FINAL REPORT

1999 Project Abstract
For the Period Ending June 30, 2001

TITLE:
W01 On-Site Sewage Treatment Alternatives: Performance, Outreach & Demonstration

Project Manager: Mark Wespetal
Affiliation: Minnesota Pollution Control Agency
Mailing Address: 520 Lafayette Road, St. Paul 55155-4198
Telephone Number: (651) 296-9322 **Fax**: (651) 297-8676
E-Mail: Mark.Wespetal@pca.state.mn.us
Web Site Address:www.bae.umn.edu/septic

Total Biennial Project Budget: No match required.

$ LCMR: $550,000
Legal Citation: ML 1999, chap. 231, Sec. 16, Subd. 0006(a).

To evaluate alternative system performance and increase the use of these systems to solve sewage treatment problems, this project had three objectives: 1. Establish five demonstration installations of alternatives and evaluate performance; 2. Monitor alternative technologies at research sites for pathogen, solids and nutrient removal; and 3. Evaluate additional methods to improve nitrogen and pathogen removal using constructed wetlands.

Overall Project Outcome and Results
Results of these three objectives are summarized as follows:

1. Five demonstrations were conducted. The alternative systems installed were sand filters, a textile filter, and a composting toilet with a drip distribution system.
2. Key findings of the research are:
    - Pressure distribution of septic tank effluent increases the performance (efficiency and operation) of most alternative systems. Alternative systems require more management than "conventional" systems.
    - Alternative systems typically achieved secondary treatment standards (as per municipal wastewater plant—25TSS and 30BOD); and many systems consistently achieved < 200 fecals/100 ml, (recreational beach standard).
    - Seasonal variations in performance and management must be accounted for in design and operation
3. Protocols and methodology for evaluating system performance using seeded bacterial pathogens and viral pathogens have been developed.

Project Results Use and Dissemination

Results of this project are detailed on a web page that was developed in the summer of 2000. The address is www.bae.umn.edu/septic. A comprehensive technology transfer plan coordinated by the principals of this project continues to provide design, construction, operation and maintenance information to homeowners, contractors, resorts, Extension educators, and local and state planning and regulatory agency staff. Tools include fact sheets, technical publications, training workshops, conferences, and satellite video conferences. These have reached more than 1600 contractors and technical experts and at least 10,000 of the lay public.

Date of Report: July 1, 2001
Project Completion Date: June 30, 2001

LCMR Final Work Program Report

I. Project Title

W01 On-Site Sewage Treatment Alternatives: Performance, Outreach & Demonstration

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Total Biennial Project Budget: No match required.

$ LCMR	$550,000
- $ LCMR Amount Spent	$548,961
= $LCMR Balance	$1,039

A. Legal Citation: ML 1999, chap. 231, Sec. 16, Subd. 0006(a).

Appropriation Language: This appropriation is from the Environment and Natural Resources Trust Fund Project to the commissioner of the Minnesota Pollution Control Agency for the third biennium to monitor previously built test sites for pathogen removal and other parameters as indicators of treatment efficiency, determine maintenance needs and system longevity and pursue the establishment of cooperative demonstration projects.

B. Status of Match Requirement: No match required.

II. and III. Final Project Summary

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IV. Outline of Project Results

A. Coordinate the establishment of demonstration wastewater sites in 5 regions of the state; evaluate the performance of existing residential alternative technologies.

   1. Five demonstration sites were designed and constructed during 2000 - 2001. The five sites were chosen based on their locations across Minnesota as well as the technology chosen. The goal was to cover the five major regions and demonstrate as many technologies as possible. Flyers were sent out for the five demonstrations conducted to all ISTS professionals in a five-county area surrounding the demonstration site as well as county and state staff. The demonstrations were well attended with approximately 25 visits per site.

