



Minnesota Pollution Control Agency

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# Assessment and Maintenance of Stormwater Best Management Practices

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Progress Report  
August 2008



University of Minnesota

**Stormwater Management Practice  
Assessment Project**



# Project Faculty



## ■ Principle Investigators



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St. Anthony Falls Laboratory

Dr. Deb Swackhamer  
Water Resources Center



## ■ Associated Faculty:

- ❑ Dr. Randal Barnes – UMN Department of Civil Engineering
- ❑ Dr. William Herb – UMN St. Anthony Falls Laboratory
- ❑ Dr. Raymond Hozalski – UMN Department of Civil Engineering
- ❑ Dr. Omid Mohseni – UMN St. Anthony Falls Laboratory
- ❑ Dr. John Nieber – UMN Department of Bioproducts and Biosystems Engineering
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- ❑ Dr. Pete Weiss – UMN St. Anthony Falls Laboratory

# Project Staff



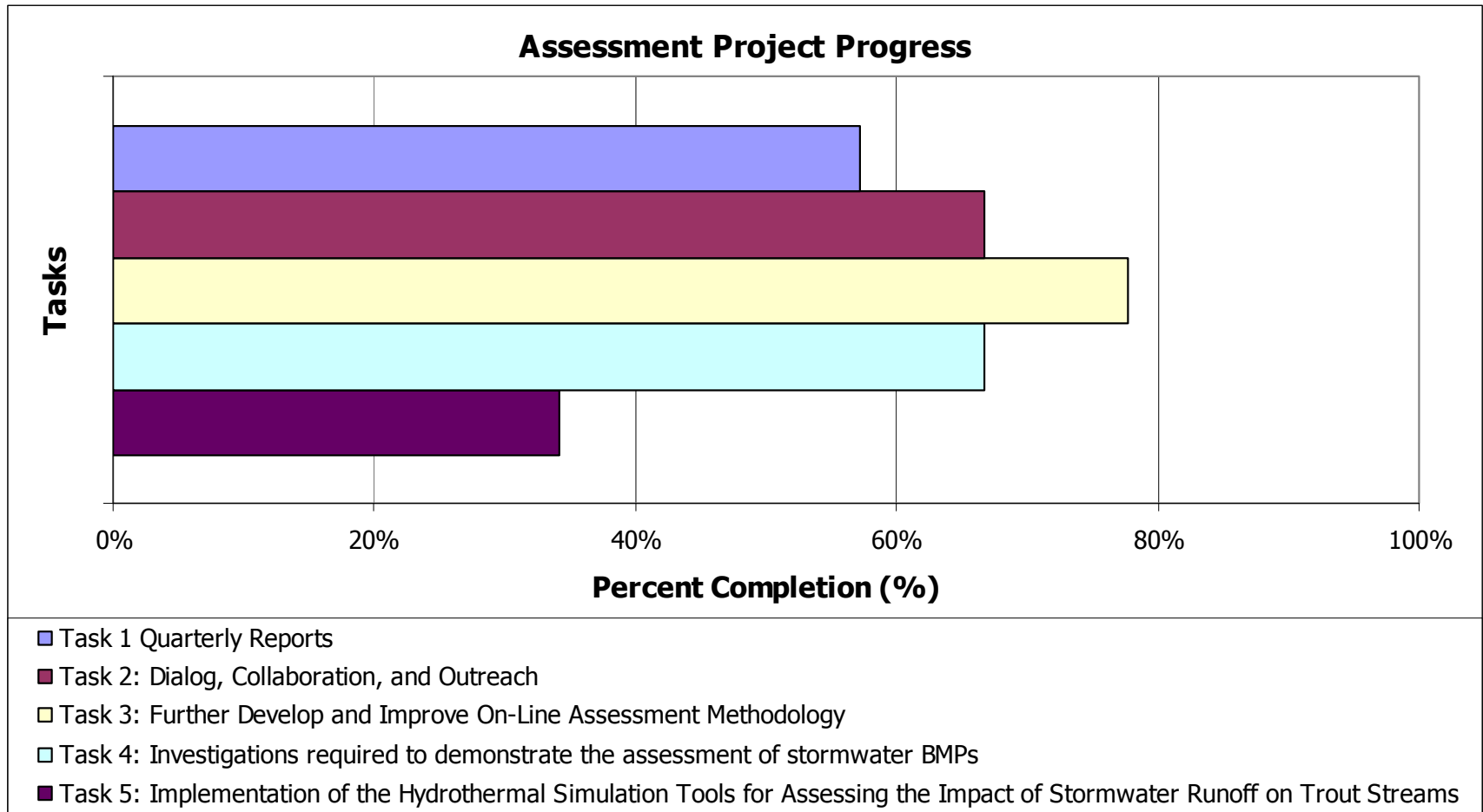
- Research Fellow
    - Andy Erickson, M.S.
  - Graduate Research Assistants
    - Greg DeGroot, Ben Janke, Greg LeFevre, Eric Novotny, David Saddoris
  - Undergraduate Research Assistants
    - Bonnie Ausk, Missy Gettel, Teigan Gulliver, Nicholas Olson, Greta Schmalle
  - High School Intern
    - Lanre Adekola
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# Project Tasks



