Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Date of Report: January 29, 2014
Date of Next Status Update Report: December 31, 2014
Date of Work Plan Approval:
Project Completion Date: June 30, 2017
Does this submission include an amendment request? No

PROJECT TITLE: Protection of State's Confined Drinking Water Aquifeers

Project Manager: James R Stark
Organization: U. S. Geological Survey
Mailing Address: 2280 Woodale Drive
City/State/Zip Code: Mounds View, MN 55112
Telephone Number: (763) 783-3230
Email Address: stark@usgs.gov
Web Address: http://mn.water.usgs.gov/index.html

Location: Statewide

Total ENRTF Project Budget:	**ENRTF Appropriation:**	**$394,000**
	Amount Spent:	**$0**
	Balance:	**$394,000**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 03h

Appropriation Language:
$394,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the United States Geological Survey to test methods of defining properties of confined drinking water aquifers in order to improve water management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Protecting the State's Confined Drinking-Water Aquifers

II.PROJECT STATEMENT: Many glacial aquifers in Minnesota used as sources of drinking water are overlain by clayey glacial deposits (confining units, see figures). These confined aquifers are critical state resources because they provide the only sources of clean, reliable drinking water to tens of thousands of urban and outstate residents of Minnesota. The confining units overlaying confined aquifers are a vitally important part of aquifer systems because they form protective barriers for the confined aquifers from land-surface contamination. The confining units also, however, limit water flow (infiltration) to confined aquifers, so replenishing water in confined aquifers is a slow and limited process. We need to better understand the hydraulic properties of confining units to ensure sustainable use of water from these important drinking-water aquifers. This project will assess hydraulic properties of the state's two major regional glacial confining units--the Des Moines and Superior lobe till confining units (see figures) by measuring detailed, site-specific information about protective confining units at two study sites that represent the state's most important confining units. The project also will provide key information and will map the extent and properties of the two confining units across the state (this portion of this proposals does not request ENRTF funding. The overall project is a collaborative effort among the U. S. Geological Survey (USGS), the Minnesota Geological Survey (MGS) and the Minnesota Department of Natural Resources (MDNR), and the Minnesota Department of Health (MDH). It augments work completed by the County Geologic Atlas Program. The effort will help to answer important questions about confining units and confined aquifers, including:

- *What are the pathways for water and contaminant movement through glacial confining units?*
- *What is the source of water replenishing glacial confined aquifers?*
- *How long does it take water to move along the flow pathways?*
- *How much water infiltrates into and recharges glacial aquifers?*
- *What are best estimates of long-term sustainable pumping from confined glacial aquifers used as sources of drinking water?*
- *How do properties of glacial confining units vary across the state?*

Problem: Confined glacial aquifers provide water to many residents in Minnesota. An important factor affecting the long-term sustainable availability of water from these aquifers is infiltration through overlying glacial till confining units. Few data exist, however, on the vertical hydraulic properties and infiltration rates through till. The lack of detailed infiltration and hydraulic data hinders the state's efforts to define the sustainability of confined aquifers. There is also a need to understand the regional variability of the properties of confining units by mapping existing and newly collected data across the state.

It is important to protect confined drinking-water aquifers from non-sustainable over-pumping. To accomplish the goal of long-term sustainability, the sources, rates and quality of water infiltrating into confined aquifers must be understood. An important factor defining sustainable water use from confined aquifers is the rate of water movement (infiltration) through overlying confining units that replenish confined drinking-water aquifers. We currently lack information about infiltration to confined aquifers because infiltration depends upon the hydraulic properties of the overlying confining units. Infiltration- rate information is needed to manage confined aquifers so that they are protected for the future. Although the MGS and MDNR have an active County Geologic Atlas Program, which maps the extent and thickness of protective confining layers, the program needs supplementary information about hydraulic properties and infiltration to confining units. Filling this gap in understanding is also required for the MDNR water appropriation-permit process to ensure long-term sustainability of water supply from confined aquifers. This project contributes toward filling that gap in information by providing detailed site-specific data about the confining units at two study sites that represent the state's most important confining units--the Des Moines and Superior lobe till deposits (see figures). Direct field measurements will provide information needed to estimate the water-bearing and water-transmitting characteristics of these aquifers.