Location	Technology	When Installed
Lake Osakis, Todd County	Sand Filter	June 2000
Cedar Lake, Wright County	Textile Filter	July 2000
Burrows Lake, Itasca County	Composting Toilet to Drip	August 2000
Duluth, St. Louis County	Textile Filters	August 2000
Bagley, Clearwater County	Sand Filter	May 2001

Please see http://gaia.bae.umn.edu/~septic/LCMR/ for more information on the demonstration projects.

An alternative systems survey letter was developed and mailed to all 87 counties in the middle of January that was used to tabulate the type and location of alternative technologies used statewide. We have receive 84 responses from the 87 Minnesota counties. Three counties did not respond (Chisago, Freeborn, and Mahnomen) and one county (Morrison) reported that "it would be too much work" to the find the information we requested.

The total number of non-standard systems in Minnesota now stands at 335, with 40 of the 83 responding counties having non-standard systems as classified by 7080. We classified the reported data into the types of non-standard systems in each county. Following are the totals. There are:

- 77 (23%) trenches,
- 51 (15%) mounds,
- 41 (12%) aerobic tanks,
- 23 (7%) sand filters,
- 22 (7%) systems with disturbed and/or compacted soils
- 20 (6%) drip lines
- 17 (5%) peat filters,
- 15 (4%) curtain drains,
- 13 (4%) constructed wetlands,
- 6 (2%) recirculating gravel filters,
- 2 (1%) at-grade systems,
- 2 (1%) textile filters.

2. The above-mentioned survey was used to evaluate alternative systems across Minnesota. The inventory of existing alternative systems included a detailed homeowner survey and field evaluation procedures to determine system performance, including the collection and analysis of wastewater samples. Twelve systems were evaluated. They are:
   5 aerobic treatment units
   2 sand filters

2 textile filters
1 peat filter
1 recirculating sand filter
1 constructed wetland

All the above technologies were operating properly aside from the wetland. The wetland vegetation had become overrun with weeds and was receiving high-strength waste from a gas station. The other systems were well below 25 mg/l for BOD and TSS and 10,000 fecal colform/100ml.

Budget for this Result:

$ LCMR	$70,694
- $ LCMR Amount Spent	$70,694
= $LCMR Balance	$ 0

Completion Date: June 30, 2001

B. Conduct an outreach and Extension campaign to transfer information to the private sector and to other public agencies [$ 0 from LCMR]

A web page to disseminate data obtained from our research project was developed in the summer of 2000. Since going online in August, 2000, the site has received over 5000 hits. There is information for homeowners and professionals in the ISTS industry. The topics include the LCMR project, research and outreach, regulations, and system options. The address is www.bae.umn.edu/septic. The website will continue to be updated.

A comprehensive technology transfer plan coordinated by the principals of this project continues to provide design, construction, operation and maintenance information to homeowners, contractors, resorts, Extension educators, and local and state planning and regulatory agency staff. Tools include fact sheets, technical publications, training workshops, conferences, and satellite video conferences. These have reached >1600 contractors and technical experts and at least 1000-10,000 of the lay public. A summary of all of these efforts was submitted separately to LCMR and MPCA staff in March 2000.

A tabulation of relevant activities is presented below.

Outreach and Education Activities, January - July 2001

January, 2001	Presentation at MDH annual meeting on alternative on-site systems	~100