- 1. Quarterly Reports**
- 2. Dialogue, Collaboration and Outreach**
  - a. Continue Dialog and Collaboration on Stormwater Assessment
  - b. Incorporate stormwater assessment into education program
- 3. Further Develop and Improve On-Line Assessment Methodology**
  - a. Select technical advisory panel
  - b. Expand testing methodology to other types of BMPs
  - c. Incorporate maintenance procedures into on-line assessment document
- 4. Investigations required to demonstrate the assessment of stormwater BMPs**
  - a. Groundwater pollution caused by infiltration
  - b. Development and demonstration of a method to determine the stormwater suspended sediment size distribution
  - c. Composting as a method of remediating stormwater pond sediments contaminated by Polycyclic Aromatic Hydrocarbons (PAHs)
- 5. Implementation of the Hydrothermal Simulation Tools for Assessing the Impact of Stormwater Runoff on Trout Streams**
  - a. Incorporating new mitigation measures to MINUHET (Minnesota Urban Heat Export Tool)
  - b. Validation of the hydrothermal simulation tool
  - c. The MINUHET training workshops and technical support
  - d. Support Data for the JPO Trading Project of the Vermillion River
  - e. Groundwater thermal model
  - f. Miller Creek temperature TMDL study

# Task Progress



## Task 2: Dialogue, Collaboration and Outreach



### ■ Presentations (All travel funded by the University of Minnesota)

- ❑ Stormwater U: Visual Inspection of Ponds. Little Canada, MN (July 2008)
- ❑ 19th Annual Erosion Control and Stormwater Management Conference and Trade Show. St. Louis Park, MN (March 7, 2008)
- ❑ Stormwater Pollution Prevention Program Design Course. Arden Hills, MN (April 8, 2008)
- ❑ Build Smart Summit, Region Five Development Commission. Bemidji, MN (April 30 – March 1, 2008)
- ❑ World Environmental and Water Resources Congress. Honolulu, HI (May 12 – 16, 2008)
- ❑ Center for Transportation Studies: Transportation Research Conference. St. Paul, MN (May 20-21)
- ❑ 7th Annual StormCon. Orlando, FL (August 3 – 7, 2008)
- ❑ Great Lakes Regional Stormwater Meeting: Inventory, Monitoring, and Maintenance of Stormwater BMPs. Columbus, OH (September 17, 2008)
- ❑ 2008 International Low Impact Development Conference. Seattle, WA (2 presentations). (November 17, 2008)
- ❑ American Water Resources Association (AWRA). New Orleans, LA (November 17-20, 2008)
- ❑ Minnesota Water Resources Conference (3 presentations). St. Paul, MN (October 27-28, 2008)
- ❑ Environmental and Water Resources Institute (EWRI) of ASCE. Bangkok, Thailand (3 presentations). (January 5-7, 2009)

## Task 2: Dialogue, Collaboration and Outreach



- Quarterly Newsletters distributed to email list of 1,400+ members
  - ❑ May 2007
  - ❑ November 2007
  - ❑ March 2008
  - ❑ August 2008
- Technical Advisory Panel (TAP) meeting proposed for Oct. 2008



## Task 2: Dialogue, Collaboration and Outreach



### Non-project websites linking to the Project, among others

- University of Vermont: Vermont Water Resources and Lake Studies Center
  - [www.uvm.edu/envnr/vtwater/announcements/Stormwater Mgmt Practice Assessment Project 2008 Univ Minnesota.pdf](http://www.uvm.edu/envnr/vtwater/announcements/Stormwater_Mgmt_Practice_Assessment_Project_2008_Univ_Minnesota.pdf)
- Rutgers University: Water Technology Website
  - [http://watertech.rutgers.edu/Publications/Member-Submitted\(Not-Peer-Reviewed\)/John Gulliver/Mar 2008 Newsletter.pdf](http://watertech.rutgers.edu/Publications/Member-Submitted(Not-Peer-Reviewed)/John_Gulliver/Mar_2008_Newsletter.pdf)
- Izaak Walton League of America: Alternative Practices to Manage Highway Runoff
  - <http://www.iwla.org/index.php?id=223>
- Great Lakes Regional Water Program - Minnesota Initiatives
  - [www.uwex.edu/ces/regionalwaterquality/FocusAreas/states/minnesota.htm](http://www.uwex.edu/ces/regionalwaterquality/FocusAreas/states/minnesota.htm)
- University of Arizona NEMO Program
  - <http://www.srn.arizona.edu/nemo/index.php?page=bmpstormwater>
- Lake Superior Streams
  - [http://www.lakesuperiorstreams.org/stormwater/duluth/stormwater plan.html](http://www.lakesuperiorstreams.org/stormwater/duluth/stormwater_plan.html)
- Municipal Research and Services Center of Washington
  - <http://www.mrsc.org/Subjects/Environment/water/SW-BMP.aspx>