It also is important to protect confined drinking-water aquifers from contamination. The quality of water in confined aquifers is presumed to be protected by overlying confining beds. Confining units comprised of till are assumed to provide protection to confined groundwater supplies because infiltration water passes more slowly

through these confining units than through surficial sand-and-gravel aquifers. Because of the increased transport time and reduced infiltration through till, however, water that was contaminated, say 20 years ago, may not have yet reached underlying confined drift aquifers. Thus, there may be a delayed adverse response from human activities on groundwater quality Scattered and isolated information suggests that groundwater and contaminants can flow from land surface through confining units to confined aquifers at varying rates and there is a critical need to understand how confining units protect the water quality of confined aquifers. These concerns identify our need to better understand the state's two important confining units.

Finally, a lack of statewide infiltration and hydraulic data hinders the state's efforts to define sustainability of confined aquifers. A database of till hydraulic information that includes infiltration rates is needed. A limited number of hydraulic tests have been conducted in the state but these data currently reside with the various agencies that conducted them. Once established, a confining-unit database can be used to determine areas of additional needs. Following establishment of the database, data from field studies that collect additional information in varying hydrogeological settings within the state can be included. These data will be able to be used to regionalize the variability of the properties of confining units by summarizing and mapping existing and newly collected data across the state, all within the context of the detailed site specific data collected in the field as part of this study.

Benefits: Information on the spatial variability of hydraulic properties and groundwater infiltration rates through till is necessary to plan for long-term water sustainability. In addition, this information to accurately evaluate contributing areas for wells completed in confined-drift aquifers are essential for the MDH's wellhead protection program because delineating and protection of these contributing areas is more complex for confined aquifers than for unconfined aquifers. Accurate simulation of infiltration through glacial till also is a critical component for calibration of groundwater flow models. Because accurate estimates of infiltration rates are lacking, model analyses must largely rely on inferred data or results of laboratory tests.

The proposed study will increase the Minnesota Department of Natural Resources understanding of the role of till confining units in water supply and the hydrologic cycle, resulting in more appropriate management decisions in glacial drift areas. Results from the specific data-collection sites will be regionalized such that results will be beneficial in other areas of this state where data are lacking. The Minnesota Pollution Control Agency will benefit from the study by gaining a better understanding of the vulnerability and susceptibility of confined drift aquifers to contamination. By obtaining a better understanding of infiltration through glacial till, the Twin Cities Metropolitan Council, Minnesota Pollution Control Agency (MPCA), and environmental consultant firms will be able to more accurately simulate groundwater movement in confined aquifers. Study results will provide the MGS, colleges, and universities with basic knowledge important to educating the public on basic science. Local water utilities, where the individual hydraulic tests will be conducted, will benefit directly from results of this study. By comparing various methods of estimating groundwater leakage, study results will be beneficial to future USGS studies of recharge and infiltration through confining units in other areas of the state and the country.

Scope and Objectives: This project will estimate the hydraulic properties and map the continuity of the state's most important confining units--the Des Moines and Superior lobe confining units. The approach involves conducting two detailed field studies in areas representing each of these confining unit types. Study sites will be selected in areas with existing high-capacity pumping wells (likely municipal-supply wells) to understand how pumping stress affects water movement. Scientific bore holes will be completed in the confining units and into the underlying confined aquifers. Field analyses will include hydraulic, geophysical and chemical tests. These tests may include mulit-well aquifer tests, single-well pump tests, geophysical logging (e.g. gamma, temperature, fluid resistivity measurements) and measures of water chemistry.

The location of the two has yet to be determined. Site selection and access permission is a significant part of this study and will take place when the study begins. Study- site selection will be a collaborative effort with the Minnesota Department of Natural Resources, the Minnesota Geological Survey, and the Minnesota Department of Health. Study sites will be located near appropriate municipal production wells in areas with approved wellhead protection plans.

A statewide database of till hydraulic information that includes infiltration rates will be developed. The database will include information from hydraulic tests that currently reside with the various entities that conducted them. Once established, a confining-unit database will be used to determine areas where data are lacking. Following establishment of the database, data from field studies that collect additional information in varying hydrogeological settings within the state can be included. These data will be able to be used to regionalize the variability of the properties of confining units by summarizing and mapping existing and newly collected data across the state, all within the context of the detailed site specific data collected in the field as part of this study. In the future, additional test sites would provide long-term data about confined glacial aquifers. These data are needed to better protect confined drinking water aquifers and to define the amount of water that can be pumped from individual confined aquifers (MDNR appropriation permit process) on a long-term and sustainable basis.

