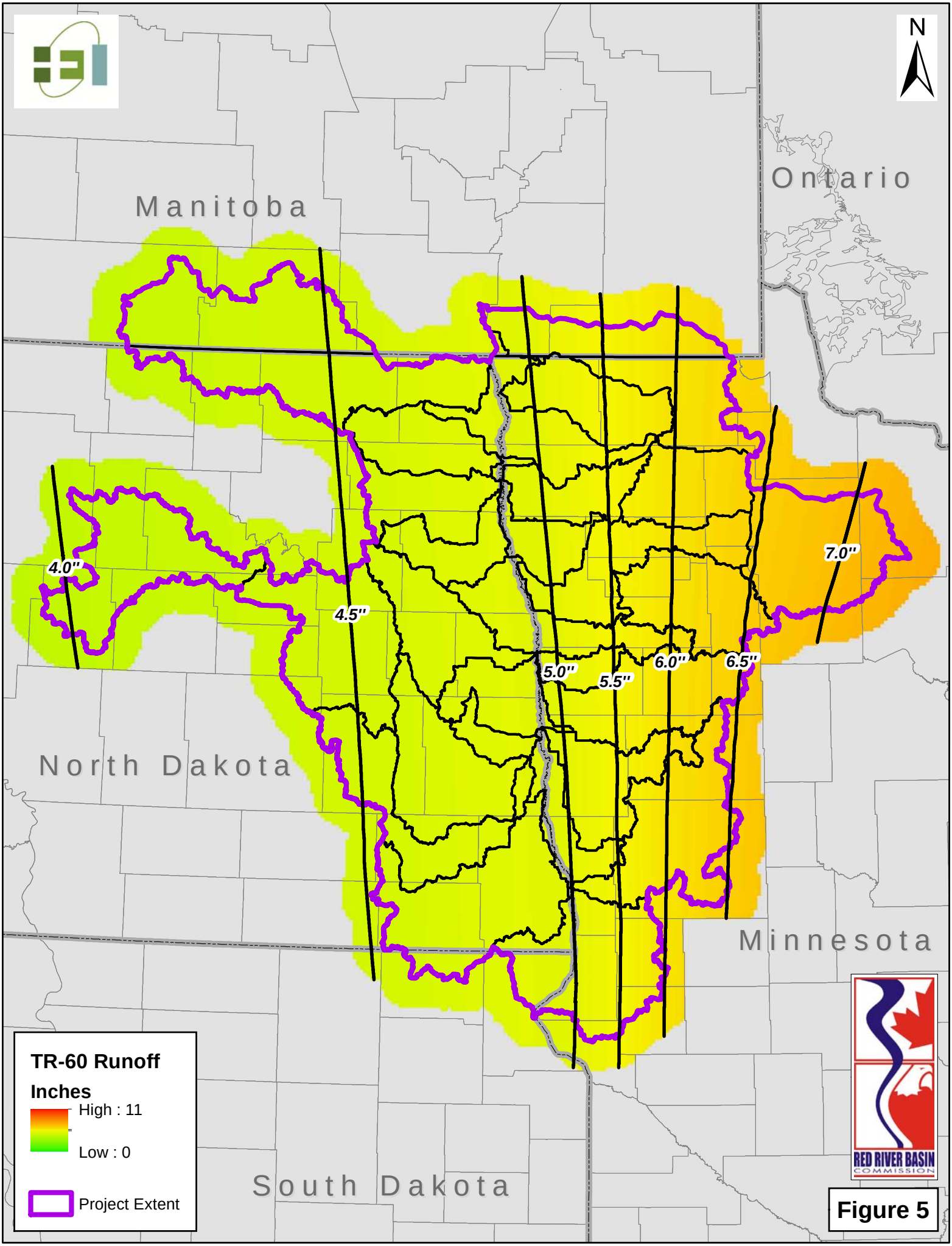

N
Manitoba
Ontario
North Dakota
Minnesota
South Dakota
4.0"
4.5"
5.0"
5.5"
6.0"
6.5"
7.0"
TR-60 Runoff
Inches
High : 11
Low : 0
Project Extent
RED RIVER BASIN COMMISSION

Figure 5

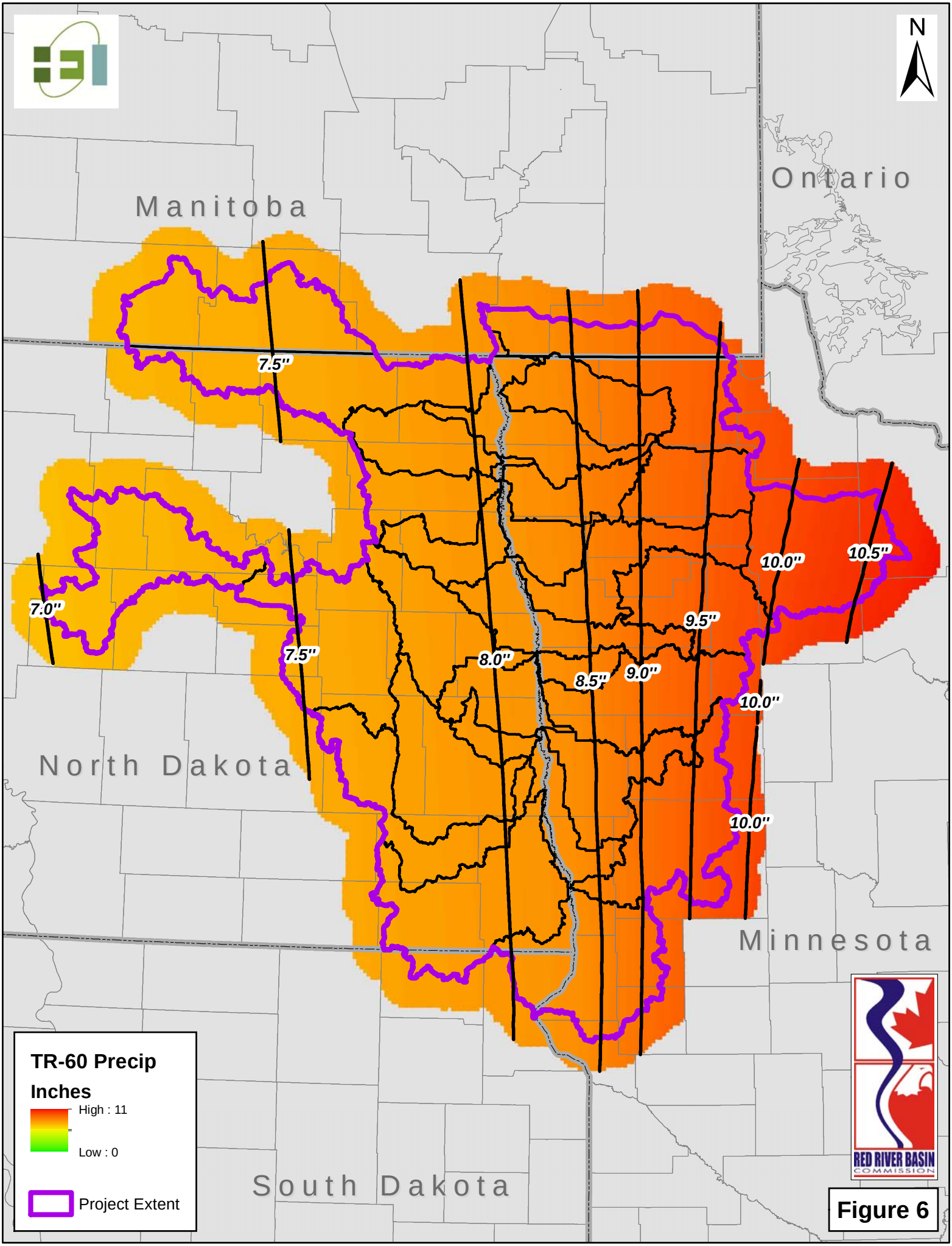

N
Manitoba
Ontario
North Dakota
Minnesota
South Dakota
7.5"
7.0"
7.5"
8.0"
8.5"
9.0"
9.5"
10.0"
10.5"
10.0"
10.0"
TR-60 Precip
Inches
High : 11
Low : 0
Project Extent
RED RIVER BASIN
COMMISSION

Figure 6

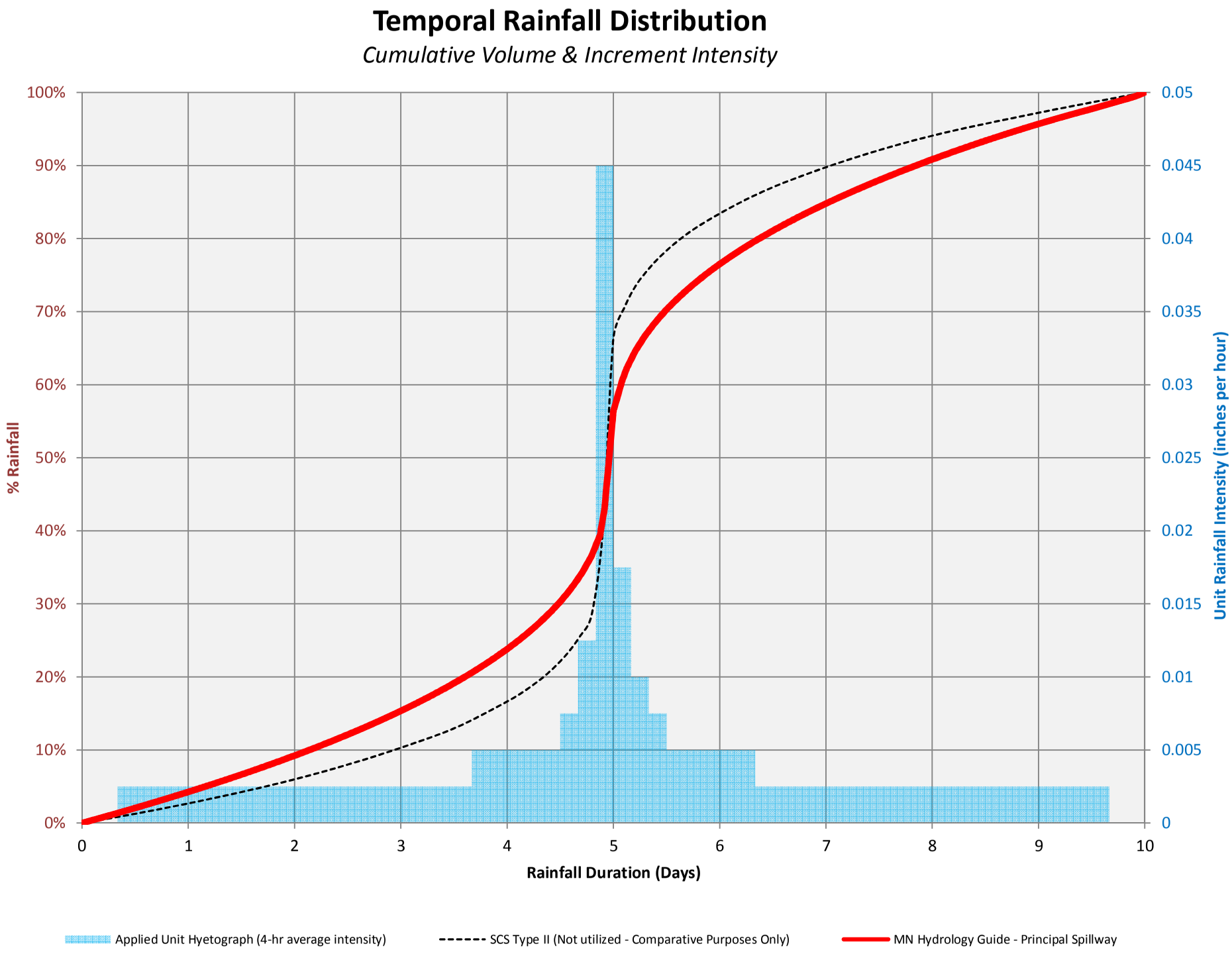

Temporal Rainfall Distribution
Cumulative Volume & Increment Intensity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Rainfall
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Unit Rainfall Intensity (inches per hour)
0
1
2
3
4
5
6
7
8
9
10
Rainfall Duration (Days)
Applied Unit Hyetograph (4-hr average intensity)
SCS Type II (Not utilized - Comparative Purposes Only)
MN Hydrology Guide - Principal Spillway

Figure 7

Appendix A – *Kriging Interpolation Metadata*

HoustonEngineering Inc.