# Task 2: Dialogue, Collaboration and Outreach



## Collaboration Partnerships

- US EPA - CWP 319
  - Performance of Low Impact Practices on Stormwater Pollutant Load Abatement
- Minnesota Department of Transportation
  - Assessment and Recommendations for Operation of Standard Sumps as Best Management Practices for Stormwater Treatment
- Minnesota Local Road Research Board
  - Estimating the Size Distribution of Suspended Sediments in Minnesota Stormwater-Phase I: Measurement Technique
  - Assessment of Underground Stormwater Management Devices under High Flow Conditions
- US EPA - Vermillion Trout Stream Thermal Trading Program
  - Support data and Heat transport model for the Vermillion River
- Minnehaha Creek/Lower Mississippi Management Organization
  - Application of method for stormwater suspended solids size distribution
- LCCMR
  - Precipitation intensity data updating by NOAA
- Three Rivers Park District
  - Tilling and composting compacted soils to decrease urban runoff
- U of M – CURA
  - Tilling and composting compacted soils to decrease urban runoff
- Proprietary Device Manufacturers
  - Grants on testing proprietary devices from three manufacturers
- Joint Water Research Grant Program
  - Estimating Size Distribution of Suspended Solids in Minnesota Stormwater

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**Total Collaboration Funds = \$1,920,000**

## Task 2: Dialogue, Collaboration and Outreach



### Outreach, Education, and Certification training:

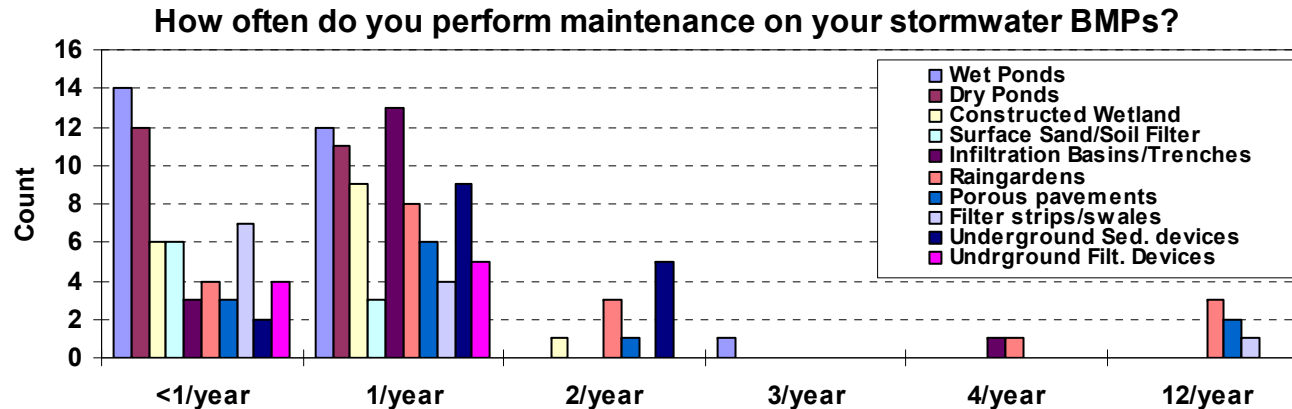
- New courses offered:
    - BBE 5480: Developing Impaired Waters Knowledge & TMDL Skills
    - CE 5180: Urban Hydrology and Land Development
  - Stormwater U Pond Maintenance Workshop, Little Canada, MN.
    - Outfalls and Pond Inventories
    - Visual Inspection of Ponds
  - Pond Maintenance Planning Team, Ramsey-Washington Metro Watershed District.
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## Task 3: Further Develop and Improve On-Line Assessment Methodology



- Statewide maintenance survey completed
- Addition of five case studies to the online assessment document
- The online assessment document is updated quarterly with new information
- Studies on amendments to compacted soils are in process
- Expansion of testing methodology to other infiltration practices (basins, trenches, etc.) is in process