The objectives of the study are as follows:

1. Explore available information to select appropriate study sites representing the primary glacial confining units in the state
2. Quantify the variability of hydrologic properties and infiltration through glacial confining units at two representative sites in Minnesota
3. Develop a database of hydraulic information for till confining units throughout Minnesota

III. PROJECT STATUS UPDATES:

Project Status as of December 31, 2014:

Project Status as of June 30, 2015:

Project Status as of December 31, 2015:

Project Status as of June 30, 2016

Project Status as of December 31, 2016

Project Status as of June 30, 2017

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Select sites for detailed study that represent the primary glacial confining units in the state. Construct scientific boreholes and testing

Description: Two field study sites will be selected for detailed hydrologic investigation. One site will be located in a part of the state where Des Moines lobe glacial till is the principal glacial confining unit. The second site will be located where the Superior lobe glacial till is the principal confining unit. Study sites will be identified and selected in consultation with staff from the Minnesota Departments of Health and Natural Resources and the Minnesota Geological Survey. Study sites will be located near municipal water-supply wells that pump from confined glacial-drift aquifers where well-head protection plans have been approved by the Minnesota Department of Health. At both study sites small-diameter observation well clusters, or piezometers, will be installed in the confined-drift aquifer, the confining unit overlying the confined aquifer, and in the surficial unconfined-drift aquifer. Two well- nest installations will be located at each of the two study sites. One well cluster, at each study site, will be located in close proximity to the municipal water-supply well. The second of the well-cluster location, at each study site, will be located at some distance from the municipal-supply wells. The

exact locations of the well nests will be determined, after the study sites are selected, based on local site and access conditions and on results of preliminary groundwater modeling simulation of local groundwater pumping and hydrologic settings. Observation wells (completed in aquifers) and piezometers (completed in confining units) will be planned and sited during the first six months of the study. They will be installed in the spring of 2015. Observation wells and piezometers will be installed in scientific boreholes after geophysical testing of the boreholes is completed. Pressure transducers will be installed in each of the observation wells and piezometers to continuously measure water levels and hydraulic head over the duration of the study. The identification and siting of study sites and well-nest locations will involve a considerable amount of time and effort to ensure that the sites represent conditions typical for the primary confining units of the state.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 236,947
Amount Spent: $ 0
Balance: $236,947

Activity Completion Date: September 2015

Outcome	Completion Date	Budget
1. Locate appropriate test sites near existing high-capacity municipal pumping wells. Sites will be selected based on input from the MGS, MDNR and MDH. Selection will be from municipal wells with well-head protection plans in place and based on evaluation of local geological conditions.	**October 2014**	**$ 10,000**
2. Obtain site access and site-use permission. Obtain drilling permits and well variances if needed. Meet with city officials. Travel and reconnaissance of potential sites.	**December 2014**	**$ 5,000**
3.Install boreholes and instrument sites for hydraulic, geophysical and chemical tests to define hydraulic properties of confining units. Locate observation well sites. Install wells and using contract driller. Conduct geophysical surveys of boreholes. Install pressure transducers and water level recording equipment. Much of these expenses are associated with contract drilling.	**September 2015**	**$ 221,947**

Activity Status as of December 31, 2014:

Activity Status as of June 30, 2015

Activity Status as of December 31, 2015

Activity Status as of June 30, 2016

Activity Status as of December 31, 2016

Activity Status as of June 30, 2017

Final Report Summary: Activity Status as of December 31, 2017

Activity Status as of June 30, 2015

ACTIVITY 2: Conduct hydraulic, physical, geophysical and chemical testing of aquifers and confining beds. Analyze date from tests at each of two sites to determine. Determine hydraulic and hydrogeological properties of confining beds and aquifers at each of two study locations.
Description: Activity 2 will be conducted during the second and third years of the study. This activity is focused on defining hydraulic and hydrogeological properties of the state's most important confining units-- the Des

Moines and Superior till confining units. The approach is to conduct two detailed field tests-- one each of two areas that represent the principal confining in the state. The field study sites will be located adjacent to existing high-capacity municipal pumping wells to observe how pumping stress affects water movement based on properties of the confining beds. Scientific bore holes will be completed through the confining units and into the aquifers and confining units to collect the required data. Field analyses will include hydraulic, geophysical and chemical tests and conceptual groundwater modeling. These test will include aquifer tests, geophysical logging (e.g. gamma, temperature, and fluid resistivity test for example and measures of water chemistry.