January 2001	Presentation at U of MN Continuing Education Workshop on research	~100
January 2001	Presentation at MOSTCA Winter Conference on research	~75
February 2001	Presentation at AMCON Block on research	~100
February 2001	Presentation at U of MN Continuing Education Workshop on research	~100
February 2001	Booth at Home and Garden Show	~100
February 2001	Presentation at U of MN Continuing Education Workshop on research	~100
February 2001	Presentation in Goodhue County about research	~100
March 2001	Presentation at ASAE entitled "Evaluation of Recirculating Sand Filters in a Northern Climate"	~75
March 2001	Presentation at U of MN Continuing Education Workshop	~100
March 2001	Presentation in Hubbard County about research	~100
March 2001	Presentation at Preferred Pump about research	~100
March 2001	Workshop about Peat Filters	~10
April 2001	Presentation in Todd County about research	~75
April 2001	Presentation for the Iowa Public Health Association about research	~100
April 2001	Presentation for the Belle Plaine Block and Tile about research	~100
April 2001	Presentation at U of MN Continuing Education Workshop on research	~100
May 2001	Presentation at Biocycle Conference on Research	~100
May 2001	Bagley Sand Filter Demonstration	~50
June 2001	MOSTCA Summer Seminar at Lake Washington	~75
June 2001	A series of fact sheets #7666 published by the University of Minnesota Extension Service about sand, peat and recirculating filters, aerobic treatment units, constructed wetlands and drip distribution.	~1000s

Budget for this Result:

$ LCMR	$	0
- $ LCMR Amount Spent	$	0
= $LCMR Balance	$	0

Completion Date: June 30, 2001

C. Continue monitoring programs for pathogen and nutrient removal
The focus of this effort is to establish *long-term* performance and operation & maintenance data for the alternative technologies most likely to succeed in Minnesota.

Winter and Spring monitoring at the NERCC systems and the Grand Lake CW continued at regular frequencies for the routine suite of parameters (2-4 week sampling frequencies, as for 1995-2000, depending on the system and parameter). A total of 28 alternative (i.e., performance) ISTSs (all sized for single family homes) were routinely monitored at the southern site at Lake Washington and at the Grand Lake and NERCC sites (northern) near Duluth. TSS, BOD, fecal coliform bacteria, nitrogen and phosphorus concentrations were analyzed for inflows (septic tank) and outflows. Additional internal samples were taken along the length of the constructed wetlands using other sources of funding (Minnesota Sea Grant). All systems were capable of treating septic tank effluent to secondary levels (25TSS/30BOD/200-1000 fecals) and so this is the minimum standard against which all systems were compared.

Beginning in summer 2000 the Septic Tank Effluent (STE) from the correctional facility that feeds the NERCC systems was diluted with well water to reduce the concentrations of BOD and nitrogen to levels more typical of many residential STEs. Another experiment increased STE inflows for at least one of the single pass sand and peat filters at NERCC to establish *high end* performance. These data were collected through June 2001. Preliminary results were presented in March 2001 at the 9th National Symposium on Individual and Small Community Sewage Systems, American Society of Agricultural Engineers (ASAE) meeting in Ft. Worth, TX (Monson Geerts et al. 2001) and are listed on the with the combined articles, manuscripts and fact sheets at our project web site http://www.bae.umn.edu/septic). Final results will be presented in the form of a manuscript submitted to a peer-reviewed journal with a summary added to the project web site.

In addition to nutrients, organic matter, and fecal coliform indicator bacteria, the systems are also being assayed for virus removal. Research included routine

monitoring of the systems for naturally occurring indigenous coliphage viruses (somatic and F-2 phages that infect bacteria) as well as a series of cold- and warm-weather experiments in which the sand and peat filters and a constructed wetland were "seeded" with a high concentration of a lab-cultured model virus. The MS-2 bacteriophage virus is non-pathogenic and widely accepted internationally as a surrogate for investigating disinfection processes and human-disease-causing enteric viruses. These experiments continued through summer 2001 via other funding sources and will form the basis of a graduate student's Master's thesis. The first year of somatic phage data from the constructed wetlands is included in a journal manuscript (Axler et al. 2001, Water Science & Technology) and the complete data set as well as the results of the MS-2 experiments will be included in journal manuscripts. Summaries will be prepared for the project web site as soon as they are completed.