# Task 3: Statewide Maintenance Survey



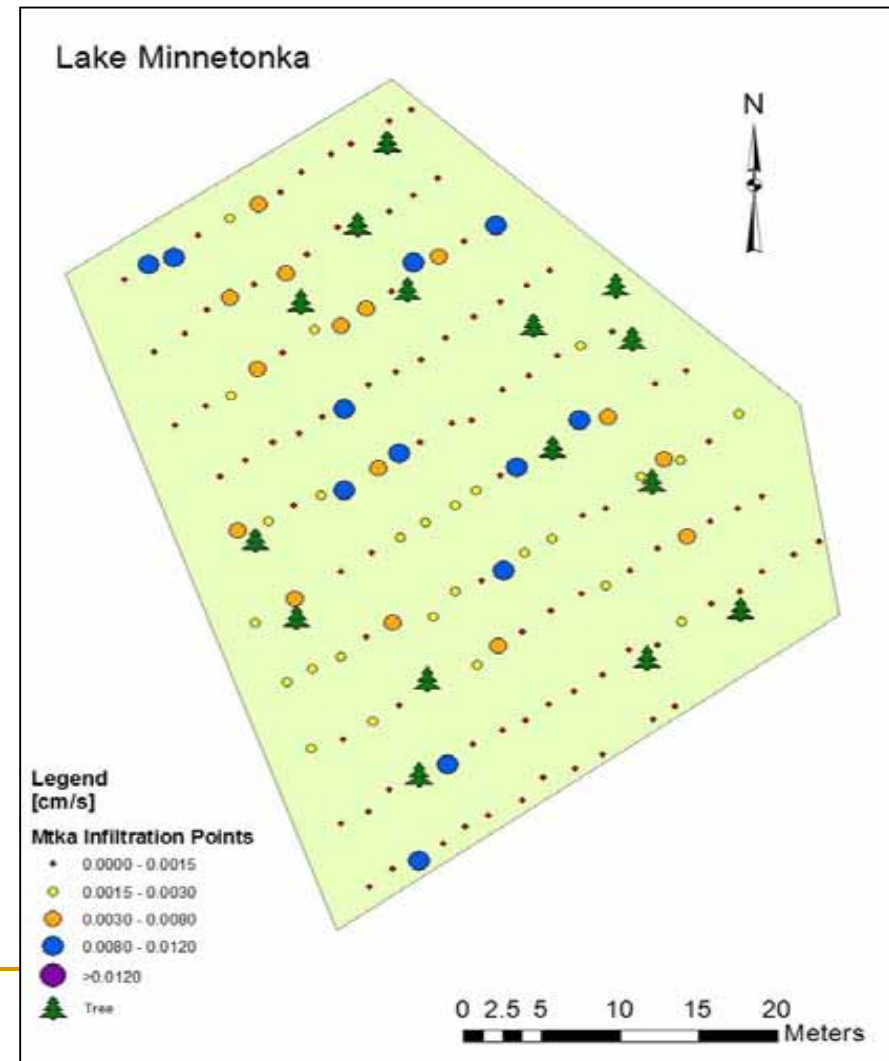
## Conclusions:

- Wet ponds are dominant BMPs in Minnesota
- Wetlands are most difficult to maintain and need largest staff-hours among three pond type BMPs
- Most of the ponds in Minnesota are inspected once or less per year
- Sediment removal, pipe clogging, and invasive vegetation are the major factors reducing the effectiveness of ponds
- Costs for a certain maintenance activity vary significantly depending on cities
- Generally sediment removal and repair of inlet/outlet structure are major activities accounting for the large portion of total maintenance costs
- Accurate estimation the sediment accumulation rate in a BMP is very important to establish the schedule and budget for maintenance

# Task 3: Studies on amendments to compacted soils are in process



- Phase I: Preliminary Testing
  - Modified Philip-Dunne Permeameter (MPD)
- Phase II: Plot Division
  - Tilled plot, Tilled plot with compost addition, Control plot
- Phase III: Runoff Testing
  - Synthetic rainfall



## **Task 4: Investigations required to demonstrate the assessment of stormwater BMPs**



- Impacts of infiltration on groundwater literature review complete
- Composting to remediate PAH concentrations in wet pond sediments
  - Recent revision to the work plan
  - Literature review is underway
  - Proof of concept laboratory studies and field study are planned