This activity is focused on testing and analyses of local hydraulic and hydrogeological properties to determine infiltration rates and physical properties of confining units and aquifers. Geophysical, geotechnical, isotopic, chemical and hydraulic testing at each site will be conducted. These properties of the confining beds will include infiltration and leakage rates, grain-size and soil texture, vertical and horizontal hydraulic conductivity, and hydrologic storage. Geologic, geophysical and water chemistry samples will be collected from boreholes and observation wells installed for the study. Hydraulic-head data from piezometers and observation wells completed in aquifers and confining beds will be analyzed based on the hydraulic responses to pumping. Water levels will be measured continuously in all observations wells using pressure transducers and data loggers. Vertical hydraulic conductivity and infiltration rates will be estimated for the confining units based on analytical techniques and on results from hydrologic models at each of the sites, under pumping conditions measured in underlying and overlying aquifers. Laboratory permeability tests also well be used to evaluate spatial variability in permeability. The rates of infiltration to confined aquifers also will be determined using environmental tracers such as chlorofluorocarbons, sulfur hexafluoride, or tritium by measuring vertical profiles of these environmental tracer concentrations through the confining units. The average rates of infiltration also will be computed based on the vertical gradient of water movement through the confining unit. Time of travel tests will be determined by conducting a tracer test. A conservative tracer such as potassium bromide will be applied within boreholes and monitored in underlying observation wells to evaluate infiltration rates. These tests should prove very useful in evaluating the effects of till weathering and fracturing. Site-scale groundwater flow models will be used to simulate individual hydraulic tests and to test hypotheses regarding recharge through till. A USGS Scientific Investigations Report will be published. The report will summarize the project, the data collected during the project and the results of the analyses of data collected from the project.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 157,053
Amount Spent: $ 0
Balance: $157,053

Activity Completion Date: September 2017

Outcome	Completion Date	Budget
1. Conduct hydraulic, geotechnical, geophysical and isotopic tests at each study site. Extensive field testing of geologic deposits. Water sampling. Hydraulic testing of aquifer responses to pumping. These tests are focused on determining hydraulic properties of geologic strata.	**October 2015**	**$ 72,053**
2. Analyze and interpret tests, define hydraulic properties and infiltration rates at each study site	**July 2016**	**$ 30,000**
3. Conduct conceptual groundwater modeling of pumping responses. This work will further quantify aquifer and confining bed properties.	**October 2016**	**$ 25,000**
4 Report on results. Prepare draft report. Conduct colleague report. Obtain USGS report approval	**June 2017**	**$ 25,000**
5 Seal and abandon test wells according to state well code	**April 2017**	**$ 5,000**

Activity Status as of December 31, 2014:

Activity Status as of June 30, 2015

Activity Status as of December 31, 2015

Activity Status as of June 30, 2016

Activity Status as of December 31, 2016

Activity Status as of June 30, 2017

Final Report Summary: Activity Status as of December 31, 2017

Activity 3: Assess variability in properties of confining units across Minnesota. Analyze results from boreholes, wells and geophysical and chemical tests. Define spatial variably in hydraulic properties and infiltration through confining beds, statewide.

Description: This activity addresses the variability in properties of confining units across Minnesota. There are no ENRTF funds requested for this activity. The activity will be funded with DNR-Clean Water funds and USGS Cooperative Water Program Funds. This section is described as a stand-alone document and there is some repetition.

Many glacial aquifers used for drinking water are overlain by clayey glacial deposits. These confined drinking-water aquifers are a critical state resource because they provide the only source of clean, reliable drinking water to tens of thousands of urban and outstate residents of Minnesota. The confining units overlaying the confined drinking-water aquifers are a vitally important part of the aquifer system because they are protective barriers to the confined aquifers from land-surface contamination. The confining units also, however, limit water flow (infiltration) to confined aquifers, so replenishing water in confined aquifers is a slow and limited process. We need to better understand the hydraulic properties of confining units to ensure sustainable use of water from these important drinking-water aquifers. This activity would assess regional hydraulic properties for the state's two major regional confining units: the Des Moines and Superior lobe glacial till confining units. The project would provide key information to map the extent and general properties of the two confining units. The project would focus on important questions about confining units and confined aquifers:

- **What are the properties of the confining units and how do they vary over space?**
- **What are the pathways for water and contaminant movement through confining units?**
- **How long does it take water to move along the flow pathways?**

It is important to protect confined drinking-water aquifers from contamination and from over-pumping. Therefore, the sources of water to these confined aquifers must be understood. This project would compile information about the State's most important confining units; the Des Moines and Superior lobe glacial till deposits (see figures). This activity is a collaborative effort among the USGS, the Minnesota Geological Survey, the MDH, and the MDNR. It augments work completed in the County Geologic Atlas Program.

