

**M.L. 2016, Chp. 186, Sec. 2, Subd. 03k Project Abstract**

For the Period Ending June 30, 2019

**PROJECT TITLE:** Evaluate Temperature, Streamflow, and Hydrogeology Impact on Brook Trout Habitat

**PROJECT MANAGER:** Bob Tipping

**AFFILIATION:** Minnesota Department of Health

**MAILING ADDRESS:** 625 Robert Street North

**CITY/STATE/ZIP:** Saint Paul, MN 55164

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**WEBSITE:**

**FUNDING SOURCE:** Environment and Natural Resources Trust Fund

**LEGAL CITATION:** [M.L. 2016, Chp. 186, Sec. 2, Subd. 03k]

**APPROPRIATION AMOUNT:** \$ 115,000

**AMOUNT SPENT:** \$ 115,000

**AMOUNT REMAINING:** \$ 0

**Sound bite of Project Outcomes and Results**

Detailed stream temperature profiles combined with fish inventories show links between hydrogeologic setting and brook trout distribution and abundance. Results demonstrate how geologic maps of southeastern Minnesota, funded in large part by the ENRTF, can be used to manage trout populations dependent on base flow to streams.

**Overall Project Outcome and Results**

The recent discovery of resurgent brook trout populations in southeastern Minnesota streams has led to increased interest in documenting and improving critical habitat for this native species. Distributed Temperature Sensing (DTS) technology using fiber optic cables, combined with detailed mapping of geologic conditions and hydraulic head were used to identify areas of preferential base flow at three southeastern Minnesota trout streams— East Indian Creek in Wabasha County, Trout Brook in Dakota County, and Valley Creek in Washington County. Results were compared to fish inventories conducted by the Minnesota Department of Natural Resources to evaluate influence of focused groundwater input on brook trout distribution and abundance. Continuous stream temperature measurements along one meter segments over distances up to 1900 meters were taken in winter when air and groundwater temperatures are most different. Transition from mixed populations of brown and brook trout to predominantly brook trout corresponded specific stream reaches showing preferential base flow inputs from groundwater.

At the regional scale, artesian conditions were compared to bedrock geology and brook trout abundance to locate areas where brook trout, including remnant brook trout, may be most successfully established. Brook trout are found almost exclusively in streams where the Oneota Dolomite and underlying bedrock units are uppermost bedrock. Streams in these settings have springs characterized by relatively constant temperatures, and are supplied by groundwater in generally poor connection to the land surface compared to near-surface aquifers. As such, they have relatively low susceptibility to high turbidity and contaminant pulses resulting from extreme storm events. At both regional and local cases our work (see attached) demonstrates to natural resource managers the direct geologic control on hydraulic head conditions – particularly on vertical head gradients between bedrock layers and the role they play both in stream base flow and brook trout distribution and abundance.

**Project Results Use and Dissemination**

The attached report is currently being revised for release as an Open-File Report available publically via the University of Minnesota's Digital Conservancy (<https://conservancy.umn.edu/>), and for peer-reviewed journal submittal. As a project that includes a hybrid of disciplines, it is expected that results will be presented at meetings with both groundwater and natural resource management focus. To date, the results have been

presented to a group of local residents and landowners from East Indian Creek in Wabasha County, organized by Jen Wahls, Landuse Outreach Coordinator for Wabasha County SWCD and by Nick Budde, student scholarship recipient at the Minnesota Groundwater Association Spring 2018 Conference (also attached).



## Environment and Natural Resources Trust Fund (ENRTF) M.L. 2016 Work Plan Final Report

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**Date of Report:** September 26, 2019

**Final Report**

**Date of Work Plan Approval:** June 7, 2016

**Project Completion Date:** June 30, 2019

**Does this submission include an amendment request?** No

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**PROJECT TITLE:** Evaluate Temperature, Streamflow, and Hydrogeology Impact on Brook Trout Habitat

**Project Manager:** Bob Tipping

**Organization:** Minnesota Department of Health

**Mailing Address:** 625 Robert Street North

**City/State/Zip Code:** Saint Paul, MN 55164

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**Web Address:** <http://health.state.mn.us> [former: <http://www.mnngs.umn.edu/>]

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**Location:** Dakota, Goodhue, Wabasha, Olmsted, Winona, Houston, Fillmore

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**Total ENRTF Project Budget:**

**ENRTF Appropriation:** \$115,000

**Amount Spent:** \$115,000

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**Balance:** \$0

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**Legal Citation:** M.L. 2016, Chp. 186, Sec. 2, Subd. 03k

**Appropriation Language:**

\$115,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the Minnesota Geological Survey to evaluate links between southeastern Minnesota stream temperatures, trout habitat, and bedrock hydrogeology to improve trout stream management. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

## **I. PROJECT TITLE: Protecting Native Brook Trout: Temperature, Streamflow and Hydrogeology**

### **II. PROJECT STATEMENT:**

The recent discovery of resurgent brook trout populations – brook trout present in 68% of southeastern Minnesota streams compared to only 3% in the early 1970s - has led to an increased interest in documenting and improving critical habitat for this native species - the most temperature-sensitive of southeastern Minnesota's trout population. Many of the brook trout analyzed were not associated with known hatchery sources, leading investigators at the Minnesota DNR and University of Minnesota to focus on potentially remnant lineages that have proven their ability to sustain themselves in this region (Hoxmeier, Dieterman and Miller, 2015). Brook trout often display distinct distributions along stream reaches, thought to be caused by stream temperature, discharge, competition with brown trout, or a combination of all three. Previous groundwater and geologic investigations, funded in part by the LCCMR, have shown that specific layers within the bedrock provide greater groundwater flow. Stream reaches that cross these layers are subject to greater groundwater inputs, increased base flow and lower temperature along and downstream from these reaches thus providing habitat conditions supportive to brook trout.

The goal of this project is develop a workable temperature sensing methodology and apply the methodology to candidate trout stream reaches to quantify the changes in temperature, flow, and trout distributions that occur along them. Advances in temperature measurements using fiber optic cables (distributed temperature sensing, DTS) allow temperature to be recorded through time at regularly spaced intervals, over distances of 1 to 2 kilometers. Stream reaches to be measured will be chosen based on geologic mapping by the Minnesota Geological Survey, focusing in areas where different geologic conditions exist and information on trout distribution and abundance are available.