## Task 5d: Thermal Impact Model for the Vermillion River

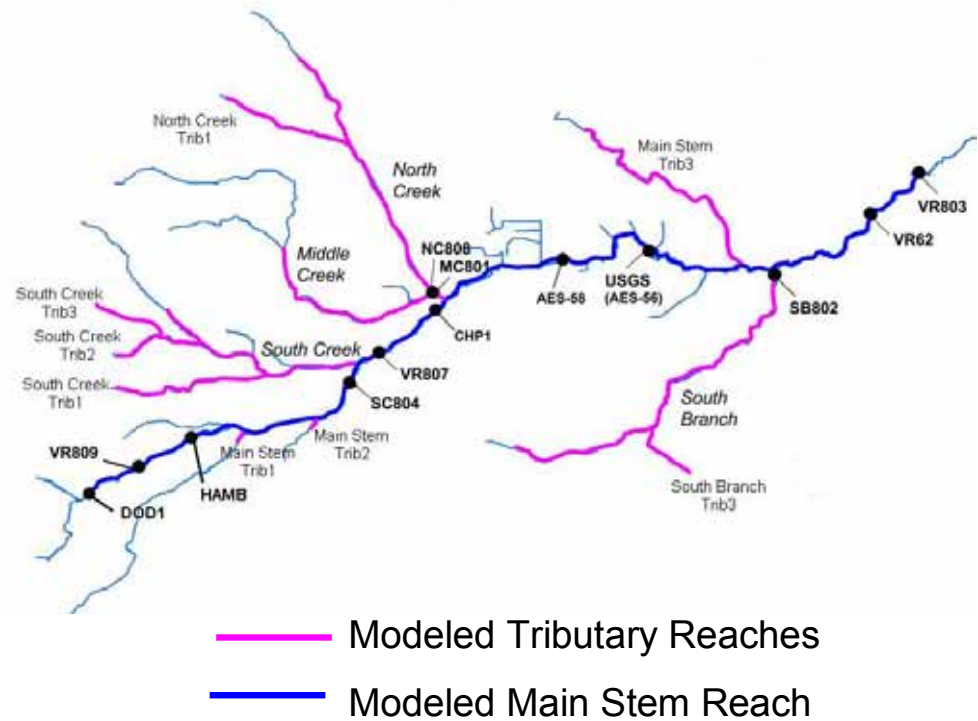


Goal: Simulate the impact of land use changes on streamflow and temperature in the Vermillion River

The thermal impact model includes:

1. A GIS based model for surface runoff and runoff temperature (work by Applied Ecological Services, Inc. and SAFL)
2. An unsteady model for stream baseflow and the response to surface runoff inputs (EPA-Riv1 model)
3. An unsteady stream temperature model developed at SAFL that includes atmospheric heat transfer, sediment heat transfer, and groundwater inputs.

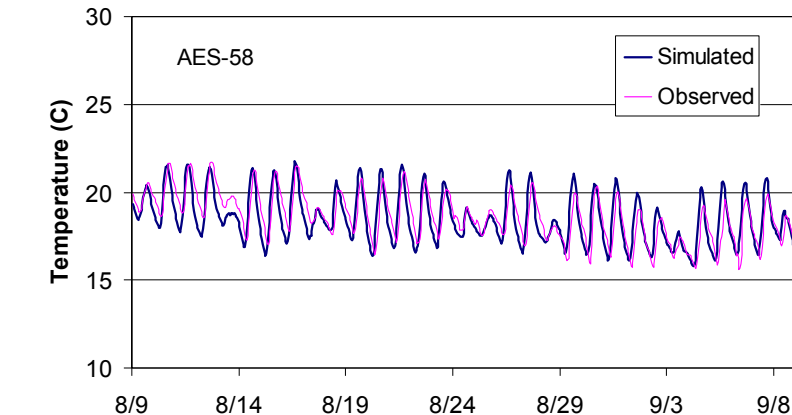
### Model Extent



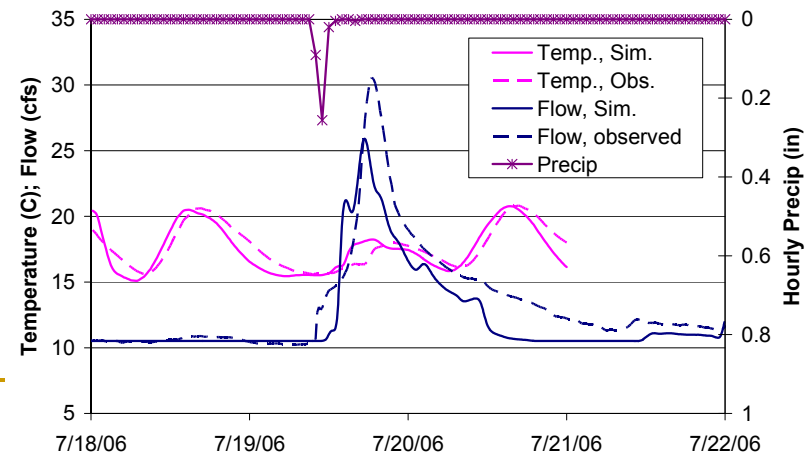
# Task 5d: Calibration and Verification of Thermal Impact Model



Simulated and observed stream temperature in the Vermillion River main stem during baseflow conditions, Aug 9 – Sept. 8, 2006



Simulated and observed stream flow and temperature in response to July 19 storm



## 1. Baseflow conditions

- Typical mid-summer baseflow conditions were determined from flow records
- Determine shading and sheltering coefficients and groundwater inputs
- Used period of time with relatively steady flow conditions (August 9 to September 8, 2006)
- Simulated stream temperature matched observed within 0.75 – 1.5 °C RMSE