The important factor defining sustainable water use from confined aquifers is the rate of water movement (infiltration) through overlying confining units to replenish confined drinking-water aquifers. We lack information about rates of infiltration to confined aquifers because infiltration depends upon the hydraulic properties of the overlying confining units. Infiltration rates are needed to manage confined aquifers so that they are protected for the future. Although the MGS and MDNR have an active County Geologic Atlas Program, that maps the protective confining layers, the Program needs supplementary specific information about hydrologic properties of confining units. Filling this gap in understanding also is required for the MDNR water appropriation-permit process to ensure long-term sustainability of water supply from confined aquifers. Finally, there is a need to understand how confining units protect the water quality in confined aquifers. The quality of water in confined aquifers is presumed to be protected by overlying confining beds. However, scattered and isolated information suggests that groundwater and contaminants can flow from land surface through confining units to confined aquifers at varying rates. These many concerns identify our need to better understand the state's two important confining units. The activity will assess data to map properties and continuity of the state's most important confining

units, the Des Moines and Superior glacial till confining units. This information is needed to protect confined drinking water aquifers and to define the amount of water that can be pumped from individual confined aquifers (MDNR appropriation permit process) on a long-term and sustainable basis.

This project provides critical information for sustainable management of Minnesota's groundwater resources. The project complements and augments work being done by the County Geologic Atlas Program (MGS and MDNR) and fits with MDNR's planned changes to MDNR water appropriation-permit program. The project fulfills strategic directions for understanding water budgets described in the University of Minnesota's Water Sustainability Framework. The project would be a major step forward toward defining the hydrogeological properties of the important protective Des Moines and Superior glacial till units throughout the state

Summary Budget Information for Activity 3:

ENRTF Budget: $ None
Amount Spent: $ 0
Balance: $ NA

Activity Completion Date: June 2017

Outcome	Completion Date	Budget
1. Assemble data on hydraulic properties of confining beds statewide	June 2016	$70,000
2. Compare and synthesize data from test sites and sources	June 2017	$ 30,000
3.Map and display available information from database compilation. Report on results.	June 2017	$30,000

Activity Status as of December 31, 2014: NA

Activity Status as of June 30, 2015: NA

Activity Status as of December 31, 2015: NA

Activity Status as of June 30, 2016: NA

Activity Status as of December 31, 2016: NA

Activity Status as of June 30, 2017: NA

Final Report Summary: NA

V. DISSEMINATION:

Description: Project milestone results will be communicated to LCCMR staff and to project partners with semi-annual written results. Final results from the project will be presented at a scientific conference and through the publication of a USGS Scientific Investigations Report. The final report will be delivered by December 31, 2017

Status as of December 31, 2014:

Status as of June 30, 2015

Status as of December 31, 2015

Status as of June 30, 2016

Status as of December 31, 2016

Final Report Summary;

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$ 167,000	- Studies Chief– 4% FTE - Project Chief – 20% FTE - Admin Support 1 – 7% FTE - Hydrologic Technician – 16% FTE - Groundwater/Water Quality Specialist – 6% FTE
Professional/Technical/Service Contracts:	$ 201,000	- Minnesota Geological Survey: support of glacial geologic interpretation and well siting; well cutting interpretation; analysis of fractures patterns in glacial till; stratigraphic analysis for well completing; support of hydraulic, chemical, and geophysical testing; and contributions to final report as co-authors (includes salaries, supplies, and travel) - Printing and reports services: editing and preparation for for electronic printing and distribution - Drilling contracts: drilling, well installation, well sealing, and abandonment.
Equipment/Tools/Supplies:	$ 17,000	Field supplies and data collection: pumps, pressure transducers, electronic recording devices, well packers, well casing, and shelters.
Travel Expenses in MN:	$ 7,000	Travel and lodging while working at field sites and attending local meetings
Other: See detailed budget	$ 2,600	Postage and shipping, expendable supplies and materials.
TOTAL ENRTF BUDGET:	**$ 394,000**	

Add or remove rows as needed

Explanation of Use of Classified Staff: Not applicable

Explanation of Capital Expenditures Greater Than $5,000: Not applicable

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 1.59

Number of Full-time Equivalents (FTE) Estimated to Be Funded through contracts with this ENRTF Appropriation: 0.2

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
USGS cost-share funds	$96,000		All activities—USGS administrative and indirect costs
Other state funds			
MDNR Clean Water Funds (Activity 3)	$100,000		Activity 3 supported by DNR, Clean Water Funds
Total	$196,000		