The proposed work will deliver maps showing where significant reductions in temperature and increases in stream flow are expected to occur. Because these intervals are in large part controlled by subsurface geologic conditions and detailed geologic maps exist for the region, results can be readily extended to unmeasured reaches in southeastern Minnesota. Once developed, the DTS methodology may be applicable to trout streams in other regions of Minnesota and to other aquatic resources that are sensitive to stream temperature distribution such as state and federally listed rare and endangered species

### **III. OVERALL PROJECT STATUS UPDATES:**

#### **Project Status as of January 1, 2017:**

Suitable sites for streamflow and temperature measurements were identified in two distinct hydrogeologic settings. Sites have historic trout distribution data.

#### **Project Status as of July 1, 2017:**

N/A

#### **Project Status as of January 1, 2018:**

Stream flow and temperature measurements have been made at East Indian Creek, Wabasha County, MN – the first of two distinct hydrogeologic settings picked for the project. A fish count and inventory was conducted by DNR Fisheries – Lakeville office along the same stream reach.

#### **Amendment Request (12/28/2017):**

Amendment Approved by LCCMR 01/08/2018. Activity 1 – stream reach suitability assessment, has been completed at a lower cost than expected; Activity 2 – seasonal measurements of temperature, flow and trout distribution is costing more than expected. We propose to shift the remaining Activity 1 balance for personnel [\$19,135] and travel [\$542] to respective Activity 2 budgets. Activity 2 personnel budget changes from \$25,700 to \$44,835 and Activity 2 travel budget changes from \$2,400 to \$2,942.

**Project Status as of July 1, 2018:****Amendment Request (06/29/2018):**

Activity 2 - In the workplan budget, \$12,800 was set in the budget category *Professional/Technical/Service Contracts* to cover the cost of leasing distributed temperature sensing equipment from the Center for Transformative Environmental Monitoring Systems (CTEMPS). Because this work did not require setting up a service contract, these funds were placed in the general supplies account at the University. We propose to move \$12,800 from *Professional/Technical/Service Contracts* to the *Equipment/Tools/Supplies, overall budget* category to be consistent with University budget categories; Activity 2 - Seasonal measurements of temperature, flow and trout distribution are now planned to extend to winter of 2018/2019 rather than fall 2018. We propose to change Activity 2 outcome finish dates from January 1, 2019 to January 31, 2019 to accommodate this change; Activity 2 - Seasonal measurements of temperature, flow and trout distribution has required more staff time than expected. We propose to shift \$10,000 from Activity 3 personnel to Activity 2 personnel.

Amendment Approved: [08/01/2018]

Activity 1 is completed. Activity 3 is will begin January 1, 2019

**Project Status as of January 1, 2019:**

Temperature measurements have been made in Trout Brook, Dakota County, MN – the second of two distinct hydrogeologic settings picked for the project. A fish count and inventory is planned by DNR Fisheries – Lakeville office along the same stream reach. Twelve shallow piezometers were installed along the stream in order to measure vertical hydraulic head gradients. Seven of the piezometers were also equipped with temperature sensors to measure stream bed and stream water temperatures. One additional DTS installation at Brown's Creek in Washington County Minnesota is under consideration, pending access and equipment availability.

**Project Status as of April 15, 2019:****Amendment Request (04/15/2019):**

Activity 3 data interpretation and final report requires more staff time than expected and Activity 2 Professional/Technical/Service Contracts, Activity 2 Equipment/Tools/Supplies, and Activity 2 and 3 travel are less than expected. To cover the additional personnel costs for Activity 3, we propose shifting \$1,800 from Activity 2 Service contracts, \$13,928 from Equipment/Tools/supplies, \$867 from Activity 2 travel and \$633 from Activity 3 travel to Activity 3 personnel. Activity 2 and Activity 3 budget totals have been adjusted for this proposed transfer.

Amendment Approved by LCCMR 4/21/2019

**Project Status as of September 26, 2019:****Amendment Request (09/26/2019):**

All final account entries not available when August 16<sup>th</sup> report was submitted. As a result the following adjustments were made. Service Contract for \$272 not spent, budget amount changed to 0; Supplies total less than reported, budget amount for Activity 2 changed from \$17,900 to \$17,728; personnel more than reported, budgeted amount for Activity 3 changed from \$32,928 to \$33,038; travel more than reported, budgeted amount for Activity 3 changed to \$167 to \$501.

Amendment Approved by LCCMR 10/10/2019

**Overall Project Outcomes and Results:**

The recent discovery of resurgent brook trout populations in southeastern Minnesota streams has led to an increased interest in documenting and improving critical habitat for this native species. Distributed Temperature Sensing (DTS) technology using fiber optic cables, combined with detailed mapping of geologic conditions and hydraulic head were used to identify areas of preferential base flow at three southeastern Minnesota trout

streams— East Indian Creek in Wabasha County, Trout Brook in Dakota County, and Valley Creek in Washington County. Results were compared to fish inventories conducted by the Minnesota Department of Natural Resources to evaluate influence of focused groundwater input on brook trout distribution and abundance. Continuous stream temperature measurements along one meter segments over distances up to 1900 meters were taken in winter when air and groundwater temperatures are most different. Transition from mixed populations of brown and brook trout to predominantly brook trout corresponded specific stream reaches showing preferential base flow inputs from groundwater.

At the regional scale, artesian conditions were compared to bedrock geology and brook trout abundance to locate areas where brook trout, including remnant brook trout, may be most successfully established. Brook trout are found in almost exclusively in streams where the Oneota Dolomite and underlying bedrock units are uppermost bedrock. Streams in these settings have springs characterized by relatively constant temperatures, and are supplied by groundwater in generally poor connection to the land surface compared to near-surface aquifers. As such, they have relatively low susceptibility to high turbidity and contaminant pulses resulting from extreme storm events. At both regional and local cases our work (see attached) demonstrates to natural resource managers the direct geologic control on hydraulic head conditions – particularly on vertical head gradients between bedrock layers and the role they play both in stream base flow and brook trout distribution and abundance.

#### **IV. PROJECT ACTIVITIES AND OUTCOMES:**

##### **ACTIVITY 1: Stream reach suitability assessment**

**Description:** To identify sites suitable for streamflow temperature measurement, we will use County Geologic Atlas maps from the Minnesota Geological Survey and previous trout distribution investigations to target potential reaches. Because the cable must remain submerged during measurement phases, factors such as stream depth, morphology, and bed characteristics will be considered. Ideally, we will identify reaches in several different geologic settings where contributions to streamflow will be primarily from groundwater (baseflow).