Method	**Kriging**
Type	Ordinary
Output type	Prediction
Dataset #	1
Trend type	First
Searching neighborhood	Standard
Type	Standard
Neighbors to include	8
Include at least	2
Sector type	Eight
Angle	346.31053161621094
Major semiaxis	169942.9005941546
Minor semiaxis	147778.07487150046
Trend removal	Local Polynomial Interpolation
Power	1
Weight	612101.2340864153
Searching neighborhood	Standard
Type	Standard
Neighbors to include	402
Include at least	10
Sector type	Full
Angle	0
Major semiaxis	939610.1182135559
Minor semiaxis	939610.1182135559
Variogram	Semivariogram
Number of lags	9
Lag size	20000
Nugget	14.661472153407502
Measurement error	0
Model type	Spherical
Range	169942.9005941546
Anisotropy	Yes
Minor range	147778.07487150046
Direction	346.31053161621094
Partial sill	4.894144174914004

Appendix B – *Synthetic Gridded Precipitation Technical Memorandum*

HoustonEngineering Inc.

Red River Basin-Wide Standardized Melt Progression Event Analysis Tools
Author: Houston Engineering Inc.
Date: 4/10/2013

Background
The purpose of the toolset is to create a gridded precipitation HEC-DSS file from spatially varying rainfall depths and start times. Gridded precipitation data is summarized within HEC-DSS through a Standard Hydrologic Grid (SHG) cell orientation, as defined in the HEC-GeoHMS User's Manual. In general, these tools utilized gridded precipitation depths, gridded precipitation start times, and a user defined time-series curve for rainfall depths over the incremental time period. Tools previously developed as part of the FM-Metro/USACE HEC-HMS Model Development for the Red River Basin (Phase I). These tools utilized NEXRAD radar precipitation data to develop HEC-DSS gridded precipitation files, and were developed by Barr Engineering. The first tool takes precipitation depths and timing to create a table summarizing snow melt by time and location. The second tool takes that snow melt table and converts it into ASC grids. The third tool takes the ASC grids and converts them into a DSS file.

Tool Specifications
The tools are written utilizing python (version 2.7) scripting techniques. The script tools have been set up to work from within the ArcToolbox of ArcGIS. Three tools were developed to generate the HEC-DSS gridded precipitation data, and are described below:

1. The first tool developed utilizes input precipitation depths and timing information to create a table summarizing the incremental precipitation depth for every SHG cell. Scripting techniques for Tool No. 1 were generated using ArcPy 10.1, therefore this tool is only compatible with ArcGIS 10.1 or later.
2. Output from Tool No. 1 is utilized in this tool to generate ASC grids for the project area for each time step. This tool utilizes "B04. Convert Calibrated Rainfall Table" created by BARR Engineering for the FM Metro/USACE Red River Basin HEC-HMS model development. Minor modifications were made to the script developed by BARR Engineering to accommodate this application.
    - The first modification was adding a constant value to calculate the X and Y values for each cell. This change was made so that the output ASC grids line up with the input SHG grid cells used.
    - The next change was taking out a process at the end of the script which calculated the sum of all of the output ASC grids. The final changes were merely aesthetic and did not alter the functions of the script. They mostly included deleting lines that were already commented out originally. Tool No. 2 is compatible in ArcGIS 9.3 or later.
3. Tool No. 3 utilizes the ASC grid output information from Tool No. 2 to generate the HEC-DSS gridded precipitation file. This tool utilizes "B05. Convert ASC Grids to DSS" created by BARR Engineering for the FM Metro/USACE Red River Basin HEC-HMS model development. One modification was made to the script developed by BARR Engineering
    - The modification mandates the user to input the time interval the DSS file uses instead of using the default embedded in the tool. This change was made because the time interval used in Tool No. 1 will not always be one hour. Tool No. 3 is compatible in ArcGIS 9.3 or later.

Loading the VTP toolbox into ArcToolbox:
To load the toolbox into ArcToolbox:

1. Start ArcMap and open ArcToolbox.
2. In ArcToolbox, right-click on ArcToolbox
3. Click on Add Toolbox, navigate to the VTP.tbx and click Open
4. Click the plus symbol to the left of the Convert VTP toolbox to expand it. The toolbox will contain the VTP scripts.
5. Double-click on the script to open the GUI.

Tool 1: Virtual Thaw Progression Table –

Tool 1 - Inputs:

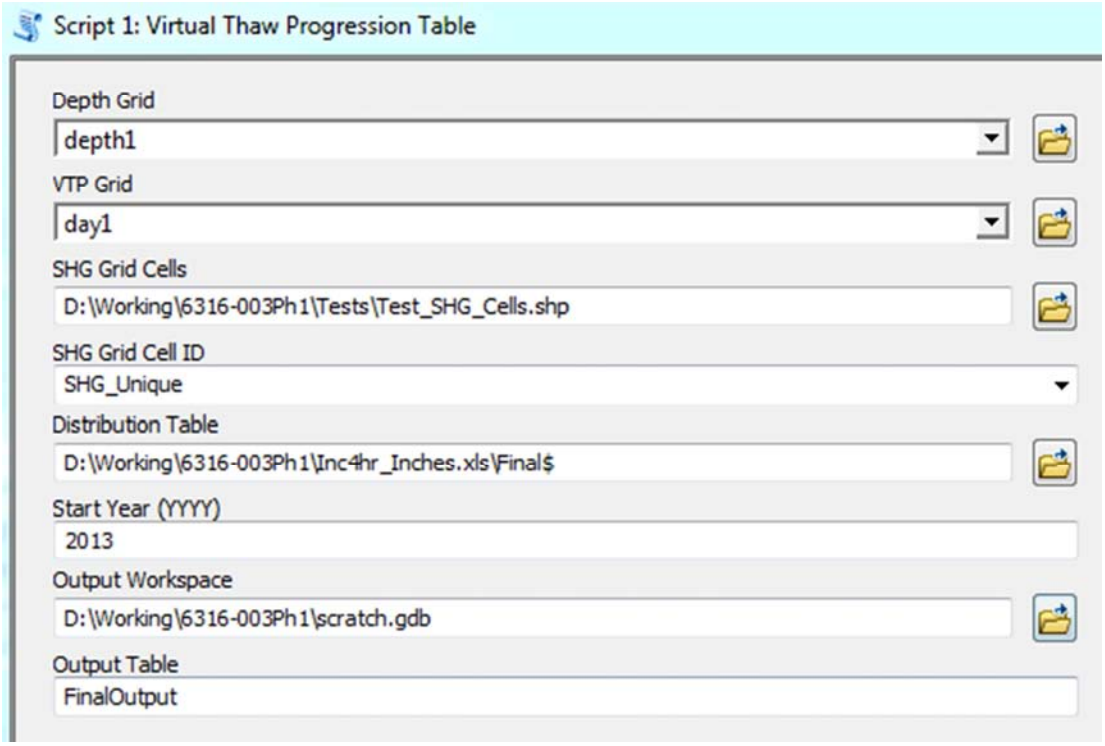


Figure 1. Script 1 Inputs

Input Summary:

Depth Grid - Raster input that contains the snow depth for the study area.

VTP Grid - Raster input that contains the start day for Virtual Thaw Progression in decimal days, with day 0, hour 0 being January 1st at midnight. The raster values need to be in decimal days. For example, if a the value of a cell equals 42.5, that will correlate to February 12th at 12:00 PM (noon)

SHG Grid Cells – SHG Grid Cells that cover the study area

SHG Grid Cell ID – This should be the SHG_Unique field. The format of the data in this field should be XX000_0000

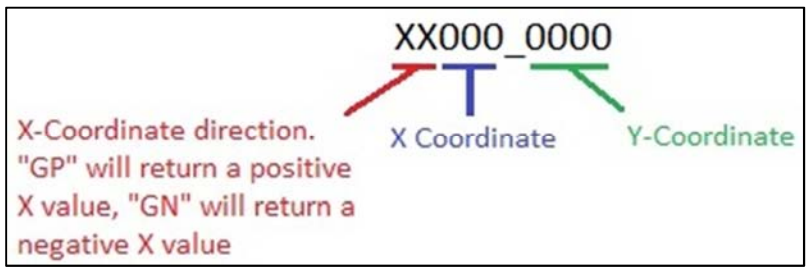


Figure 2. SHG Grid Cell Coordinate Determination

Distribution Table - Snow melting distribution table. Must include a field named *hrs* and a field named *melt_pct*.

hrs – Represents the hours after the Virtual Thaw Progression date. This field requires equal interval ascending numbers starting from 0, which represents the staring hour of the Virtual Thaw Progression. The second number in the series will represent the time-step interval.

melt_pct - This field represents the percent of the snow depth that melts within the specified interval. The format should be a decimal percent (2% would be formatted to .02). The numbers in this column must sum to 1.

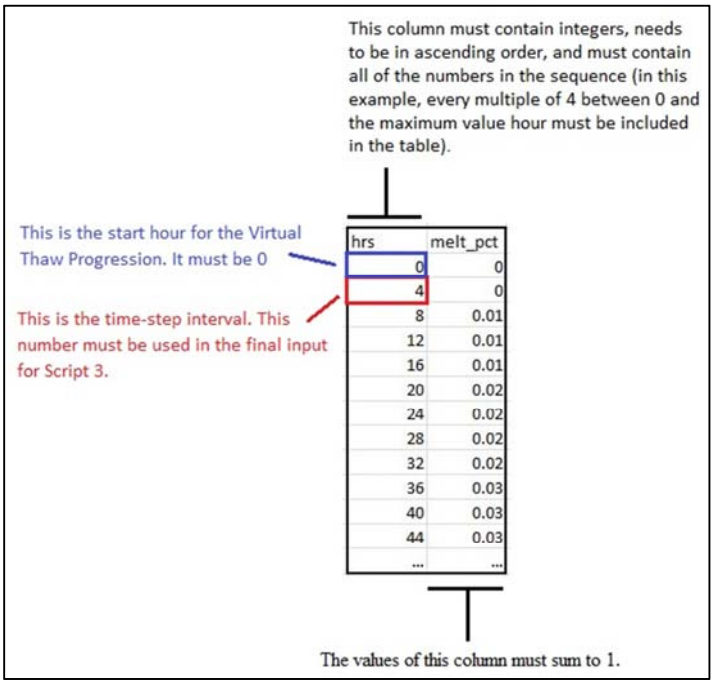


Figure 3. Example Distribution Table

Start Year – The year you would like the dates to be associated with. Must be a four-digit integer Example: 2013

Output Workspace – The geodatabase or folder path you would like the outputs to be placed in.