## 2. Response to stormwater runoff

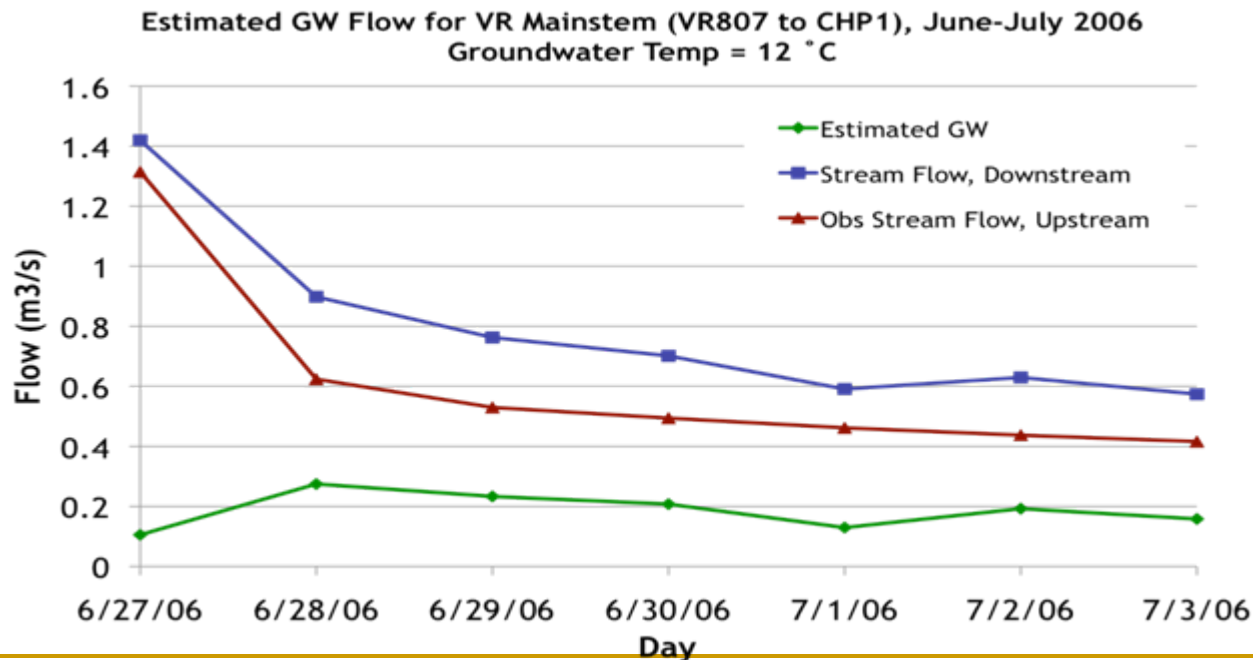
- Use 1" rainfall event on July 19, 2006
- The model was able to reproduce the observed flow/temperature pulse for South Creek and the main stem from South Creek to Empire
- Currently completing analysis storm response for future development scenarios and mitigation techniques



## Task 5d: Estimate Groundwater Input to stream reaches



- Partially funded by the Vermillion River JPO
- Purpose: Estimate groundwater inflow to the main stem and tributaries of the Vermillion River from observed stream temperature and flow data
- Approach: Heat budget for a stream reach using cells-in-series model, treating atmospheric heat flux, sediment heat transfer, and groundwater input as heat source terms
- Applications: Main stem from Denmark Ave to Chippendale Ave (~2 mile reach)  
Tributaries: North Creek, South Creek , South Branch