##### **Summary Budget Information for Activity 1:**

**ENRTF Budget:** \$ 6,823  
**Amount Spent:** \$ 6,823  
**Balance:** \$ 0

<b>Outcome</b>	<b>Completion Date</b>
<b>1.</b> Identification of potential stream reaches for measurement based on hydrogeologic setting and historic trout distribution data	December 1, 2016

##### **Activity Status as of January 1, 2017:**

Suitable sites for 2017 streamflow temperature and flow measurements in Wabasha and Dakota Counties were identified and confirmed with field visits. Field visits included reconnaissance streamflow measurements, originally scheduled as part of activity 2. Appropriate land owners and/or responsible parties have been contacted for stream access. Additional sites were also identified for 2018. Conducted a literature review on data collection and analysis using Distributed Temperature Sensing (DTS) equipment.

##### **Activity Status as of July 1, 2017:**

N/A

##### **Activity Status as of January 1, 2018:**

Activity 1 completed. Requesting remaining personnel and travel balances from Activity 1 [19,677] be transferred to Activity 2 personnel and travel budget.

##### **Activity Status as of July 1, 2018:**

N/A

**Activity Status as of January 1, 2019:**

N/A

**Activity Status as of April 15, 2019:**

N/A

**Final Report Summary:**

Through benefit of cooperation with landowners and Dakota County Parks, we were able to conduct this work in three distinct hydrogeologic settings. The number of potential sites scoped as part of this activity far exceed the number that we would be able to install at. This became apparent once we began the process of installation, data collection and removal (Activity 2)

**ACTIVITY 2: Seasonal measurements of temperature, flow and trout distribution**

**Description:** Temperature data will be collected in different seasons from Spring 2017 until Winter 2018/2019. Fish population assessments and streamflow measurements will be conducted seasonally during the same time period.

**Summary Budget Information for Activity 2:**

**ENRTF Budget:** \$ ~~75,082~~  
\$ 74,638

**Amount Spent:** \$ 74,638

**Balance:** \$ 0

<b>Outcome</b>	<b>Completion Date</b>
1. Application for DTS equipment from Center for Transformative Environmental Monitoring Programs (CTEMPS)	December 31, 2016
2. Equipment acquired and training completed	May 1, 2017
3. Practical aspects and pitfalls of using DTS equipment to measure stream temperatures identified. Seasonal measurements of stream temperature, flow and trout distribution taken.	June 1, 2018
4. links between stream temperature, streamflow and bedrock geology analyzed	January 31, 2019
5. links between brook trout populations and bedrock geology analyzed	January 31, 2019

**Activity Status as of January 1, 2017:**

Staff from the Center for Transformative Environmental Monitoring Programs (CTEMPS) contacted and application for DTS equipment submitted. Installation dates subject to change depending on equipment and staff availability, and final decisions on first installation season (spring or late summer-fall, 2017). Portable flow-meter purchased and reconnaissance measurements made at target sites.

**Activity Status as of July 1, 2017:**

N/A

**Activity Status as of January 1, 2018:**

DTS measuring equipment and cable received from CTEMPS . Two-thousand meters of cable installed in East Indian Creek headwaters – Wabasha County, Minnesota, the first of two distinct hydrogeologic settings picked for the project. Stream temperature data was collected at 5 minute intervals from August 25th to September 28th, 2017. Data are currently being calibrated and analyzed. A winter DTS measurement at this site is planned

for the week of January 8<sup>th</sup> through January 12<sup>th</sup>, 2018. A fish count and inventory was conducted by DNR Fisheries – Lakeville office along this same stream reach. Fish species are primarily brook trout, with the proportion of brook trout to brown trout increasing upstream. Synoptic stream flow measurements made after the fish inventory confirms base flow increasing along the reach. Activity 2 has cost more than expected in the original budget. Requesting remaining personnel and travel balances from Activity 1 [19,677] be transferred to Activity 2 personnel and travel budget. It is expected this change will cover the cost of DTS measurements at the second site.

#### **Activity Status as of July 1, 2018:**

A winter DTS measurements were made between January 8<sup>th</sup> and January 29<sup>th</sup> 2018 in the East Indian Creek headwaters – Wabasha County. Data from the Fall 2017 and Winter 2018 installations were calibrated and analyzed. Outcrop mapping, borehole geophysics and passive seismic transects were conducted at Trout Brook in southeastern Dakota County in preparation for the second DTS installation, scheduled to take place in late fall/early winter of 2018, possibly stretching into January of 2019 depending on conditions and equipment availability. Installation in Dakota County has moved from fall 2018 to winter 2018/2019 in order to take advantage the greater temperature differential between groundwater and surface water at that time.

#### **Activity Status as of January 1, 2019:**

A total of 1800 meters of cable was installed in Trout Brook – Dakota County Minnesota, the second of two distinct hydrogeology settings picked for the project. Stream temperature data were collected at 5 minute intervals along 1300 meters of cable from December 11<sup>th</sup> to December 19<sup>th</sup> 2018. An additional 500 meters of cable was installed on December 19<sup>th</sup>. Stream temperature data were collected on both cables at 8 minute intervals from December 19<sup>th</sup> until December 25<sup>th</sup>. Twelve shallow piezometers were installed along the stream in order to measure vertical hydraulic head gradients. Seven of the piezometers were also equipped with temperature sensors to measure stream bed and stream water temperatures. Prior to cable installation, re-splicing of cable ends were required due to a break in the original 2000 meter cable used at East Indian Creek.

One additional DTS installation at Brown's Creek in Washington County Minnesota is under consideration, pending access and equipment availability.

#### **Activity Status as of April 15, 2019:**

A total of 1600 meters of cable was installed at Valley Creek – Washington County Minnesota. This third site was added because of mapped faults along the measured stream reach – providing a third distinct hydrogeologic setting for the project. Shallow piezometers added to Trout Brook.

#### **Final Report Summary:**

Installation activities and data calibration ended up being the most labor intensive and time consuming parts of the project. By the third installation at Valley Creek in Washington County, methods for cable and equipment installation and removal had been work out and these tasks went far more smoothly than the first installation at East Indian Creek, Wabasha County. The additional work to install shallow piezometers with temperature transducers was not in the original work plan, but provided valuable data at low cost, and will be used in future investigations to supplement DTS profiles. DTS equipment has a steep learning curve, but the data provided could not be obtained in any other way. Perhaps the biggest benefit from this activity was to understand the pitfalls and the benefits of these methods. With this knowledge we can provide clear direction and advice for future DTS projects.