Output Table – The name of the output file

Tool 1 - Outputs:

***PrecipZones* Table -**

Table

PrecipZones

OBJECTID *	SHG_UNIQUE	ZONE_CODE	DEPTH	MELTDAY	MELTHOUR
1	GN113_1348	1	7.402034	98.80193	2372
2	GN112_1348	2	7.409376	98.71538	2368
3	GN111_1348	3	7.416728	98.63283	2368
4	GN110_1348	4	7.424067	98.55074	2364
5	GN109_1348	5	7.431413	98.47923	2364
6	GN108_1348	6	7.438751	98.41389	2360
7	GN107_1348	7	7.446092	98.35292	2360
8	GN106_1348	8	7.453427	98.29291	2360
9	GN105_1348	9	7.460761	98.2168	2356
10	GN104_1348	10	7.468094	98.14857	2356
11	GN103_1348	11	7.475423	98.11641	2356
12	GN102_1348	12	7.482753	98.07517	2352
13	GN101_1348	13	7.490077	98.03815	2352
14	GN100_1348	14	7.497406	97.9996	2352

Figure 4 PrecipZones Output

Field Summary:

SHG_UNIQUE – This is the unique SHG grid cell taken from the SHG grid cell input.

ZONE_CODE – Unique zone ID.

DEPTH – This is the mean depth of the SHG grid cell. This is determined by running the Zonal Statistics as Table tool in ArcGIS on the input depth grid.

MELTDAY – This is the mean melt start day of the SHG grid cell. This is determined by running the Zonal Statistics as Table tool in ArcGIS on the input VTP grid.

MELTHOUR – This takes the "MELTDAY" value and converts the decimal day to hours from January 1st and midnight. This value is rounded to the nearest interval determined by the input distribution table interval.

***VTP* Table -**

Table

MW_3_20

OBJECTID *	hrs	melt_pct	SHG_UNIQUE	DEPTH	Precip	MELTHOUR	StartDate	EndDate	REALHOUR	X	Y
80	76	0.01	GN113_1348	7.402034	0.07	2372	13APR3000:0000	13APR3000:0400	2448	-113	1348
81	80	0.01	GN113_1348	7.402034	0.07	2372	13APR3000:0400	13APR3000:0800	2452	-113	1348
82	84	0.01	GN113_1348	7.402034	0.07	2372	13APR3000:0800	13APR3000:1200	2456	-113	1348
83	88	0.02	GN113_1348	7.402034	0.15	2372	13APR3000:1200	13APR3000:1600	2460	-113	1348
84	92	0.02	GN113_1348	7.402034	0.15	2372	13APR3000:1600	13APR3000:2000	2464	-113	1348
85	96	0.02	GN113_1348	7.402034	0.15	2372	13APR3000:2000	14APR3000:0000	2468	-113	1348
86	100	0.02	GN113_1348	7.402034	0.15	2372	14APR3000:0000	14APR3000:0400	2472	-113	1348
87	104	0.02	GN113_1348	7.402034	0.15	2372	14APR3000:0400	14APR3000:0800	2476	-113	1348
88	108	0.03	GN113_1348	7.402034	0.22	2372	14APR3000:0800	14APR3000:1200	2480	-113	1348
89	112	0.05	GN113_1348	7.402034	0.37	2372	14APR3000:1200	14APR3000:1600	2484	-113	1348
90	116	0.18	GN113_1348	7.402034	1.33	2372	14APR3000:1600	14APR3000:2000	2488	-113	1348
91	120	0.07	GN113_1348	7.402034	0.52	2372	14APR3000:2000	15APR3000:0000	2492	-113	1348
92	124	0.04	GN113_1348	7.402034	0.3	2372	15APR3000:0000	15APR3000:0400	2496	-113	1348
93	128	0.03	GN113_1348	7.402034	0.22	2372	15APR3000:0400	15APR3000:0800	2500	-113	1348
94	132	0.02	GN113_1348	7.402034	0.15	2372	15APR3000:0800	15APR3000:1200	2504	-113	1348
95	136	0.02	GN113_1348	7.402034	0.15	2372	15APR3000:1200	15APR3000:1600	2508	-113	1348
96	140	0.02	GN113_1348	7.402034	0.15	2372	15APR3000:1600	15APR3000:2000	2512	-113	1348
97	144	0.02	GN113_1348	7.402034	0.15	2372	15APR3000:2000	16APR3000:0000	2516	-113	1348
98	148	0.02	GN113_1348	7.402034	0.15	2372	16APR3000:0000	16APR3000:0400	2520	-113	1348
99	152	0.01	GN113_1348	7.402034	0.07	2372	16APR3000:0400	16APR3000:0800	2524	-113	1348
100	156	0.01	GN113_1348	7.402034	0.07	2372	16APR3000:0800	16APR3000:1200	2528	-113	1348
101	160	0.01	GN113_1348	7.402034	0.07	2372	16APR3000:1200	16APR3000:1600	2532	-113	1348

Figure 5. Output VTP Table

Field Summary:

hrs – This is from the input distribution table. This denotes the hour in the distribution table that each row is representing.

melt_pct – This is from the input distribution table. It correlates to the "hrs" field in the distribution. It represents the percentage of snow melt applied to the total depth of the SHG grid cell for the specified time period in the distribution.

SHG_UNIQUE – This is the unique SHG grid cell taken from the SHG grid cell input

Depth – This is the mean depth of the SHG grid cell as taken from the "Precip Zones" output. This is determined by running the Zonal Statistics as Table tool in ArcGIS on the input depth grid

Precip – This is the precipitation value for the SHG cell at the defined time ("StartDate"). This value is rounded to the nearest hundredth decimal for use in DSS.

MELTHOUR – This is the number of hours after January 1st at midnight (00:00) that the melt distribution starts. The melthour is taken from the "Precip Zones" output. This is determined by running the Zonal Statistics as Table tool in ArcGIS on the input VTP grid, then converting the decimal day value to hours. This value is rounded to the nearest interval determined by the interval of the input distribution table.

StartDate – This takes the "REALHOUR" variable and converts it into a date based on the number of hours form January 1st at midnight. This will be used in the ASC Grids and the DSS file. The format is DDMMMYYYY:HHHH with the moth being an abbreviated string.

EndDate – This is the same format as StartDate, but this is the date is determined by adding the distribution interval to the StartDate.

REALHOUR – This represents the number of hours form January 1st at midnight that this interval starts (correlates directly with "StartDate"). This is used to determine the date and time of the specific SHG cell and the amount of precipitation during this interval.

X – The X-coordinate of the SHG grid cell, determined from the "SHG_UNIQUE" field. (See "SHG Grid Cell ID" in the Inputs section for more details.)

Y – The Y-coordinate of the SHG grid cell, determined from the "SHG_UNIQUE" field. (See "SHG Grid Cell ID" in the Inputs section for more details.)

Tool 1 - Notes:

- This script takes the SHG cells, and uses zonal statistics to calculate the average snow depth and starting thaw date. Using these inputs, an input distribution table is included in each cell staring at the thaw date to calculate snow melt precipitation for each time increment. The end result is a table that identifies a cell, a time interval, and the snow melt precipitation.
- After running Zonal Statistics, each cell will have an average start day in decimal days. This number will be converted to integer hours (ex. 50.5 days = 1212 hours). If the distribution table has an interval greater than 1 hour, the integer hour will be rounded to the nearest multiple interval. For example – if the distribution table interval is 4 hours, and the start hour is 2011, 2011 will be converted to 2012 (the nearest multiple of 4)
- The distribution table at a particular SHG grid cell starts at the VTP hour from the input grid. From this table, the snow melt precipitation is calculated at each hour interval by taking the snow depth (in the SGH cell from the input depth raster) and multiplying it by the melt percentage in the distribution table. Each SHG cell will have a value for every time interval included in the entire study area.
    - For example - the earliest SHG cell VTP starts at 1200 hours, the latest SHG cell VTP starts at 1600 hours, and the distribution table is 240 hours long. Every SHG cell will have a value for each hour interval between 1200 hours and 1840 hours. The snow melt precipitation values will be 0 for every hour outside of the distribution hours in the SHG grid cell.
- The precipitation value is calculated by multiplying the melt percentage from the input distribution table and the depth determined from the input depth grid. This value is rounded to the nearest hundredth. This is required as DSS cannot handle values more specific than 2 decimal places.

Tool 2: Convert Snow Melt Data to ASC Grid –

Tool 2 - Inputs:

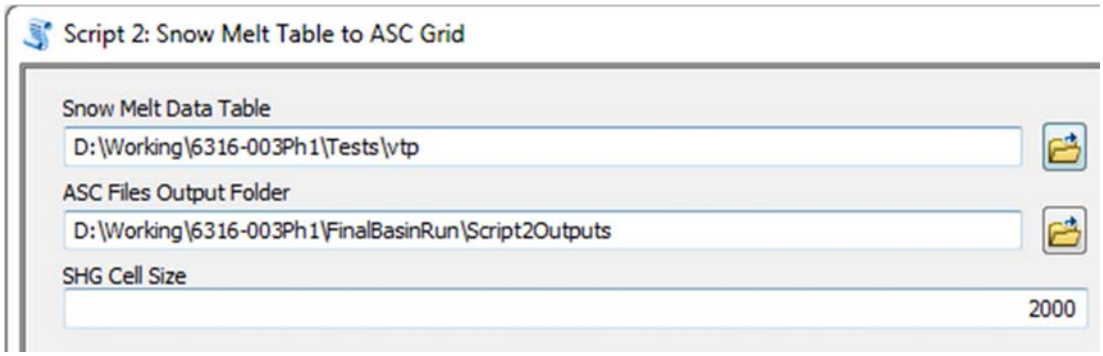


Figure 6. Script 2 Inputs

Snow Melt Data Table – The output table created from script 1

ASC Files Output Folder – An empty folder to store the output ASC grids

SHG Cell Size – The cell size of the input SHG cells (in meters) in script 1. Default is 2000

Tool 2 - Outputs:

Tool 2 creates ASC grids for every time interval defined in the VTP table output from Script 1

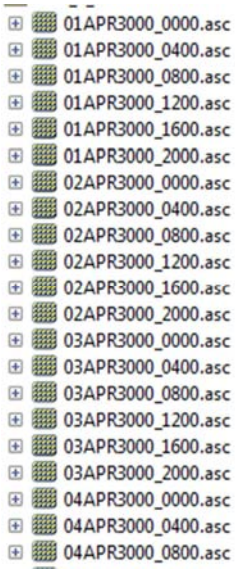


Figure 7. ASC Grids in ArcCatalog

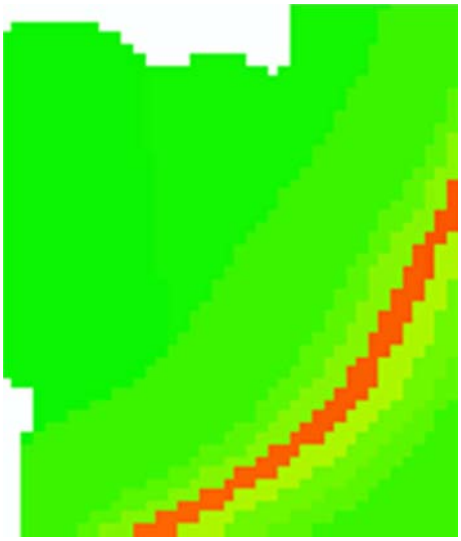


Figure 8. Sample ASC Grid

Tool 2 - Notes:

- This script takes the output table from script one and creates an ASC grid for each time series that exists in the table.
- The location of each cell is determined from the X and Y coordinates in the table. Those coordinates are determined from the unique SHG cell ID. Refer to the Script 1 inputs section for reference.