VII. PROJECT STRATEGY:

A. Project Partners: U. S. Geological Survey, Minnesota Geological Survey, Minnesota Department of Natural Resources, Minnestoa Department of Health

P**roject Team/Partners**

Name	Affiliation	Role
James Walsh *	Minnesota Department of Health	Site selection—data support
Steve Robertson *	Minnesota Department of Health	Site selection—data support
Perry Jones	United States Geological Survey	Borehole testing; report, data base
Michael Menheer	United States Geological Survey	Drilling support and data collection
Lisa Syde-Hagen	United States Geological Survey	Administrative Support
Angela Hughes	United States Geological Survey	Administrative Support
James Stark	United States Geological Survey	Site selection, hydraulic testing
Tony Runkle	Minnesota Geological Survey	Glacial Stratigraphy-Hydraulic testing, Reporting
Bob Tipping	Minnesota Geological Survey	Glacial stratigraphy- Hydraulic Testing, Reporting
Jan Faltisek*	Minnesota Department of Natural Resources	Regional hydrogeological analyses

* Participation as collaborator and advisor not receiving ENRTF funding

B. Project Impact and Long-Term Strategy:

This project provides critical information for sustainable management of Minnesota's groundwater resources. The project complements and augments work being done by the County Geologic Atlas Program (MGS and MDNR) and fits with MDNR's planned changes to MDNR water appropriation-permit program. The project fulfills strategic directions for understanding water budgets described in the University of Minnesota's Water Sustainability Framework. Finally, the LCCMR project meshes seamlessly with Activity 3 focused on compilation and mapping statewide variability in hydrogeological properties of the Des Moines and Superior Lobe confining unit using existing data. These two related efforts represent major steps toward defining the hydrogeological properties of the important protective Des Moines and Superior confining till units throughout the state. The project is similar to an ongoing LCCMR project focused on confining properties of the St. Lawrence bedrock confining unit. Based on successful completion of this project, additional funding may be requested to supplement and to enhance date and information from this project.