#### **ACTIVITY 3: Critical reach mapping and report**

**Description:** Report with interpretation of collected data will provide, for the first time, maps showing the extent of both measured and projected cold water reaches, their correlation with trout habitat, and their position relative to specific bedrock hydrogeologic conditions.



**Summary Budget Information for Activity 3:****ENRTF Budget:** \$ ~~33,095~~

\$33,028

**Amount Spent:** \$ 33,028**Balance:** \$ 0

Outcome	Completion Date
1. Map capturing key reaches where significant reductions in temperature and increases in stream flow to occur. Map will also show areas where significant reductions in temperature and increases in flow are expected to occur based on investigation results.	June 1, 2019
2. Map identifying distribution of brook trout associated with colder reaches	June 1, 2019

**Activity Status as of January 1, 2017:**

no activity during the reporting period

**Activity Status as of July 1, 2017:**

N/A

**Activity Status as of January 1, 2018:**

no activity during the reporting period

**Activity Status as of July 1, 2018:**

no activity during the reporting period

**Activity Status as of January 1, 2019:**

no activity during the reporting period

**Activity Status as of April 15, 2019:**

Work has begun on data interpretation and analysis, figures, and report outline.

**Activity Status as of June 29, 2019:**

Work completed on data interpretation and analysis, figures, and report outline and final report text.

**Final Report Summary:**

Work completed and final report reviewed by co-authors. Maps included as attachment and as figures in final report.

**V. DISSEMINATION:**

**Description:** Report and maps will be disseminated as Minnesota Geological Survey Open File Report, stored at the University of Minnesota's Digital Conservancy (<http://conservancy.umn.edu/>) and accessible via the Minnesota Geological Survey's web site (<http://www.mnngs.umn.edu/>). Results will be presented in talks at Minnesota Ground Water Association and MN Water conferences. Publication in peer-reviewed journals will also be pursued.

**Status as of January 1, 2017:**

no activity during the reporting period

**Status as of July 1, 2017:**

N/A

**Status as of January 1, 2018:**

no activity during the reporting period

**Status as of July 1, 2018:**

**Status as of January 1, 2019:**

no activity during the reporting period

**Status as of April 15, 2019:**

no activity during the reporting period

**Status as of August 16, 2019:**

Report in review for distribution as MGS open-file report.

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**Final Report Summary:**

The attached report is currently being revised for release as an Open-File Report available publically via the University of Minnesota's Digital Conservancy (<https://conservancy.umn.edu/>), and for peer-reviewed journal submittal. As a project that includes a hybrid of disciplines, it is expected that results will be presented at meetings with both groundwater and natural resource management focus. This is the time where trout investigations in southeastern Minnesota have been conducted within the context of detailed geologic and hydraulic head mapping. The results demonstrate the value of this approach to assess focused groundwater inputs on trout distribution and abundance at both local and regional scales. As such, project results benefit natural resource, landuse, and water use managers. To date, the results have been presented to a group of local residents and landowners from East Indian Creek in Wabasha County, organized by Jen Wahls, Landuse Outreach Coordinator for Wabasha County SWCD and by Nick Budde, student scholarship recipient at the Minnesota Groundwater Association Spring 2018 Conference.

**VI. PROJECT BUDGET SUMMARY:**

**A. ENRTF Budget Overview:**

Budget Category	\$ Amount	Overview Explanation
Personnel:	\$ 94,438	1 project manager and hydrogeologist at 14.8% FTE each year for 3 years (\$41,890); 1 lead geologist at 6.6% FTE each year for 3 years (\$20,156); 1 geologist at 5.5% FTE each year for 3 years (\$11,818); 1 geologist at 7.1% FTE each year for 3 years (\$12,969); field tech support (\$5,967); geophysicist (\$1,638)
Professional/Technical/Service Contracts:	\$ 0	Fiber optic cable repair (\$0) [not billed]
Equipment/Tools/Supplies:	\$ 17,728	leasing Distributed Temperature Sensing (DTS) equipment during the project and technical support from Center for Transformative Environmental Monitoring Programs (CTEMPS), administered jointly by Oregon State University, University of Nevada-Reno, and National

		Science Foundation (\$6716.69); Portable Velocity Meter with 20' Cable for stream gauging (\$4,982.47); Supplies to submerge and protect data collection equipment (\$1751.54); Final shipping costs for DTS equipment – 3 shipping events (\$1967.33); 2000 meters of armored fiber optic cable (\$2,000); DTS cable collectors (\$0); DTS water-tight splice boxes (\$310)
Travel Expenses in MN:	\$ 2,834	Final Travel expenses between potential and established field sites
<b>TOTAL ENRTF BUDGET: \$ 115,000</b>		

**Explanation of Use of Classified Staff:** N/A

**Explanation of Capital Expenditures Greater Than \$5,000:**

A Portable Velocity Meter with 20 feet of cable for stream gauging is expected to cost \$4,903. This purchase will cost less than contracting out for professional services, provide more scheduling flexibility, and allow us to conduct flow surveys at more than one site. After the project has ended, the equipment will continue to be used by the Minnesota Geological Survey and Earth Sciences Department at the University of Minnesota for research and educational purposes.

**Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:** 0.85

**Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:** 0.06

**B. Other Funds:**

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
<b>Non-state</b>			
	\$	\$	
<b>State</b>			
DNR Fisheries (In-kind Support)	\$ 15,200	\$	One month salary equivalent, in each of two project years for John Hoxmeier, MNDNR Fisheries to lead the fish population assessment and assist with DTS equipment installation and monitoring
MPCA (In-kind Support)	\$ 16,000		One month salary equivalent in each of two project years for MPCA staff person to assist with siting, DTS equipment installation and monitoring
University of Minnesota (In-kind Support)	\$ 46,362		The University of Minnesota's Facilities and Administrative rate is 52% of modified total direct costs (total direct less graduate student fringe, capital equipment, subawards over \$25,000 and on-site facilities rental). The amount, if F&A expenses would have

			been allowed on this project, would be \$46,362
Minnesota Geological Survey (MGS)	\$ 922	\$ 922	MGS provided travel support to workshop on use of DTS equipment
<b>TOTAL OTHER FUNDS:</b>	<b>\$ 78,484</b>	<b>\$ 922</b>	

Additional funding provided by MGS to support attending DTS workshop, December 10-11, 2016

## VII. PROJECT STRATEGY:

### A. Project Partners:

Project Partners Not Receiving Funds:

- Minnesota Department of Natural Resources – Fisheries Division: John Hoxmeier providing in-kind support to lead fish population assessment and to assist with Distributed Temperature Sensing (DTS) equipment installation and monitoring.
- Minnesota Pollution control Agency: Staff providing in-kind assistance with DTS equipment installation and monitoring.
- University of Minnesota Department of Earth Sciences: Technical support for equipment field testing.