Tool 3: Convert ASC Grid to DSS File –

Tool 3 - Inputs:

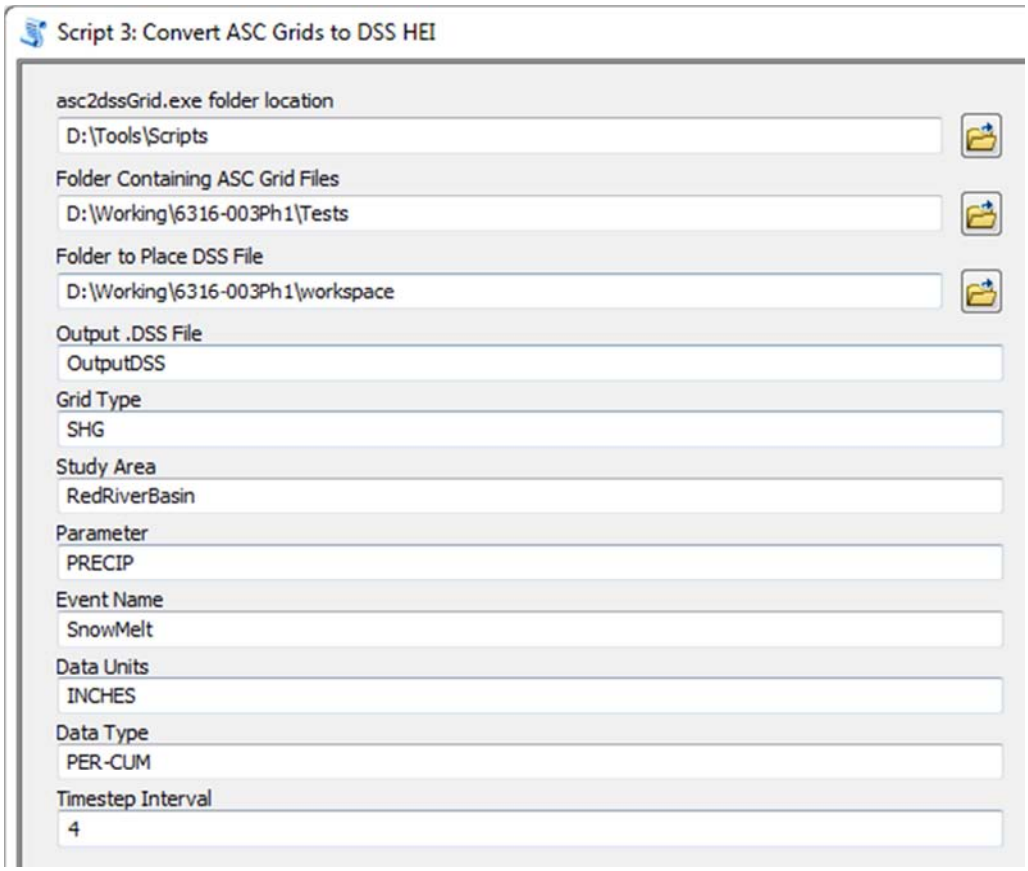


Figure 9. Script 3 Inputs

Input Summary:

asc2dssGrid.exe Folder Location – The folder in which the asc2dssGrid.exe is located

ASC Grid Files Folder – The output folder specified in script 2 that include the ASC Grids

Folder to Place DSS File – The folder location to place the output DSS file

Output DSS File – the name of the output DSS file

Grid Type – Must be SHG. That is the default

Study Area – Name of the study area

Parameter – Must be PRECIP. That is the default

Event Name – Name the event for DSS reference

Data Units – Units of measurement. INCHES is the default

Data Type – Must be PER-CUM. That is the default

Timestep Interval – This is the time interval as determined by the distribution table in Script 1, and it must match that number. This determines the difference between start and end times for each interval in the DSS file.

Tool 3 - Outputs:

Tool 3 creates a DSS file based on the ASC grids from Script 2.

Tool 3 - Notes:

- This script is designed to take the folder that contains the ASC grids (output from script 2) and convert them into a DSS file.
- This script utilizes *asc2dssGrid.exe* executable file previously developed.

Troubleshooting:

- Make sure that all of the inputs are in the proper format. Refer to the inputs section for help.
- If you are dealing with a large number of SHG cells (> ≈ 4000 cells) be sure to write Script 1's output to a File Geodatabase. There is a known issue with the Append tool in ArcGIS in the context of this script tool when writing to a folder.
- For Script 3, a DSS file will not be created if file paths have excessive lengths. Try to copy the ASC grid and the DSS file output folders to a local drive (such as a C drive) to run.
- Be sure that the folder used for the ASC grids only contains the applicable ASC grids.

Disclaimer:

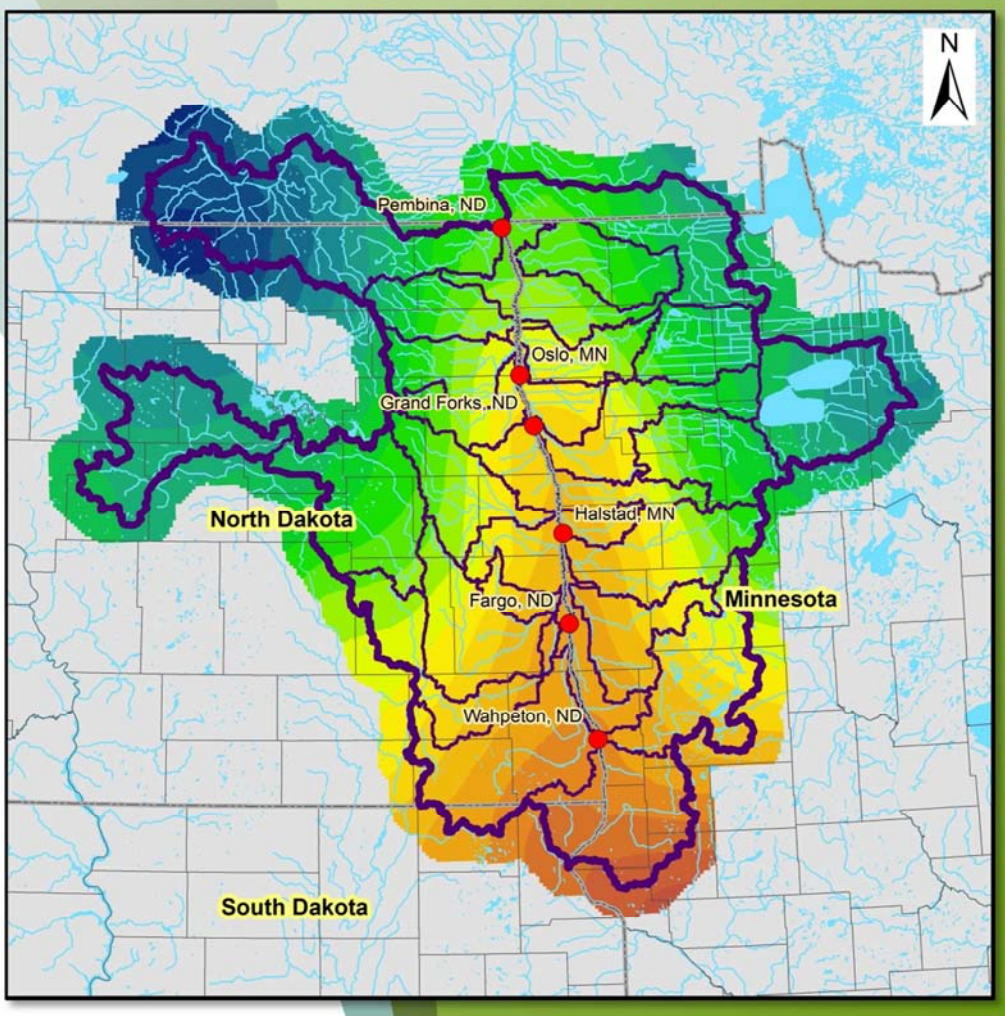
1. Houston Engineering, Inc. does not warranty or provide technical assistance beyond the documentation provided herein.
2. Documentation provided does not negate the need for a thorough quality control review by future users of the provided tools.
3. The future user of the provided tools assumes full liability of future applications. Houston Engineering, Inc. assumes no liability of future applications of the provided tools.
4. Houston Engineering, Inc. does not guarantee software or hardware compatibility or warranty any potential software of hardware defects to may arise as a result of the provided tools.

Acknowledgements:

BARR Engineering provided the base code for Scripts 2 and 3. These scripts were developed as part of the FM Metro/USACE Red River Basin HEC-HMS Development effort.

Halstad Upstream Retention Project - Appendix B

Red River Basin Standardized Melt Progression Event Sensitivity Analysis



In cooperation with:

Houston Engineering Inc.

moore engineering, inc.

WIDSETH SMITH NOLTING

Prepared for the Red River Basin Commission by:

Houston Engineering, Inc.
1401 21st Avenue North
Fargo, ND 58102
3/10/2014
HEI Proj. No. R136316-003

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1 BACKGROUND

1.1 PURPOSE AND SCOPE

The Initial Standardized Melt Progression Event was applied to tributary HEC-HMS hydrologic models for landscape conditions that existed during the 1997 spring flood to generate inflow hydrographs for the Red River mainstem HEC-RAS hydraulic model. Resultant Red River mainstem hydrographs were compared to 100-year balanced hydrographs developed by the US Army Corps of Engineers. This comparison suggested that the Initial Standardized Melt Progression Event produced a much more attenuated hydrograph with similar volumes and a reduced peak flow at USGS Gage 05054000 (Red River at Fargo, ND). The hydrograph at Fargo, ND generated using the Initial Standardized Melt Progression Event is presented in **Figure B1.**

In order to better understand how the Initial Standardized Melt Progression Event impacts peak flows experienced along the Red River, a sensitivity analysis was completed on three variables:

- Runoff volume
- Virtual thaw progression
- Melt duration

These variables were assessed to better understand how reasonable modifications impact the Red River mainstem. The resultant hydrographs were compared to the US Army Corps of Engineers 100-year balanced hydrograph at Fargo, ND in an effort to develop a Standardized Melt Progression Event that produced similar results.