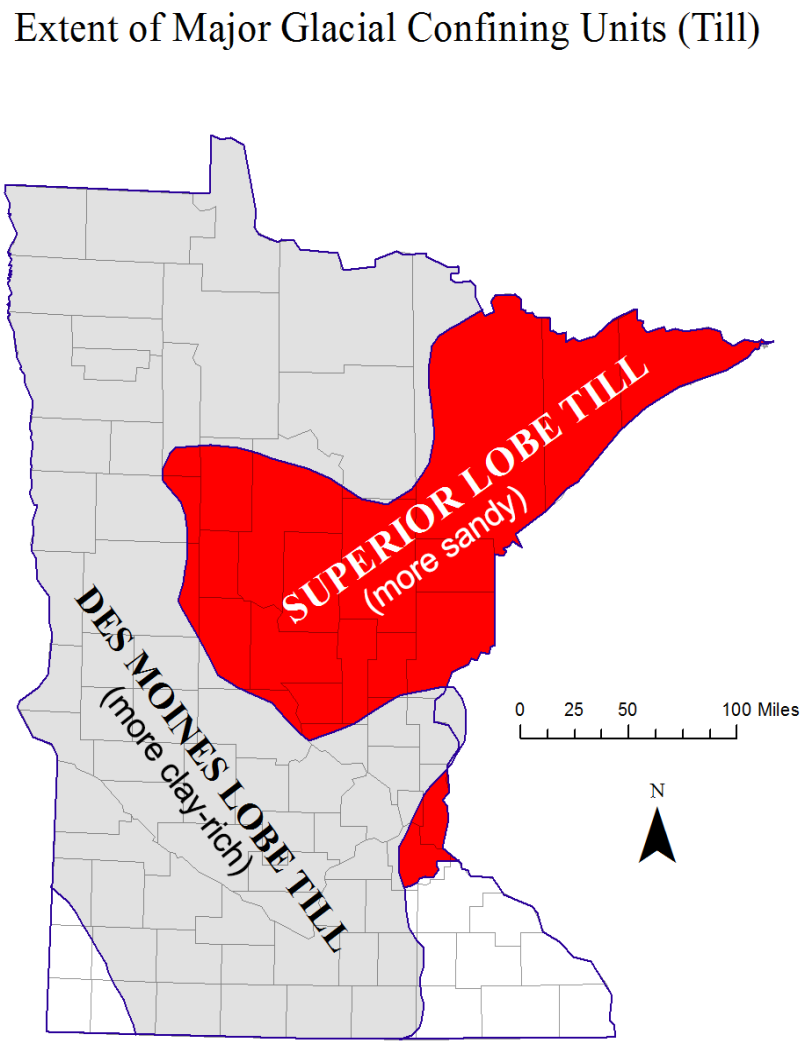
C. **Spending History:**

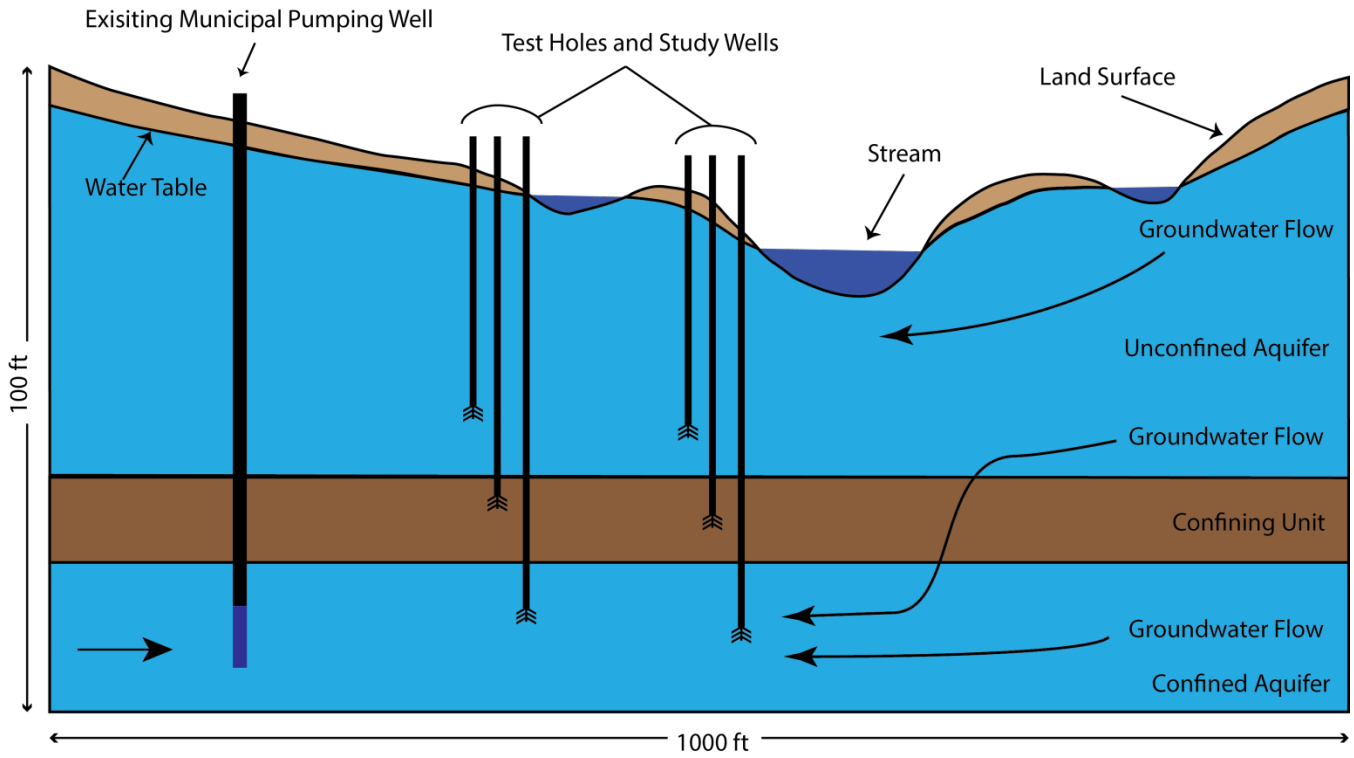
Funding Source	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13	M.L. 2013 or FY14
LCCMR-ENRTF	NA	NA	NA	NA	NA
USGS Cooperative Water Program	NA	NA	NA	NA	NA
MDNR Clean Water Fund	NA	NA	NA	NA	NA

VIII. ACQUISITION/RESTORATION LIST: NA

IX. VISUAL ELEMENT or MAP(S): Shown below

Conceptualized graphic showing extent of the Des Moines lobe glacial till (gray) and the Superior lobe glacial till (red).





Conceptual model of land surface, glacial unconfined aquifer, confining unit (brown) and confined aquifer with production well.

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: NA

XI Research Addendum: This proposal is being completed in great details. The detailed proposal will be revised based on USGS peer review comments. The proposal will then be approved by the USGS and added to this document. The expected date of proposal approval is April 30, 2014.