## Task 5e: Effects of urbanization on natural groundwater recharge

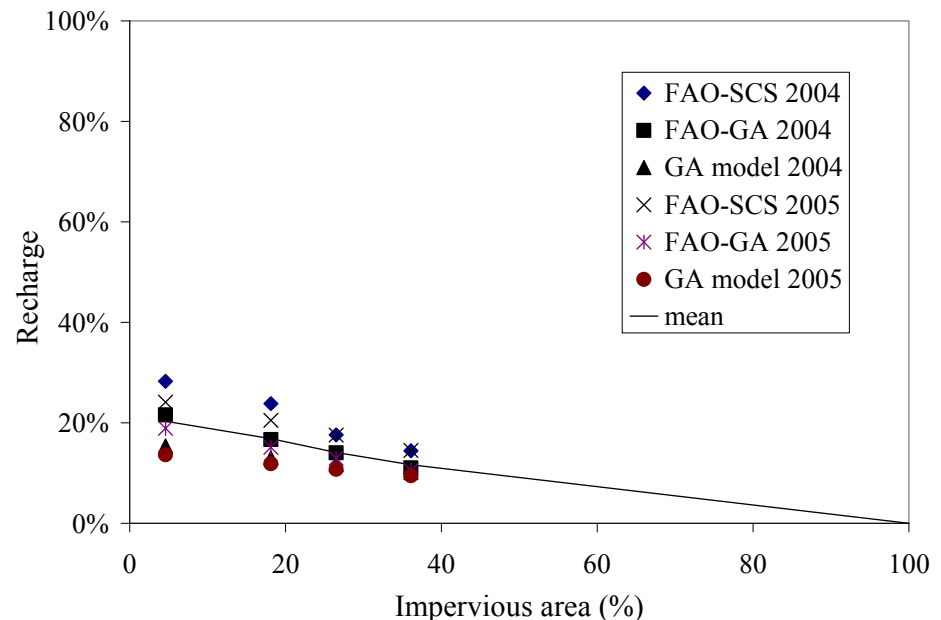


Goal: Predict effects of urbanization on groundwater recharge

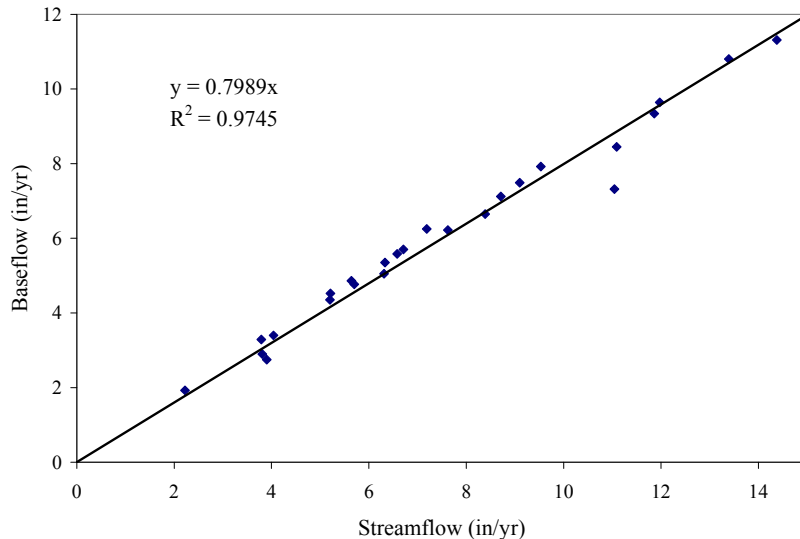
- Three models, using various commonly used methods, were developed to obtain an average effect of urbanization on groundwater recharge from precipitation.
- Conducted on a small tributary watershed (6.8 sq km) to the Vermillion River with similar levels of development to entire watershed.

- Four development scenarios were used (undeveloped, present, projected “plus 50 years” and “plus 100 years”).
- Concluded that an increase in impervious areas from 18% to 36% will decrease annual natural recharge 30% to 40%.

%Recharge vs. %Impervious Area for different models  
(from SAFL Report 490 (Erickson and Stefan 2007))

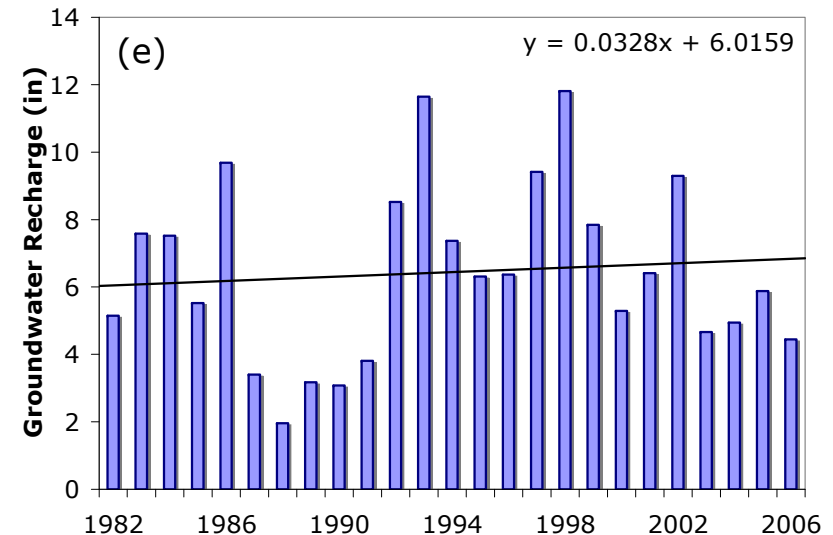


## Task 5e: Baseflow analysis on the upper Vermillion River using the USGS gauging site near Empire, MN



- Baseflow analysis conducted using USGS program PART and RORA (Rutledge 1998).
- On average, 80% of streamflow comes from groundwater.

- No statistical trends in baseflow using the Kendall's tau test could be found even though watersheds development level increased from 10% to 30% over time period.
- Concluded that artificial recharge must be supplementing natural recharge and plays important role in urban recharge.