1.2 PHYSICALLY-BASED MODEL VS. HISTORIC HYDROLOGIC ASSESSMENT

Developing a physically-based hydrologic model to generate flood hydrographs consistent with statistically based balanced hydrographs presents a unique challenge for watershed assessment. A physically-based model, such as HEC-HMS, utilizes topography, soils, and landuse characteristics to determine how runoff accumulates to form a flood hydrograph. Physically based models are generally calibrated using known historic flood information to ensure reasonable parameters are used. Statistically-based assessment uses observed flow information, typically from a gaging location, to derive peak discharges and volume/duration information for a recurrence interval. This analysis also takes into account the impacts of regulated flows, such as diversion structures or upstream detention facilities. This information is then combined to develop a balanced hydrograph for a recurrence interval.

While statistically based analysis relies on historic information that is a result of historic watershed conditions, a physically-based hydrologic model relies on reasonable watershed condition assumptions. Examples of these assumptions include Antecedent Soil Moisture Condition, hydraulic considerations influencing flow routing, and operational impacts of reservoirs and other flood control structures. Despite relying on reasonable assumptions, physically-based hydrologic modeling allows for a more in-depth assessment of how regions of the watershed contribute to a flood hydrograph and is critical for assessing the magnitude of impact of distributed upstream detention.

2 SENSITIVITY ANALYSIS METHODOLOGY

2.1 RUNOFF DEPTH

Runoff volumes were first analyzed to assess how the Red River mainstem would react to reduced volumes. Four additional runoff volumes were analyzed; 1.5", 2.5", 3.5", and 4.5", along with the NRCS TR-60 runoff volume used for the Initial Standardized Melt Progression Event. The melt progression and duration remained consistent with the Initial Standardized Melt Progression Event. The four additional runoff events were modeled with the tributary HEC-HMS hydrologic models and the Red River mainstem HEC-RAS hydraulic model.

2.2 VITRUAL THAW PROGRESSION

The Virtual Thaw Progression was also assessed to determine if variations in melt progression occur during years of high flows at Fargo, ND. Temperature information at observation points were filtered to only include years of data that produced the highest 10 historic flows observed between 1970 and 2013 along the Red River at Fargo, ND (USGS Gage No. 05054000). Historic floods for Fargo, ND are presented in **Figure B2.** Virtual Thaw dates derived at used to develop the Initial Virtual Thaw Progression and the Fargo Top 10 Floods Virtual Thaw Progression are compared in **Figure B3**. Virtual thaw dates were interpolated using Kriging methods to develop a Fargo Top 10 Floods Virtual Thaw Progression. When compared to the Initial Virtual Thaw Progression, the Fargo Top 10 Floods Virtual Thaw Progression starts slightly later in the southern portion of the Red River Basin. Once the melt is initiated, the Fargo Top 10 Floods Virtual Thaw Progression progresses much more rapidly to the north. This comparison is illustrated in **Figure B4**.

2.3 MELT DURATION

The Initial Standardized Melt Progression Event assumed that, once initiated by the melt progression, runoff would leave the landscape over period of 10 days. Reduced melt durations of 4 days and 7 days were analyzed to assess impacts of a more rapid melt to flood hydrographs experienced along the Red River mainstem. Temporal distributions used for the 4-day, 7-day, and 10-day sensitivity analysis are illustrated in **Figure B5**.

3 CONCLUSIONS

3.1 RESULTS

The variations in runoff depth, virtual thaw progression, and melt duration were analyzed using the tributary HEC-HMS hydrologic model and the Red River mainstem HEC-RAS hydraulic model to develop series of flood hydrographs along the Red River mainstem. These hydrographs were reviewed to determine consistency with the US Army Corps of Engineer's Balanced 100-year Hydrograph at Fargo, ND.

Modeling results indicated that the reduced volume scenarios produced hydrographs along the Red River with similar attenuation and lesser magnitude as those produced from the Initial Standardized Melt Progression Event. Both the Initial Virtual Thaw Progression and the Fargo Top 10 Floods Virtual Thaw Progression were analyzed with 4-day, 7-day, and 10-day melt durations to produce modeling results for six scenarios. Review of these results suggested that melt duration has a more significant impact on peaks along the Red River mainstem than the virtual thaw progression. In general, a four day melt duration combined with the Initial Virtual Thaw Progression appeared to produce a hydrograph similar to the 100-year recurrence USACE balanced hydrograph at Fargo, ND. Resultant hydrographs from this runoff scenario are presented in **Figures B6.1 – B6.4**.

3.2 ADDITIONAL CONSIDERATIONS

The resultant Standardized Melt Progression Event from this sensitivity analysis represents one scenario to produce an approximate 100-year recurrence flood at Fargo, ND. Other runoff events could occur that vary from assumptions used in this sensitivity analysis and result in a similar flood hydrograph at Fargo, ND. These variations could result in differing levels of benefit achieved from proposed projects for similar flood hydrographs along the Red River mainstem.

While this runoff scenario may produce results adequate for assessing impacts to the Red River mainstem above Halstad, MN, additional sensitivity analysis would be required to assess to determine applicability downstream of Halstad, MN.

3.3 AGENCY COORDINATION

Staff members from the Fargo-Moorhead Diversion Authority, US Army Corps of Engineers, and the Minnesota Department of Natural Resources were consulted throughout this sensitivity analysis to ensure general acceptance of methodology used to evaluate retention upstream of Halstad, MN. In general, this peer group determined that this approach was adequate for the RRBC HUR Project, recognizing that additional analysis may be required to assess resiliency to floods deviating from assumptions used in the Standardized Melt Progression Event.

REFERENCES

1. Fargo-Moorhead Metro Basin-Wide Modeling Approach – Hydrologic Modeling, *HEC-HMS Model Development for Various Tributaries above the Red River of the North at Halstad, MN*, December 23, 2011.

2. US Army Corps of Engineers, *Integrated Final Feasibility Report and the Final Environmental Impact Statement,* July 2011

3. U.S. Department of Agriculture, Natural Resources Conservation Service, *Earth Dams and Reservoirs*, Technical Release No. 60, July 2005.

4. U.S. Department of Agriculture, Natural Resources Conservation Service, *Hydrology Guide for Minnesota.*

Appendix B - Figures

In cooperation with:

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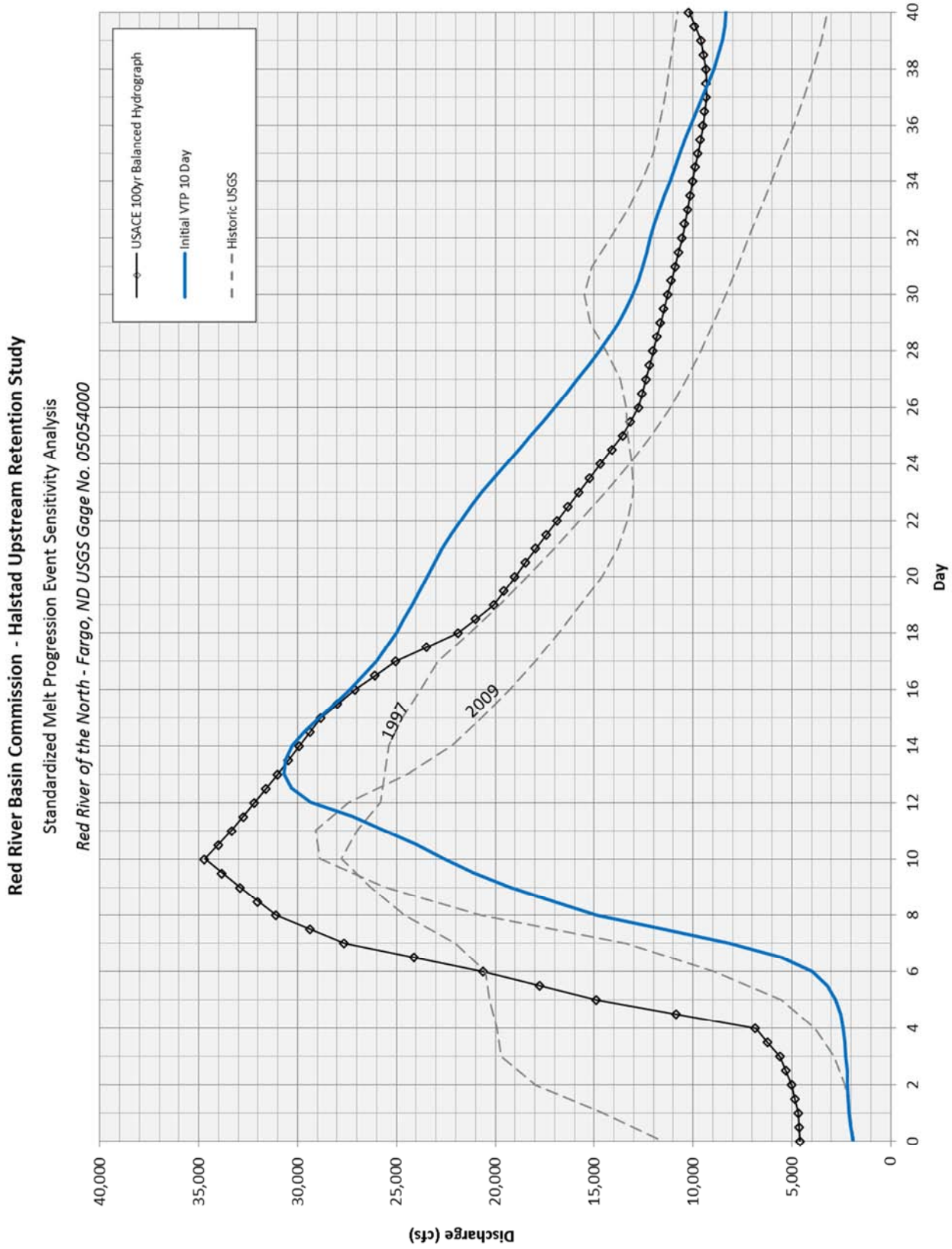
Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Fargo, ND USGS Gage No. 05054000
USACE 100yr Balanced Hydrograph
Initial VTP 10 Day
Historic USGS
1997
2009
Discharge (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day
0
2
4
6
8
10
12
14
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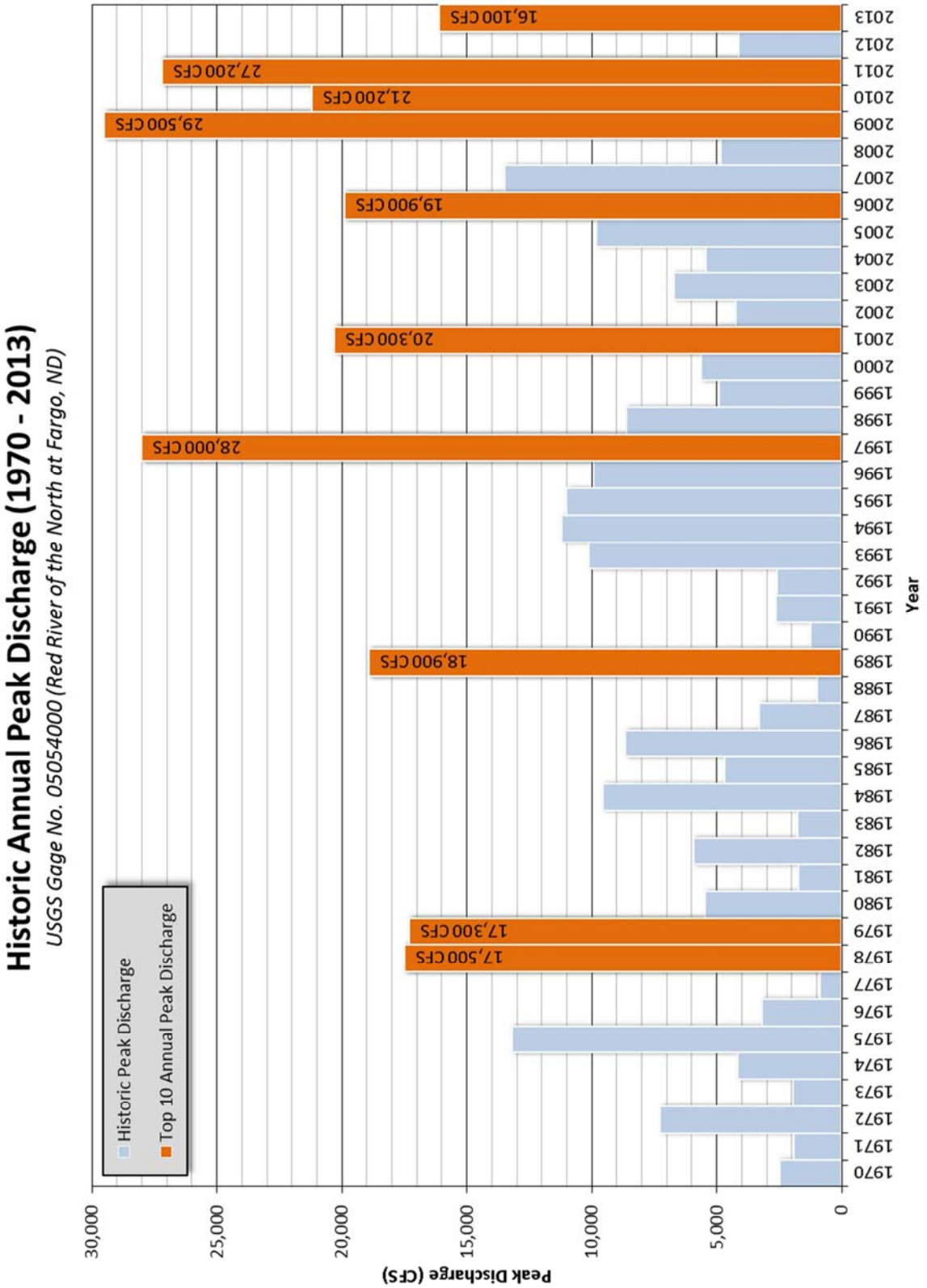
28
30
32
34
36
38
40