Project Partners Receiving Funds:

- Center for Transformative Environmental Monitoring Systems (CTEMPS), jointly operated by Oregon State University, Corvallis and the University of Nevada, Reno, and funded by the National Science Foundation: \$12,800 to lease DTS equipment used during the investigation.

### B. Project Impact and Long-term Strategy:

The proposed work will deliver maps showing where significant reductions in temperature and increases in stream flow are expected to occur. Because these intervals are in large part controlled by subsurface geologic conditions and detailed geologic maps exist for the region, results can be readily extended to unmeasured reaches in southeastern Minnesota. Once developed, the DTS methodology may be applicable to trout streams in other regions of Minnesota and to other aquatic resources that are sensitive to stream temperature distribution such as state and federally listed rare and endangered species.

The study will benefit the MN DNR in developing better management strategies for conserving recently discovered remnant brook trout populations in Minnesota. Given that brook trout rely heavily on cold groundwater inputs, information on these inputs is crucial toward understanding limits to their distribution. With a predicted increase in air temperatures over the next half century, identifying coldwater springs and stream reaches will become even more valuable in terms of providing coldwater fish refuge.

### C. Funding History:

<b>Funding Source and Use of Funds</b>	<b>Funding Timeframe</b>	<b>\$ Amount</b>
Proposed project builds on County Geologic Atlas mapping program, with the first southeastern Minnesota Geologic Atlas map completed in 1982. Since 2007, <b>Statewide</b> ENRTF 2007-2014 \$3,952,199; CWF 2010-2014 \$674,000; DNR 2007-2014 \$2,155,694; Fed cost-sharing 2008-2013 \$663,791. ENRTF 2015-2018 \$2,040,000	2007 - 2018	\$9,485,684
Clean Water Fund - County Geologic Atlases for Houston and Winona Counties	7/1/2010 – 12/31/2014	\$305,000
ENTRF funded a 2010 project "Investigation of the hydrologic properties of the St. Lawrence Formation" (M.L. 2010, Chp. 362, Sec. 2, Subd. 3a). The results of that investigation have led to findings that we will apply to this proposed project	7/1/2010 – 6/30/2013	\$307,000

Investigation of bedrock controls on nitrate distribution in southeastern Minnesota streams, funded by the Minnesota Pollution Control Agency - 319/Clean Water Partnership/TMDL project	1/3/2011 – 6/30/2013	\$73,563
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# VIII. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:

A. Parcel List: N/A

B. Acquisition/Restoration Information: N/A

# IX. VISUAL COMPONENT or MAP(S):

A.

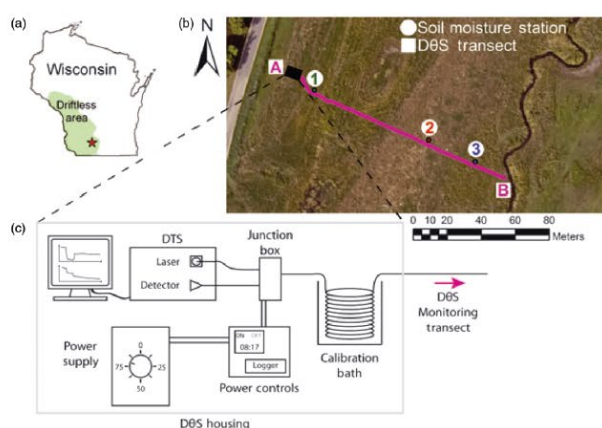


B.



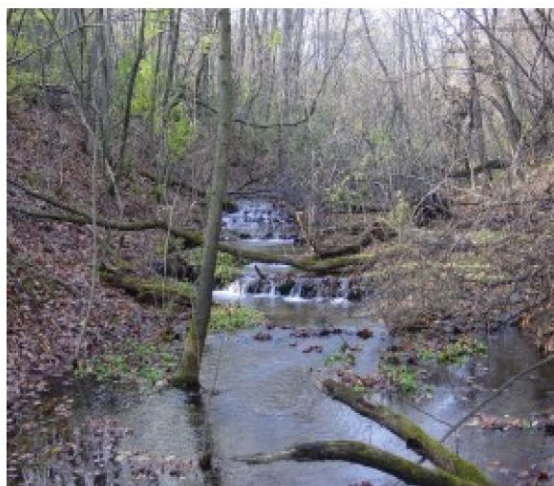
**Southeastern Minnesota brook trout** average less than 10 inches, although brook trout up to 17 inches are occasionally caught. Because brookies can tolerate only the cleanest and clearest water, fishing for this species invariably takes anglers to the most pristine and scenic areas of the southeast.

C.



Distributed Temperature Sensing installation in southwestern Wisconsin. (Striegl and Loheide, 2012)

D.



Brook trout, streams and temperature, southeastern Minnesota. **A.** Brook trout require cold, clean water to thrive. **B.** Photo of brook trout from MnDNR news release, April 16, 2015. **C.** Distributed Temperature Sensing (DTS) installation to look at soil moisture profiles, southwestern Wisconsin. **D.** Photo of trout stream from MnDNR news release, April 16, 2015.

- A. [http://www.dnr.state.mn.us/fishing/trout\\_streams/trout\\_species.html](http://www.dnr.state.mn.us/fishing/trout_streams/trout_species.html)
- B. <http://news.dnr.state.mn.us/2015/04/16/for-trout-fishing-in-southeastern-minnesota-these-are-the-good-old-days/>
- C. Striegl, A. and Loheide, S., 2012, Heated distributed temperature sensing for field scale moisture monitoring, Groundwater, v. 50 no. 3, p. 340-347.