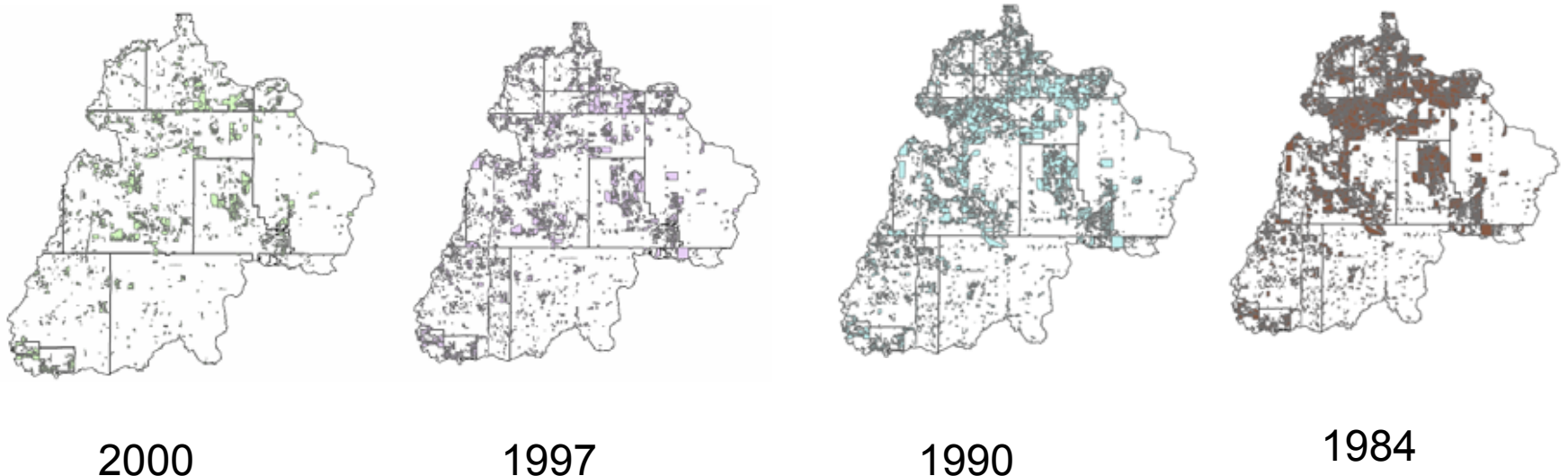


## Task 5e: Modeling artificial recharge in the Vermillion River



- Currently developing a model to investigate the effects of urbanization on the Vermillion watershed, upstream from USGS gauging site near Empire, MN.
- Model includes both natural recharge and artificial recharge.
- Will use baseflow analysis to check validity of model
- Will project development levels in watershed to investigate future changes expected in the watershed.

Areas of land use change compared to 2005 land use map



## Task 5e: Effects of development on shallow groundwater temperatures

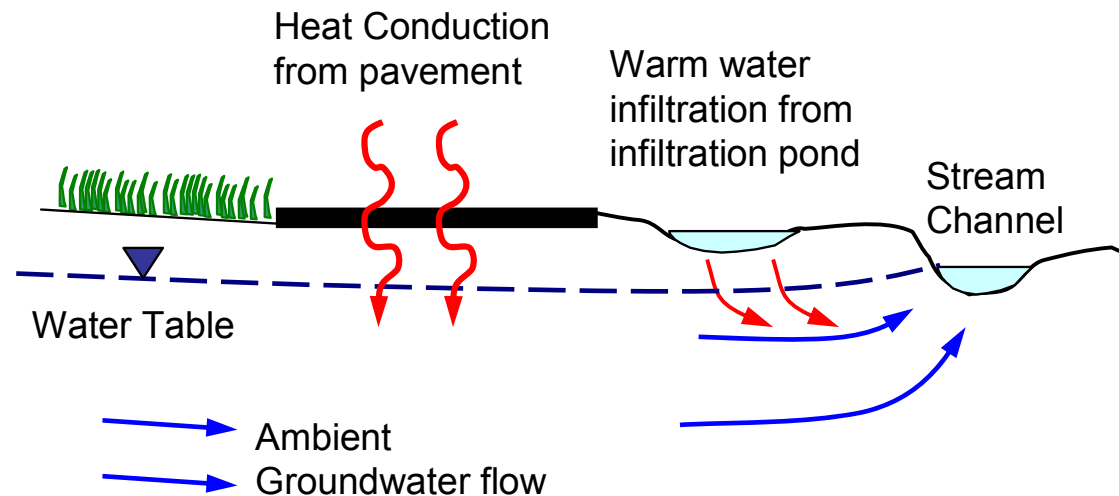


### Goals:

- Determine the necessary buffer distance between heat sources (infiltration ponds, pavement) to coldwater streams
- Evaluate the effectiveness of buffer strips in cooling the aquifer

### Approach:

- Two-dimensional groundwater temperature models
- Heat sources include infiltration Ponds, parking lots, and urban developments



## Task 5f: Miller Creek Temperature TMDL



Purpose: Develop a thermal model for Miller Creek to determine allowable heat allocations and mitigation methods to maintain Trout habitat

### Tasks in Progress:

- Analysis of existing flow, stream temperature, and climate data to characterize flow and temperature regimes
- Develop models for additional thermal mitigation structures, including underground vaults and rock cribs (also Task 5a)
- SWWM model for the Miller Creek watershed will be updated using updated land use data from NRRI (Fall 2008).

Underground stormwater storage vault installation at the UM Duluth campus



# What's next?



- Presentations:
    - Stormwater Steering Committee
    - Present before MPCA Managers
    - Several Conferences
  - Maintenance Survey to be sent to neighboring states (e.g., Iowa, Wisconsin, etc.)
  - Article on Maintenance to be published in Nov/Dec issue of Stormwater magazine
  - Field measurement for sediment sampling and particle size distribution
  - Laboratory and field studies for PAH degradation
-