Historic Annual Peak Discharge (1970 - 2013)
USGS Gage No. 05054000 (Red River of the North at Fargo, ND)
Historic Peak Discharge
Top 10 Annual Peak Discharge
Peak Discharge (CFS)
30,000
25,000
20,000
15,000
10,000
5,000
0
Year
16,100 CFS
27,200 CFS
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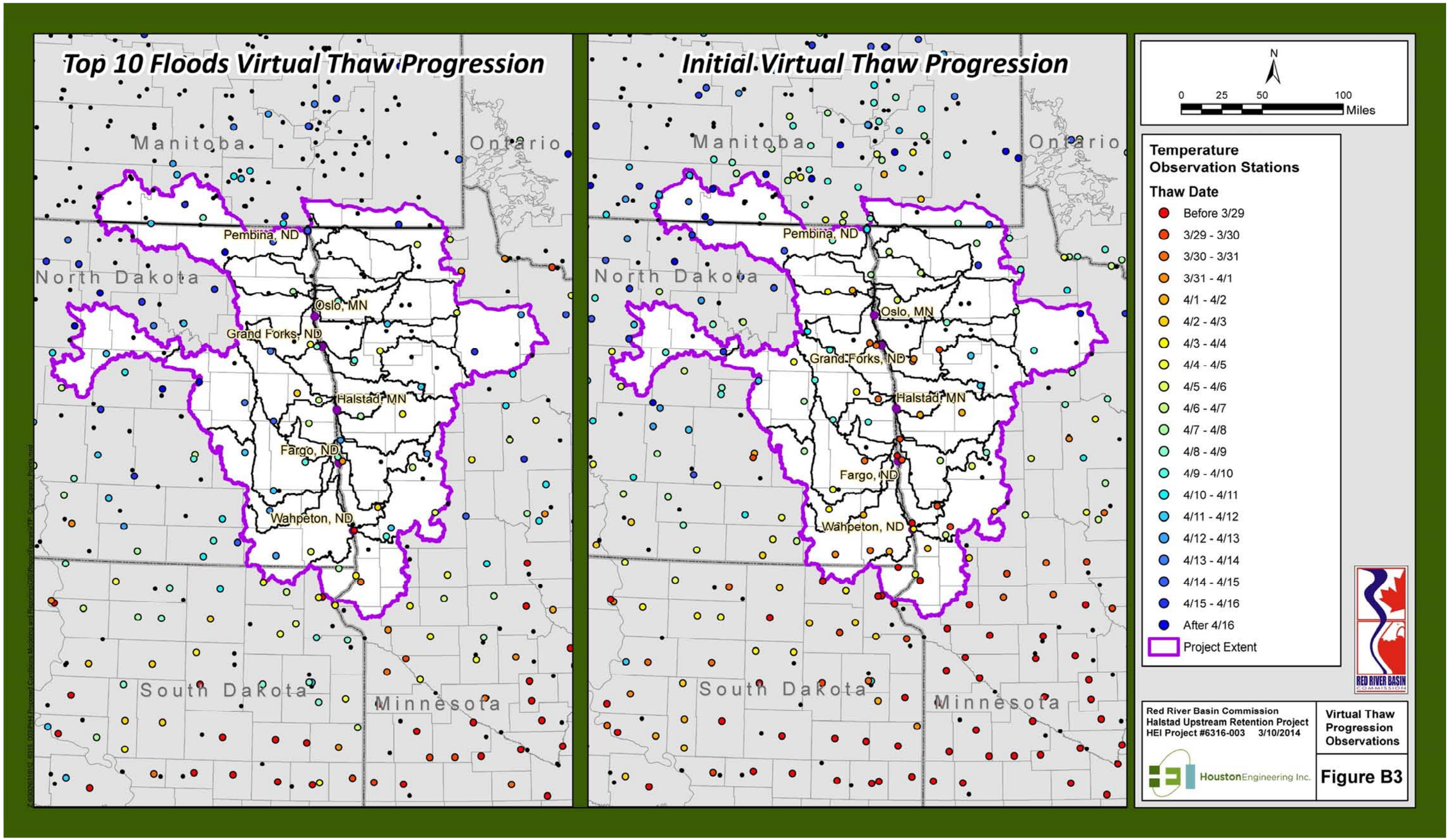
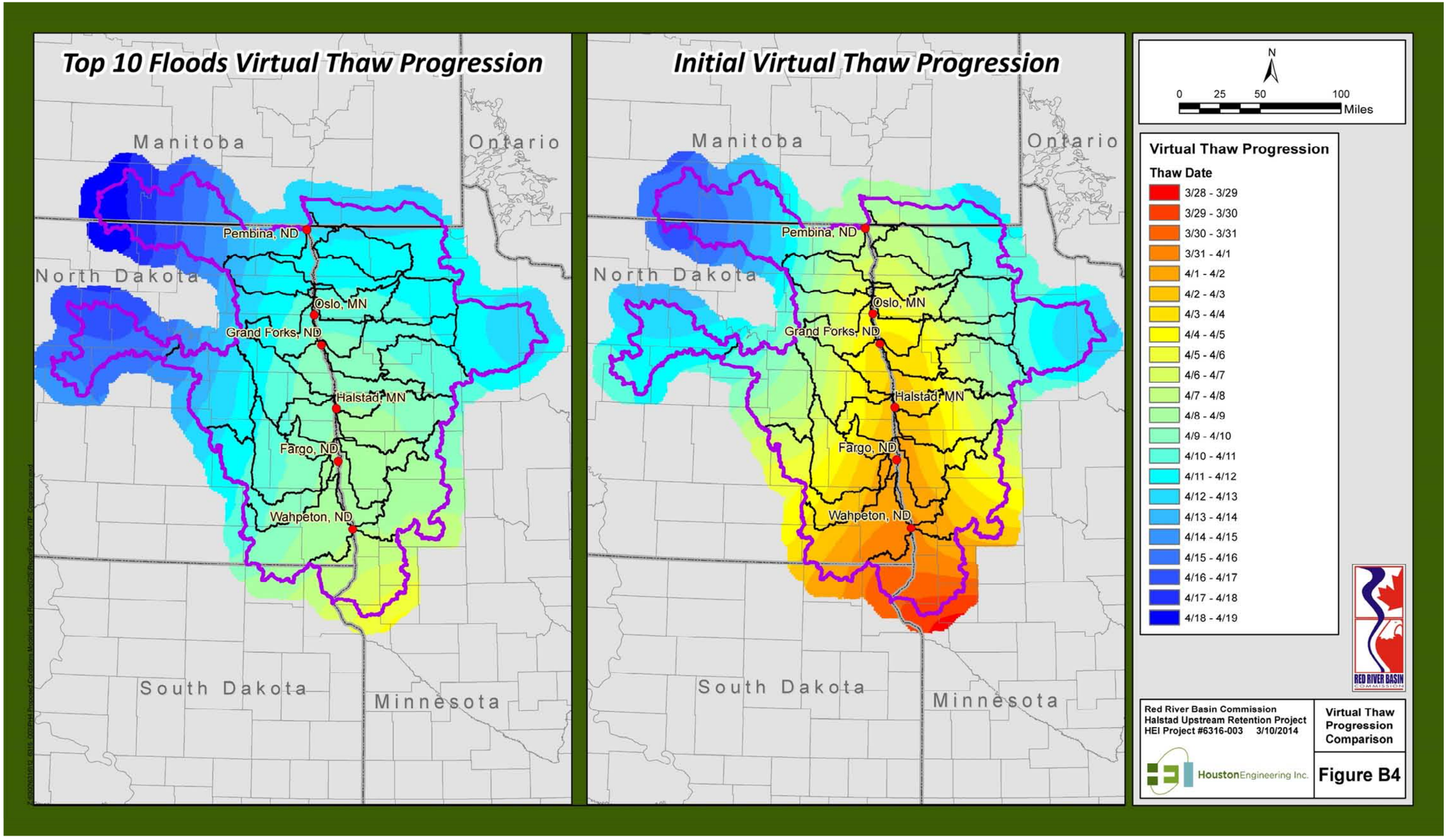
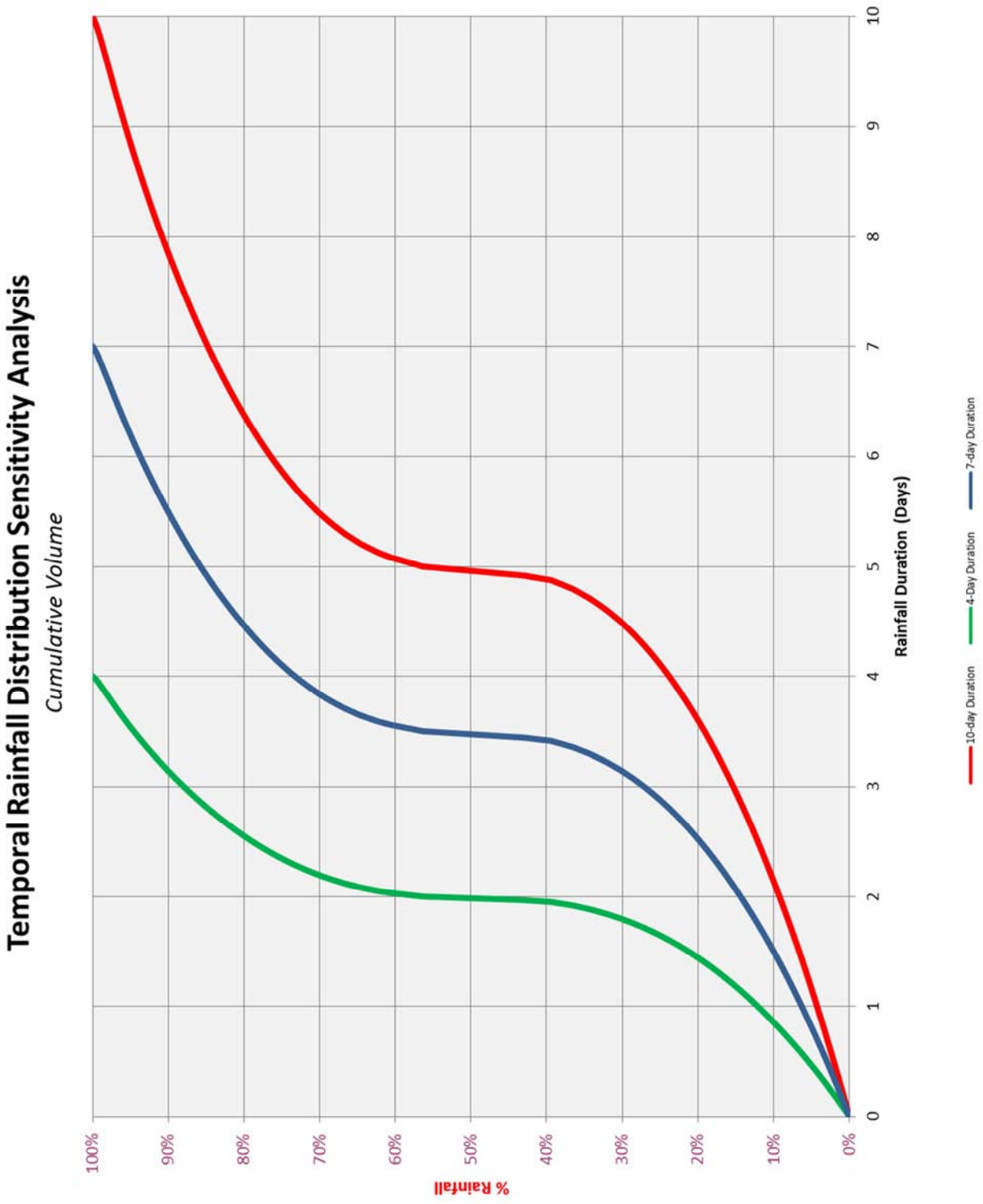
17,300 CFS
17,500 CFS