The previous winter was notable for a lack of insulating snow cover that caused a number of freezing problems both in the NERCC and Grand Lake systems, as well as throughout northeastern Minnesota. As a result, we added a layer of insulating reed-sedge peat to the constructed wetlands at NERCC and Grand Lake which, along with an earlier and more extensive snowpack, prevented a recurrence of these problems. Our Operations & Maintenance modifications for constructed wetlands were reported in two journal publications (Axler et al. 2001 and Henneck et al. 2001 in the web site publications list and are included in our project summary key finding list). A survey of regional freeze problems from winter 1999/2000 was developed in collaboration with St. Louis County and the Minnesota Pollution Control Agency (Duluth Regional Office) and the results and analysis were published as an NRRI Technical Report (Reed et al. 2001).

The systems at NERCC and Grand Lake were maintained and monitored every three weeks, with no major problems this period. The drip "hydraulic unit" was replaced in fall 2000. A new hydraulic unit for the drip system, winterized for cold weather applications, was installed, and the unit performed well during throughout its first winter and spring. Performance and maintenance characteristics were summarized for publication. A summary will be added to the project web site after completion of the publication.

As a result of NRRI's efforts to publicize Puraflo®, one more contractor was awarded certification by Bord na Móna as an installer of Puraflo® systems, bringing the total to five in St. Louis County. Approximately 30 Puraflo® systems have now been installed in St. Louis County. The Puraflo® peat biofilter systems at NERCC operated successfully over the past two years. The systems continued to be monitored for wastewater contaminants and pathogenic organisms through June 2001. Fabrication of Puraflo® modules containing MSI peat is currently on hold pending further performance data from the NERCC test

site. These systems operated successfully over the past year and a half since the modules containing MSI medium were reconstructed, and both systems were changed over from recirculation to intermittent dosing mode. In summary, both the Irish and MSI mediums achieved secondary treatment standards for TSS (25 mg/L) and BOD (30 mg/L) during summer and winter operation. The Irish medium also met secondary treatment standards for fecal coliforms (200 cfu/100 ml) during summer operation. Few problems have been encountered and none associated with the system itself or with properly trained and certified installation contractors.

The textile filter system operated successfully beginning in mid-May 2000 after winter 1999/2000 freezing problems. Modifications to correct this problem included: installing insulation and electrical heat tape on the drainpipe from the polishing sand to the dispersal sump; redirecting the blower intake to the heated solenoid box; adding insulation around the dispersal manifold; and redirecting the orifices down on the dispersal laterals to promote drainage of the laterals upon dosing. These actions were successful and the unit operated satisfactorily during winter 2000/2001.

We also initiated a comprehensive analysis of the past 5 years of research trench data from the NERCC site, including nutrients and pathogens at different soil depths receiving treated effluent from a constructed wetland, the peat filters and the untreated STE (in 2 soil types). This effort is still in progress and results will summarized on the project web site after completion. Because of the general importance of these data to the onsite wastewater community, a separate manuscript will be prepared for publication in a peer-reviewed journal.

NRRI staff contributed to the development of reports, fact sheets, newsletters and journal publications. Staff also participated in monthly meetings with a technical committee from the northeast Minnesota counties and other cooperating agencies and businesses (sponsored by the IRRRB and Northern Lights Tourism Alliance). The demonstration of alternative treatment systems such as these provides homeowners, small businesses, and environmental regulators options for mitigating the public health and water quality impacts of poor onsite sewage treatment practices. One outcome from these meetings was the acquisition of funding to develop the framework for a comprehensive model performance code for onsite treatment systems (B. McCarthy lead). A completion report for the first phase of this effort is in progress and a federal (USEPA) grant was awarded for developing and implementing the model performance-based code in 10 northern Minnesota counties (R. Otis and B.McCarthy, leads).

A number of presentations and manuscripts were prepared for national conferences and submitted for publication. These are summarized in the project

web site through December 2001.