<http://news.dnr.state.mn.us/2015/04/16/for-trout-fishing-in-southeastern-minnesota-these-are-the-good-old-days/>

**X. RESEARCH ADDENDUM: N/A**

**XI. REPORTING REQUIREMENTS:**

Periodic work plan status update reports will be submitted not later than January 1, 2017; July 1, 2017; January 1, 2018; July 1, 2018, and January 1, 2019. A final report and associated products will be submitted between June 30 and August 15, 2019.

**Environment and Natural Resources Trust Fund**  
**FINAL M.L. 2016 Project Budget**

**Project Title:** Evaluate Temperature, Streamflow, and Hydrogeology Impact on Brook Trout Habitat  
**Legal Citation:** *M.L. 2016, Chp. 186, Sec. 2, Subd. 03k*  
**Project Manager:** Bob Tipping  
**Organization:** Minnesota Geological Survey  
**M.L. 2016 ENRTF Appropriation:** \$ 115,000  
**Project Length and Completion Date:** 3 Years, June 30, 2019  
**Date of Report:** September 25, 2019

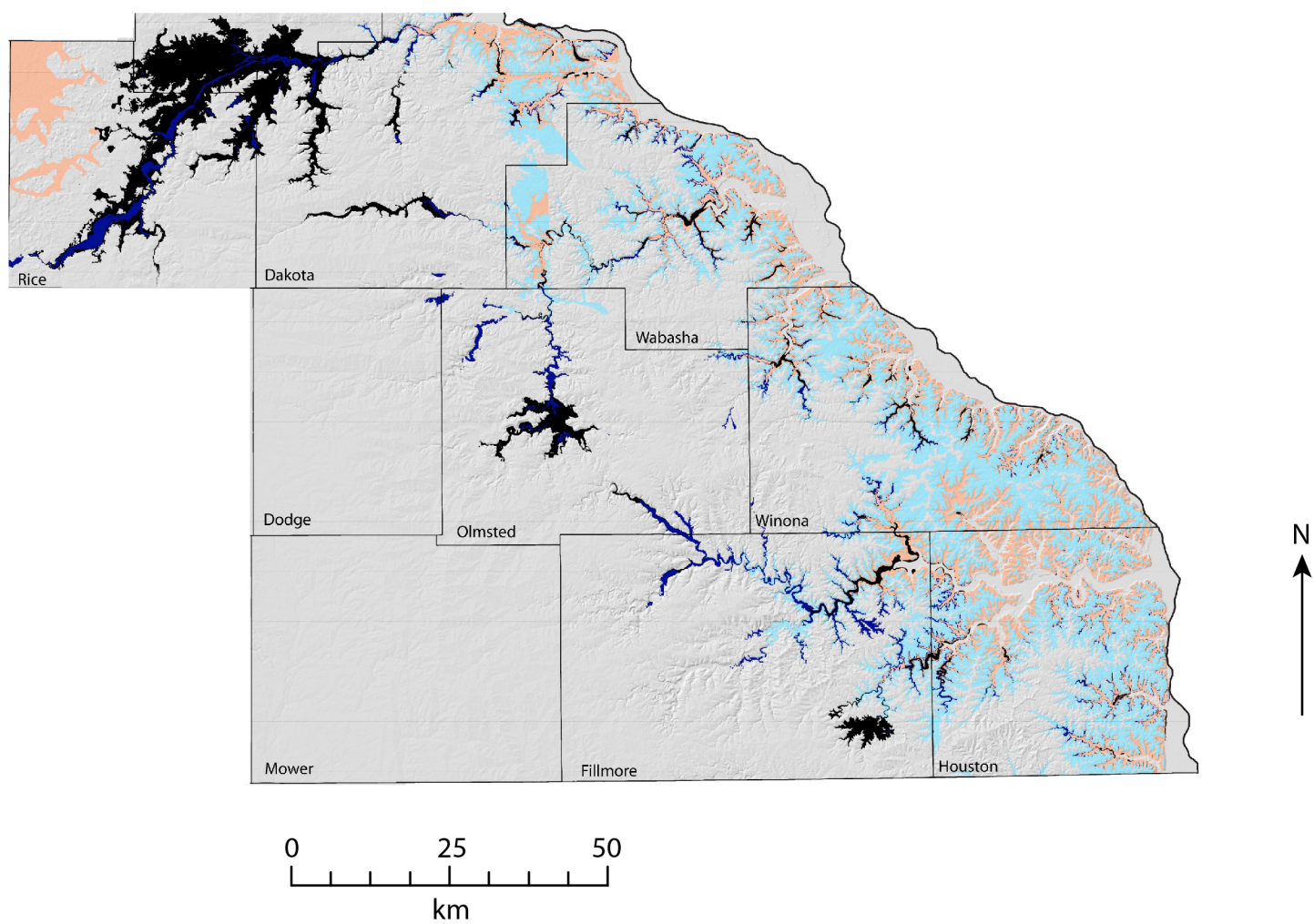


ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Activity 1 Budget 12/18/2017	Amount Spent	Activity 1 Balance	Revised Activity 2 Budget 09/25/2019	Amount Spent	Activity 2 Balance	Revised Activity 3 Budget 09/25/2019	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
<b>BUDGET ITEM</b>	<b>Stream reach suitability assessment</b>										
<b>Personnel (Wages and Benefits), overall budget</b>	\$6,565	6,565.00	\$0	\$54,835	\$54,835	\$0	\$33,038	\$33,038	\$0	\$94,438	\$0
Bob Tipping, Project Manager, Geologist: [73.6 % salary, 26.4 % benefits]; 9.5% FTE each year for 3 year: \$27,000]											
Tony Runkel, Geologist: [73.6 % salary, 26.4 % benefits];8.5% FTE each year for 3 years: \$25,800]											
Julia Steenberg, Geologist: [73.6 % salary, 26.4 % benefits]; 6.0% FTE each year for 3 years: \$13,300]											
Andrew Retzler, Geologist: [73.6 % salary, 26.4 % benefits]; 6.0% FTE each year for 3 years: \$11,000]											
<b>Professional/Technical/Service Contracts</b>											
CTEMPS Technical support in the field (2 people, 4 days). Airfare: \$1,200; lodging \$118/day; food: \$50/person per day											
<b>Equipment/Tools/Supplies, overall budget</b>				\$17,728	\$17,728	\$0				\$17,728	\$0
Center for Transformative Envionmental Monitoring Systems (CTEMPS), jointly operated by Oregon State University, Corvallis and the University of Nevada, Reno, and funded by the National Science Foundation. Leasing of Distributed Temperature Sensing (DTS) equipment used during the project											
Portable Velocity Meter with 20' Cable for stream gauging [\$4,903]											
Supplies to submerge and protect data collection equipment, and fiber optic cable in the stream bed [\$1,055 ]											
Estimated shipping for DTS equipment, [4 shipping events at \$1,500 per event: \$6,000]											
2000 meters of armored fiber optic cable used as part of the DTS installation [\$2.50/meter: \$5000]											
Cable connectors used as part of the DTS installation [18 at \$50 each: \$900]											
Water tight splice boxes [18 at \$65 each: \$1170]											
<b>Travel expenses in Minnesota</b>											
Travel between potential and established field sites – 2000 miles - 0.17/mile- and vehicle rental - \$239/week for 4 weeks – ( \$1,300); lodging – 10 days at \$118/day (\$1,180); meals – 30 days at \$48/day (\$1440)	\$258	\$258	\$0	\$2,075	\$2,075	\$0	\$501	\$501	\$0	\$2,834	\$0
<b>COLUMN TOTAL</b>	<b>\$6,823</b>	<b>\$6,823</b>	<b>\$0</b>	<b>\$74,638</b>	<b>\$74,638</b>	<b>\$0</b>		<b>\$33,539</b>	<b>\$0</b>	<b>\$115,000</b>	<b>\$0</b>