Top 10 Floods Virtual Thaw Progression
Initial Virtual Thaw Progression
Manitoba
Ontario
North Dakota
South Dakota
Minnesota
Pembina, ND
Oslo, MN
Grand Forks, ND
Halstad, MN
Fargo, ND
Wahpeton, ND
N
0 25 50 100
Miles
Temperature Observation Stations
Thaw Date
Before 3/29
3/29 - 3/30
3/30 - 3/31
3/31 - 4/1
4/1 - 4/2
4/2 - 4/3
4/3 - 4/4
4/4 - 4/5
4/5 - 4/6
4/6 - 4/7
4/7 - 4/8
4/8 - 4/9
4/9 - 4/10
4/10 - 4/11
4/11 - 4/12
4/12 - 4/13
4/13 - 4/14
4/14 - 4/15
4/15 - 4/16
After 4/16
Project Extent
RED RIVER BASIN COMMISSION
Red River Basin Commission
Halstad Upstream Retention Project
HEI Project #6316-003 3/10/2014
Virtual Thaw Progression Observations
HoustonEngineering Inc.
Figure B3


Top 10 Floods Virtual Thaw Progression
Initial Virtual Thaw Progression
Manitoba
Ontario
North Dakota
South Dakota
Minnesota
Pembina, ND
Oslo, MN
Grand Forks, ND
Halstad, MN
Fargo, ND
Wahpeton, ND
N
0 25 50 100
Miles
Virtual Thaw Progression
Thaw Date
3/28 - 3/29
3/29 - 3/30
3/30 - 3/31
3/31 - 4/1
4/1 - 4/2
4/2 - 4/3
4/3 - 4/4
4/4 - 4/5
4/5 - 4/6
4/6 - 4/7
4/7 - 4/8
4/8 - 4/9
4/9 - 4/10
4/10 - 4/11
4/11 - 4/12
4/12 - 4/13
4/13 - 4/14
4/14 - 4/15
4/15 - 4/16
4/16 - 4/17
4/17 - 4/18
4/18 - 4/19
RED RIVER BASIN COMMISSION
Red River Basin Commission
Halstad Upstream Retention Project
HEI Project #6316-003 3/10/2014
HoustonEngineering Inc.
Virtual Thaw Progression Comparison
Figure B4


Temporal Rainfall Distribution Sensitivity Analysis
Cumulative Volume
% Rainfall
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Rainfall Duration (Days)
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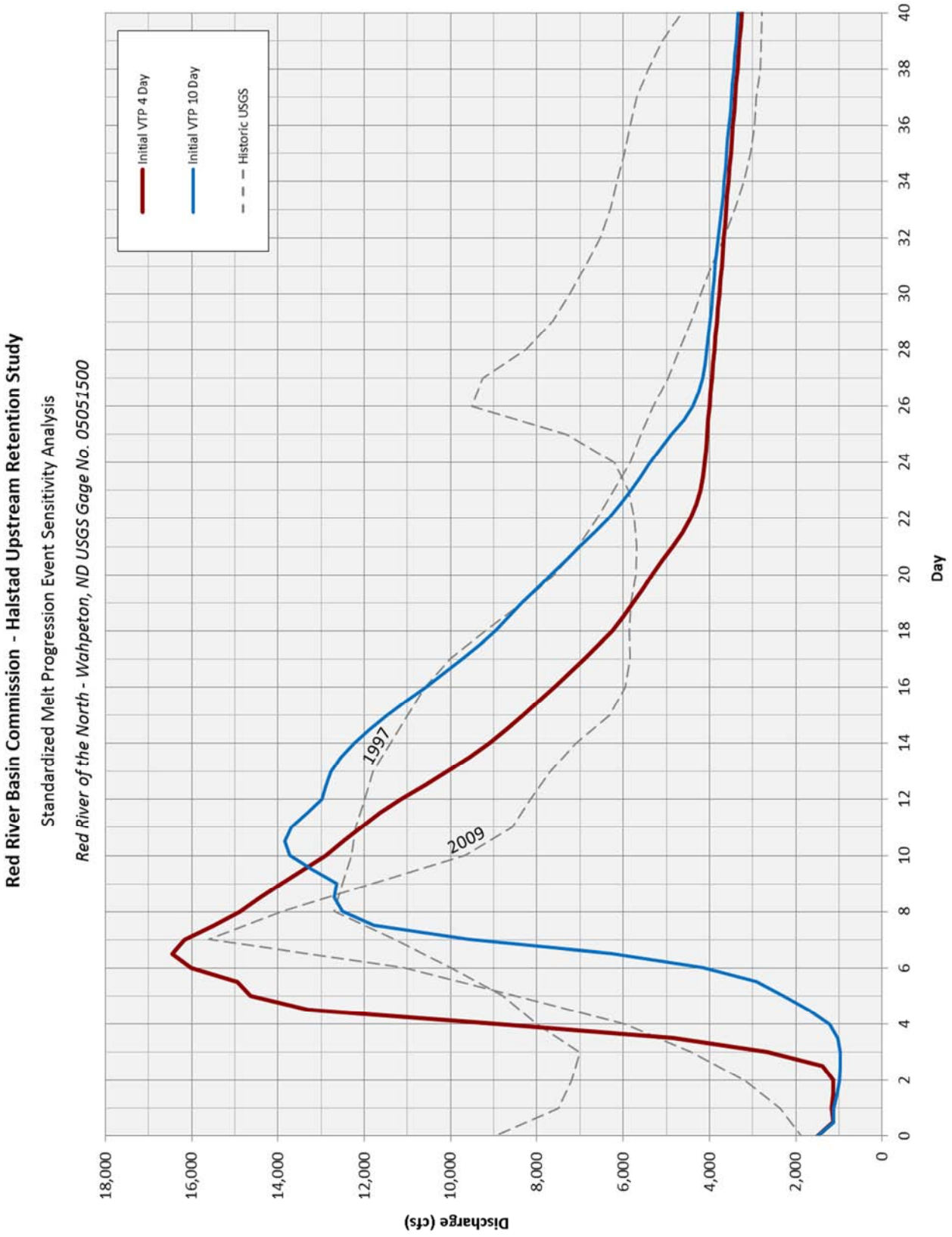
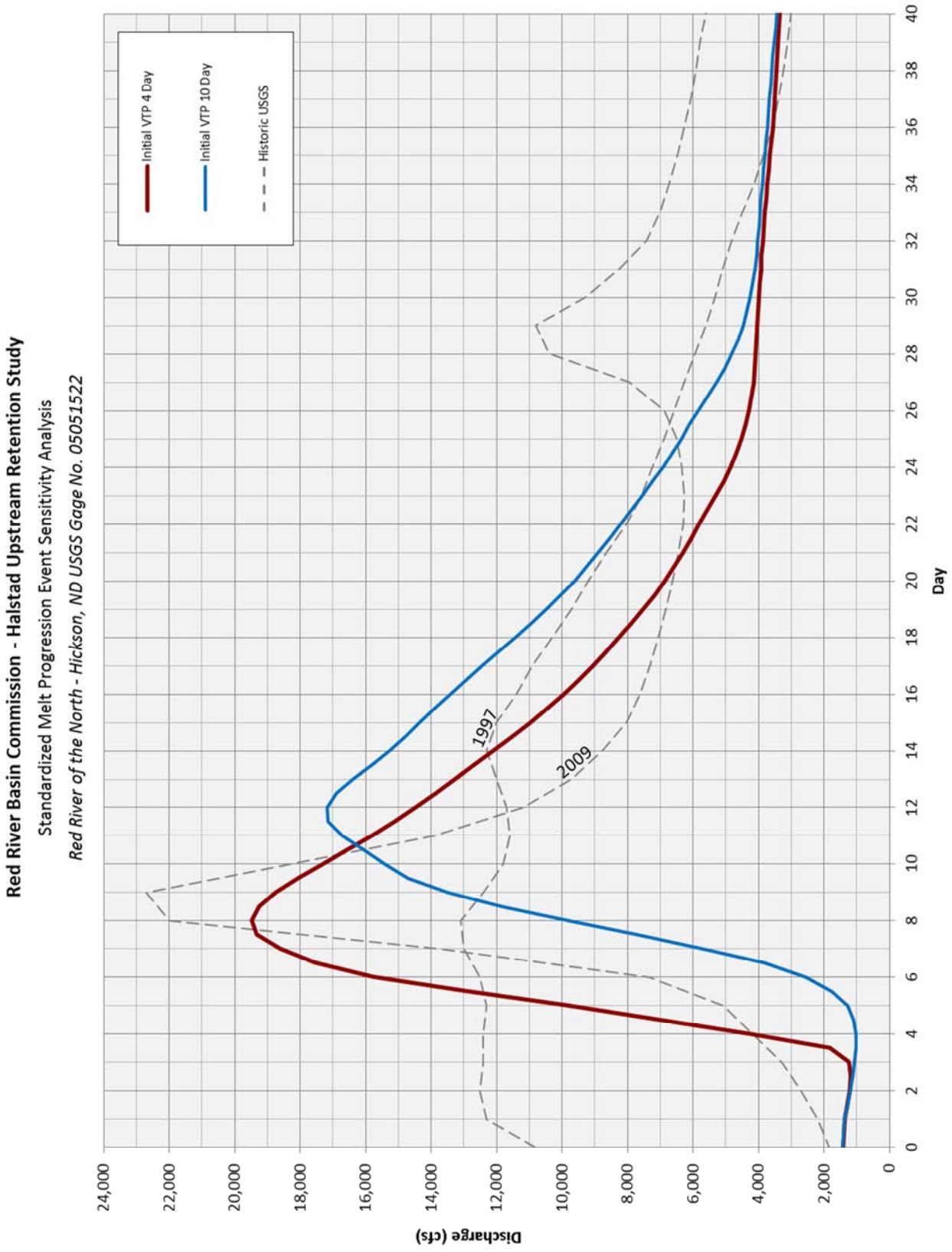
1
2
3
4
5
6
7
8
9
10
10-day Duration
4-Day Duration
7-day Duration