Routine sampling of Lake Washington continued. In the beginning of 2001 the outlet structure on the constructed wetlands froze solid. Wastewater continued to be applied. The system never exhibited any other signs of a problem, such as surfacing of effluent, and thawed almost completely in late February. A gopher problem also occurred in the summer of 2001 in one of the wetlands. A gopher burrowed into one side of the wetland and added several large piles of soil to the wetland. The wetland was subsequently repaired. The wetland plants did fairly well in 2001, but several large holes exist where no vegetation is present. This is thought to be due to lack of enough water to support the vegetation given the high temperatures.

A Mulit-flo ® aerobic treatment unit was added to Lake Washington. The unit and installation were donated by the company and a local contractor.

Key findings of the project outcomes include (order not important):

1. Gravity peat filters (Maine design) failed hydraulically within 2 years.

2. Pressure distribution of septic tank effluent increased the performance (efficiency & operation) of most systems; essential for sand & peat filters and desirable for other systems such as constructed wetlands.

3. Alternative systems required more management than "conventional" systems.

4. Alternative systems typically achieved 2° treatment standards (as per municipal wastewater plant—25TSS and 30BOD); and many systems consistently achieved < 200 fecals /100 ml, (recreational beach standard).

5. Seasonal variations in performance and management must be accounted for in design and operation: *Drip Irrigation* and *Constructed Wetlands* are particularly sensitive to potential freezing problems in a winter with low snowfall (insulation), such as 1999/2000.

6. Recirculating sand and peat filters, and constructed wetlands achieved significant N-removal; improved performance is expected with experience in their operation and performance.

7. Long-term P-removal has not been established, yet most of the systems remove some phosphorus.

8. Protocols and methodology for evaluating system performance using seeded

bacterial pathogens and viral pathogen surrogates have been developed.

9. Lakeshore homeowner associations at Grand Lake and Lake Washington were established to own and manage their community sewage treatment systems. These provided models for other lakeshore residents in other parts of the state.

10. A performance-based component has been incorporated into Minnesota Rules Chapter 7080 (*onsites*) as a result of this research.

11. Results have been used extensively in Minnesota in education programs targeting local elected officials, regulatory agency staff, onsite professionals, and contractors; results have also been presented at local, state and national/international meetings

12. A website has been developed to present project findings as well as related information and links.

Budget for this Result:

$ LCMR	$452,849
- $ LCMR Amount Spent	$451,810
= $LCMR Balance	$ 1,039

Completion Date: June 30, 2001

D. Evaluate additional methods to improve nitrogen and pathogen removal (NERCC-II constructed wetland plant species experiment).

This study focused on the difference in performance between beds planted with cattails, reeds, and bulrushes in a new system installed at the NERCC site to treat a combined effluent from the laundry, new schoolhouse, and slaughterhouse. Three subsurface flow beds, receiving influent from a common source at identical flows, were constructed in spring and summer 1999 (paid for independently by the NERCC correctional facility). However, the flows and wastewater strength were highly irregular and plant growth has been highly variable as well. Monitoring continued but at a reduced frequency due to the failure of the overall project to be re-funded.

Budget for this Result:

$ LCMR	$ 26,457
- $ LCMR Amount Spent	$ 26,457
= $LCMR Balance	$ 0

Completion Date: June 30, 2001

V. DISSEMINATION

Dissemination of project results is covered in detail under Objective B above. All monitoring data will be stored by the principal investigator on computer and will be made available upon individual request. Information is also available on the web site.

VI. CONTEXT

A. Significance:

Much of the research into how individual sewage treatment systems perform hydraulically and with regard to efficiency of treatment has been conducted over the last 25 years. The principal investigator was involved with the early efforts at the University of Wisconsin-Madison where the current sewage treatment mound design and construction parameters were developed. While this particular kind of system has been able to overcome problems associated with certain limiting soil conditions such as high water table and shallow depths to bedrock, there continues to be a need to investigate and refine additional cost-effective options to address these characteristics. In recent years, there have been claims made by alternative systems (alternative to mounds or standard trench systems) that they will accomplish the same level of treatment and hydraulically accept effluent at less cost. It is important that these alternative solutions be subjected to rigorous analysis and scrutiny before being presented to contractors, site evaluators, designers, local government officials and the public as bona fide solutions.