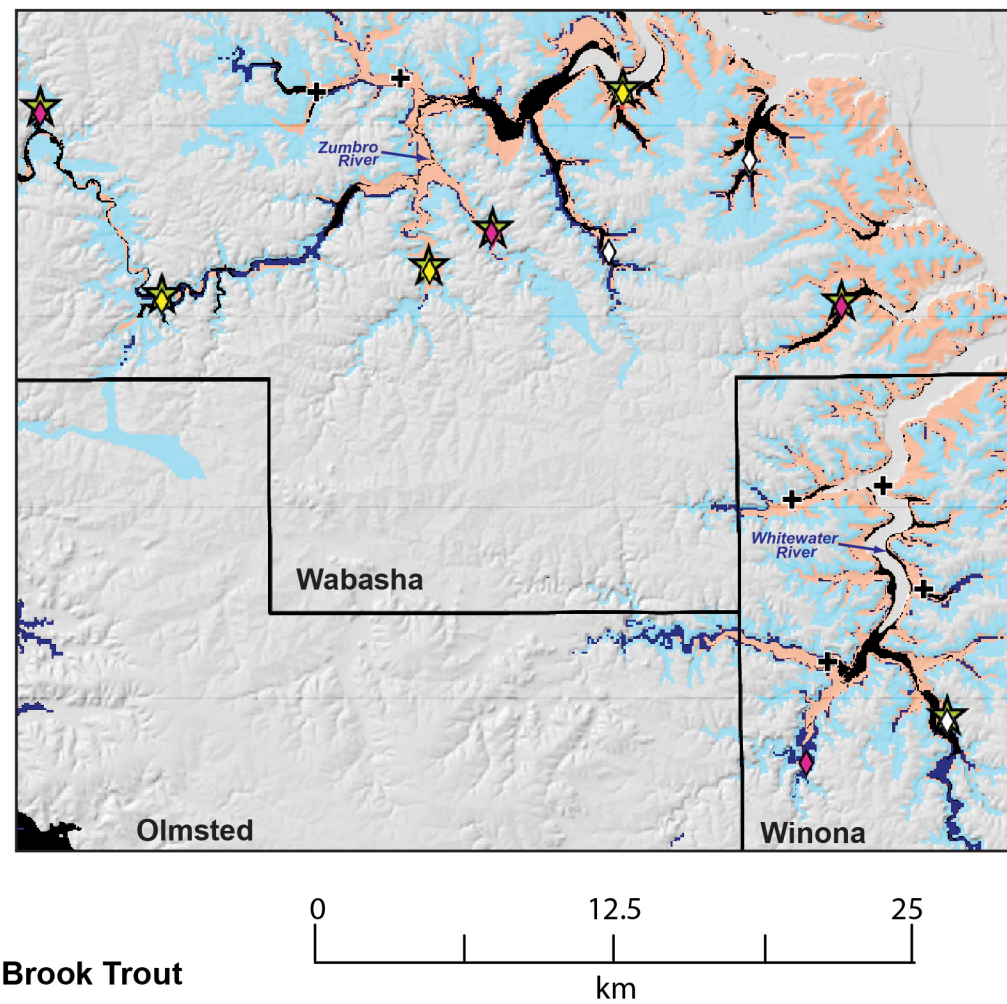


# SE MINNESOTA BROOK TROUT DISTRIBUTION COMPARED TO BEDROCK GEOLOGY AND ARTESIAN CONDITIONS

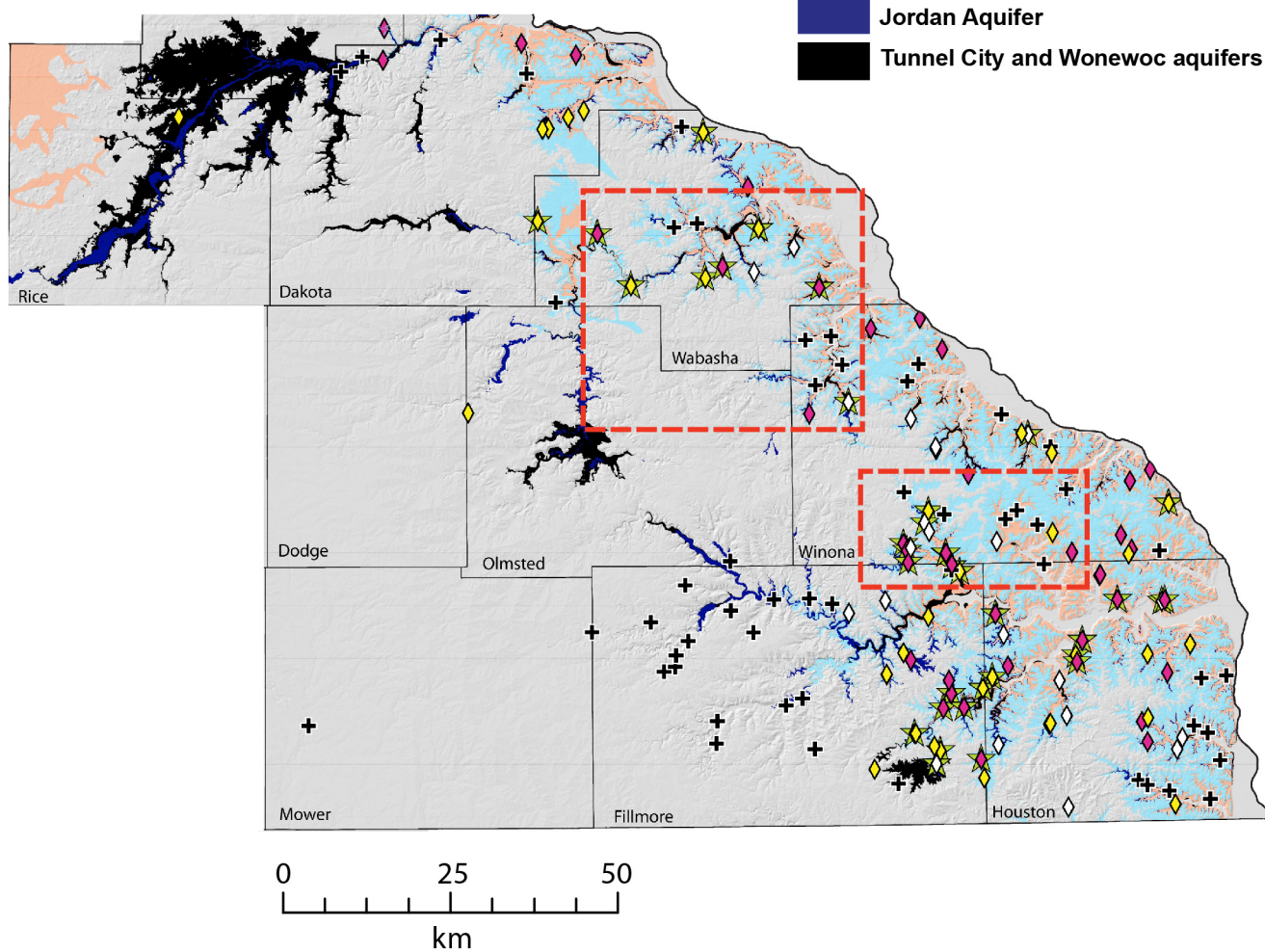
Map A



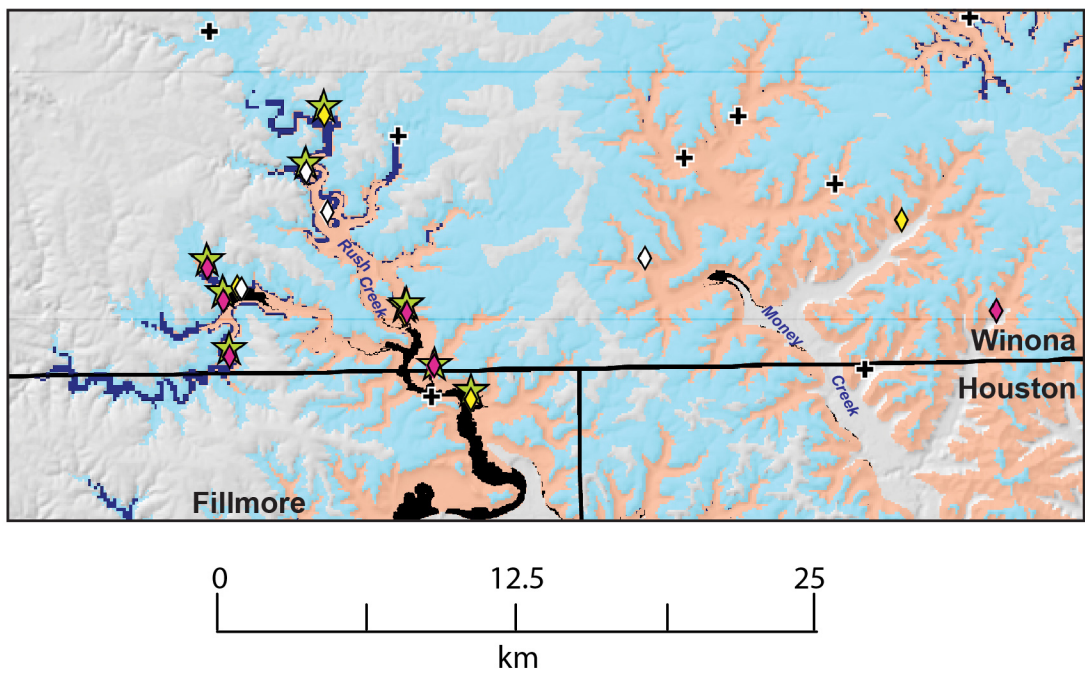
Inset 1



Map B



Inset 2



Maps highlighting the uppermost bedrock units (Oneota Dolomite downward through the Tunnel City Group) and potential artesian hydraulic head conditions that appear to be linked to preferential habitat for brook trout. **A)** Highlights the key bedrock units and greatest potential for artesian hydraulic head conditions. **B)** Map shown in A), with overlay illustrating brook trout distribution, population and genetic results. The latter shows where brook trout with remnant genetics have been identified. Bedrock map is based on compilation mapping provided in Runkel et al. (2013), which is largely derived from the County Geologic Atlas Program by the Minnesota Geological Survey and Minnesota Department of Natural Resources. Possible artesian conditions were mapped as part of this project by subtracting the elevation of the land surface from the elevation of groundwater potentiometric contours from Blum (2018). Brook trout population and genetic data are from the Minnesota Department of Natural Resources and described by Hoxmeier et al. (2015).

Local examples comparing hydrogeologic conditions to brook trout distribution. **1)** The more widespread potential artesian conditions in Rush Creek tributaries compared to Money Creek may account for the greater abundance and presence of remnant brook trout in the former; **2)** The stream reaches in this area show local inconsistency in a comparison of hydrogeologic conditions to brook trout distribution. Although higher populations and presence of remnant brook trout correspond to low bedrock units and possible artesian conditions, several other stream reaches with those same conditions have no brook trout.



UNIVERSITY OF MINNESOTA



Map produced by as part of project funded by the Minnesota Environment and Natural Resources Trust Fund, "Evaluation of Temperature, Streamflow and Hydrogeology impact on Brook Trout Habitat" Project M.L. 2016, Chp. 186, Sec. 2, Subd. 03k