XII. REPORTING REQUIREMENTS:
Ti**meLine Requirements:** This project would run from July 2014 through June 2017. This timeline would include two field seasons (2015 and 2016). Quarterly written progress reports will be provided to project partners. Final reports and manuscripts will be submitted by June 30, 2017 with publication by January 1, 2018.

Period work plan status update reports will be submitted no later than 12/31/14, 06/15/15, 12/31/15, 06/30/16, and 12/31/16. A final report and associated products will be submitted between June 30 and August 15, 2017

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Environment and Natural Resources Trust Fund
M.L. 2014 Project Budget

Project Title: Protection of State's Confined Drinking Water Aquifers
Legal Citation:Appropriation Language: M.L. 2014, Chp. 226, Sec. 2, Subd.
Project Manager: James R. Stark
Organization: U. S. Geological Survey.
M.L. 2014 ENRTF Appropriation: $ *394,000*
Project Length and Completion Date: 3 years--July 2014 through June 2017
Date of Report: May 1, 2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Select sites for detailed study that represent the primary glacial confining units in the state. Install scientific boreholes and testing equipment***			***Conduct hydraulic, physical, geophysical and chemical test on of aquifers and confining beds. Analyze data at each of two sites. Determine hydraulic and hydrogeological properties of confining beds and acquire at each for two study locations.***				
Personnel overall (wages and benefits)	***77,000***	***$0***	***$77,000***	***$90,000***	***$0***	***$90,000***	**$167,000**	**$167,000**
Studies Chief, GS13, (Project management, oversight supervision and technical review) (one person at 4%) (Benefits are 22%, Salary is 78%)-$6000								
USGS Project Chief , (GS-12) (one person at 20%) (Benefits are 27%, salary is 73%)- $79,000								
Admin Support (GS-9) (1 person at 7%) (benefits are 31%, salary is 69%)- $18,000								
USGS Hydrologic Technician (GS-11) (person at 16%) (benefits are 24%, Salary is 76%) -$42,000								
USGS Groundwater/Water Quality Specialists, (GS13) (1 person at 6%), (Benefits are 35%, Salary is 65%)-$22,000								
Professional/Technical/Service Contracts								
MGS (Minnesota Geological Survey) (staff support --Drs Runkle and Tipping). Support of glacial geologic interpretation and well siting. Well cutting interpretation. Analysis of fractures patterns in glacial till. Stratigraphic analysis for well completing. Support of hydraulic, chemical and geophysical testing. Contributions to final report as co-authors. -$60,000	$30,000	$0	$30,000	$30,000	$30,000	$0	$60,000	$60,000
MGS (Minnesota Geological Survey travel, in-state) Vehicle mileage and lodging at field sites and for local meetings- $5,000	$3,000	$0	$3,000	$2,000	$0	$2,000	$5,000	$5,000

MGS (Minnesota Geological Survey) supplies for water sampling and hydraulic testing supplies and analytical costs -$1,000	$500	$0	$500	$500	$0	$500	$1,000	$1,000
Contract printing (contract fees for USGS repor that includes editing and preparation for electronic printing and distribution)- $9,000. One contract.	$0	$0	$0	$9,000	$0	$9,000	$9,000	$9,000
Contract drillers: Drilling, well installation, well sealing and abandonment. This work will be done by a private drilling contrrator through a bidding process.- $126,000. There could be more than one contract but this can't be determined at this time prior to contract bidding	$110,000	$0	$110,000	$16,000	$0	$16,000	$126,000	$126,000
Equipment/Tools/Supplies: USGS miscellaneous field equipment and supplies for data collection, Pumps, pressure transducers, electronic recording devices, well packers, well casing and shelters. None of these individually exceed $5,000	$10,000		$10,000	$7,000		$7,000	**$17,000**	**$17,000**
Travel expenses in Minnesota: USGS travel and lodging expense in Minnesota include mileage charges for government vehicles, lodging and meal expenses while working at field sites. Lodging and mileage expenses while attending local meetings.	$3,000	$0	$3,000	$4,000	$0	$4,000	**$7,000**	**$7,000**
Other: USGS miscellaneous supplies, equipment and shipping. Miscellaneous required purchases, postage and FedEx shipping, expendable supplies and materials	$1,000	$0	$1,000	$1,000	$0	$1,000	**$2,000**	**$2,000**
COLUMN TOTAL (partial)	**$234,500**			**$159,500**			**$394,000**	**$394,000**