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Wahpeton, ND USGS Gage No. 05051500
Initial VTP 4 Day
Initial VTP 10 Day
Historic USGS
1997
2009
Discharge (cfs)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Hickson, ND USGS Gage No. 05051522
Initial VTP 4 Day
Initial VTP 10 Day
Historic USGS
1997
2009
Discharge (cfs)
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
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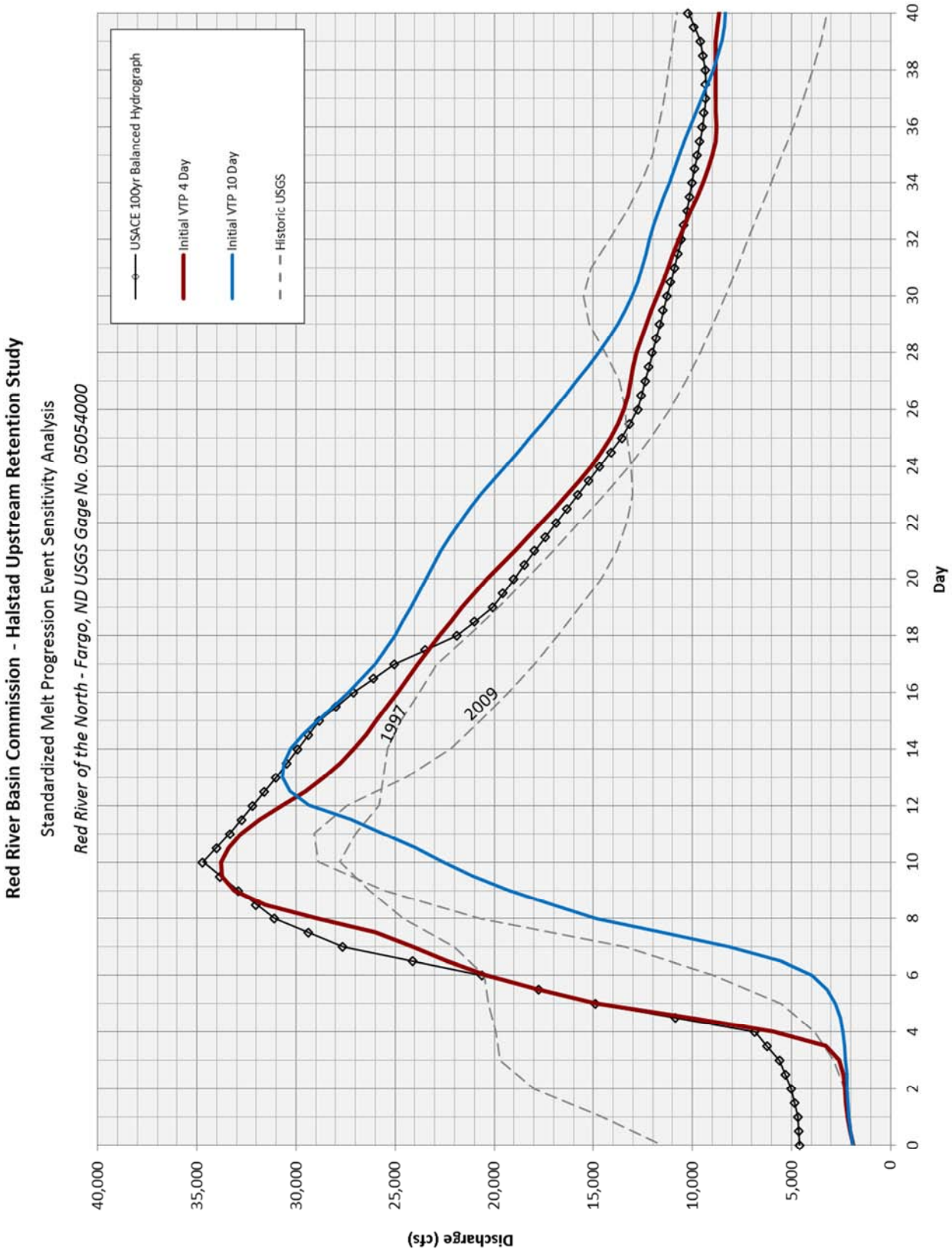
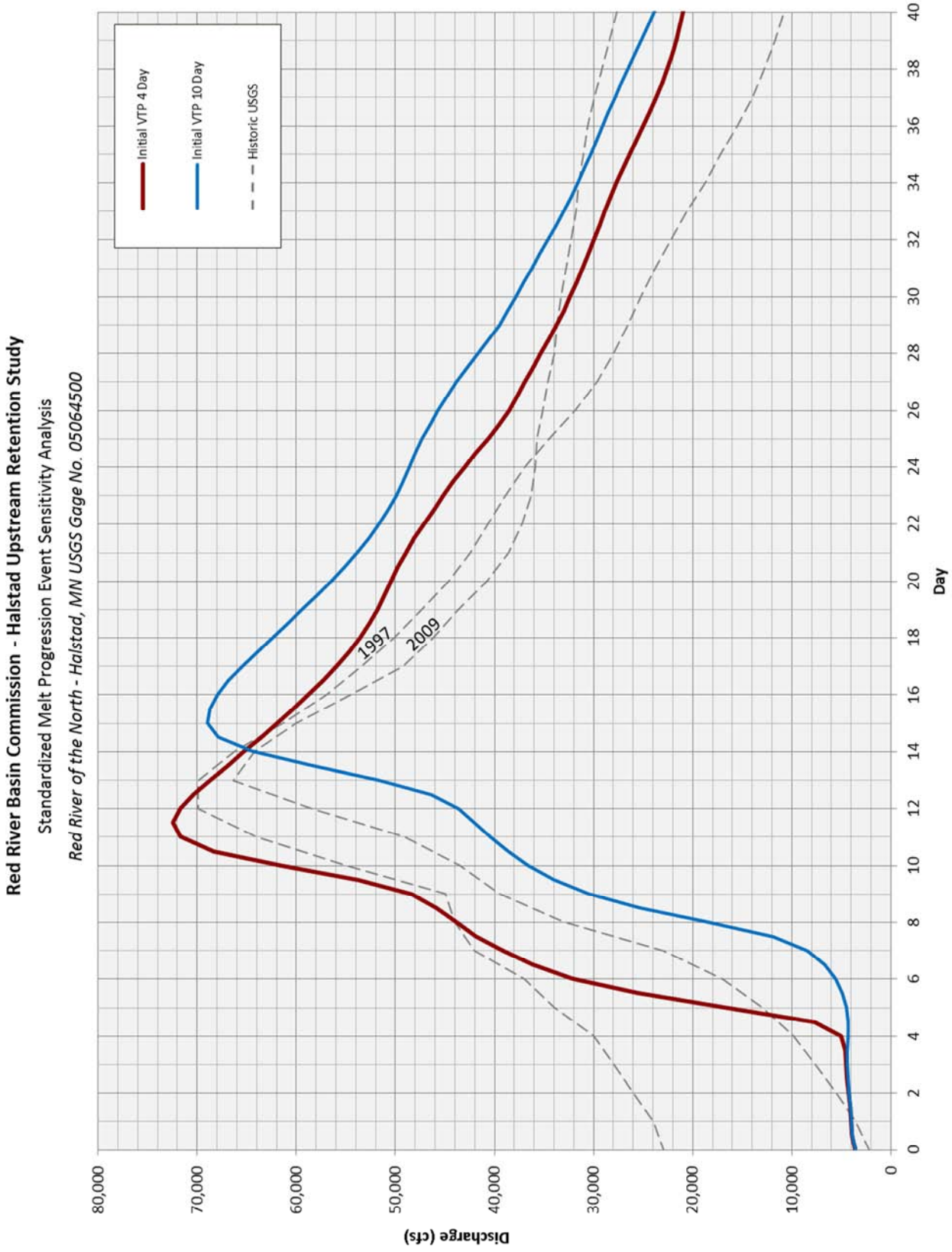
30
32
34
36
38
40


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Fargo, ND USGS Gage No. 05054000
USACE 100yr Balanced Hydrograph
Initial VTP 4 Day
Initial VTP 10 Day
Historic USGS
1997
2009
Discharge (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40


Red River Basin Commission - Halstad Upstream Retention Study
Standardized Melt Progression Event Sensitivity Analysis
Red River of the North - Halstad, MN USGS Gage No. 05064500
Initial VTP 4 Day
Initial VTP 10 Day
Historic USGS
1997
2009
Discharge (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Day
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40