The principal investigator has worked for 22 years in the state of Minnesota with the on-site industry, state agencies, and the scientific community to ensure that the Minnesota ISTS standards are technically sound, cost-effective and protect the water resources of the state and the health of the residents. The systems proposed to be evaluated were selected based on scientific studies reported in recent literature and at national symposia dealing with ISTS technology.

B. Time: This project was completed by June 30, 2001.

C. Budget Context:

	July >95-June >97 Prior expenditures on this project	July >97-June >99 Prior expenditures on this project	July >99-June >01 Current expenditures on this project
1. LCMR	**$425,000**	**$500,000**	**$548,961**
2. Other State	**$255,558**	**$189,581**	**$ unknown**
3. Non State Cash	**$807,000**	**$ 98,641**	**$ 150,524**
4. In-kind	**$285,000**	**$240,000**	**$ 203,500**
TOTAL	**$1,232,058**	**$1,028,222**	**> $354,024 (est)**

(MPCA staff time—approximately 10% of a position per year for project management and participation on Technical Advisory Team—No MPCA budget initiative for this project)

LCMR Budget Expenditures:
BUDGET AND MATCH : 1999-2001

a. See Work Plan for budget detail (Table 2) for proposed project (Jul 1999-Jun 2001)

Objective 1—$ 45,384; actual = $70,694
Objective 2—$ 0
Objective 3—$ 486,571; actual = $451,810
Objective 4—$ 18,045; actual = $ 26,457
TOTAL $ 550,000; actual = $548,961

b. Budget History : (1995-1999)
   i. LCMR: $425,000 (1995-1997); $500,000 (1997-1999)
   ii. Non-LCMR: 1995-1997 total match = $807,058; 1997-1999 total match = $528,222

Match Subtotals to date (1995-1999): $1,335,280
Match estimated for 1995-2001: $1,689,304

* other state (cash) = $445,139 (MTI, NRRI, U. of MN)
* non-state (cash) = $359,441 (Electric Power Research Institute [EPRI]; Minnesota Power; National Sea Grant; Grand Lake homeowners; L. Washington Lake Association; L. Washington homeowners)
- in-kind = $530,000 (St. Louis, LeSueur, Dakota and Rice Counties; Western Lake

Superior Sanitary District [WLSSD]; Northeast Regional Correctional Center [NERCC]; MOSTCA; local contractors and businesses)

VII. COOPERATION

University of Minnesota: The University of Minnesota (at St. Paul) Department of Soil, Water, and Climate managed this project by a pass-through contract. All funds went to this entity. The principal investigator was responsible for subcontracting with other entities to accomplish the workplan.

Dr. James Anderson (Department of Soil, Water, and Climate—St.Paul) was the overall Principal Investigator for the study. Co-Principal Investigators from the University were: David Gustafson (Agricultural Engineering Department—St.Paul), Barbara McCarthy and Dr. Richard Axler (Natural Resources Research Institute—Duluth) and Dr. Randall Hicks (Biology Department, University of Minnesota Duluth).

Other members of the Technical Advisory Team on this project were Jeff Crosby, St. Louis County Health Department; Pete Wiedman, Western Lake Superior Sanitary District; Terry Bovee, Minnesota Department of Health; Randy Stoppleman, Minnesota On-Site Sewage Treatment Contractors Association; and Joe Magner, Mark Wespetal and Gretchen Sabel, Minnesota Pollution Control Agency.

VIII. LOCATION: See attached map.

IX. REPORTING REQUIREMENTS: Semi-annual program reports were submitted not later than January 1, 2000, July 1, 2000; January 1, 2001; and the final six-month work program update and final report by June 30, 2001.

X. RESEARCH ADDENDUM: Submitted September 30, 1998 along with Workplan.