2008 Project Abstract
For the Period Ending June 30, 2010

PROJECT TITLE: Improving Water Quality on the Central Sands
PROJECT MANAGER: John Moncrief and Carl Rosen
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: ML 2005 First Special Session, [Chap. 1], Article 2 , Sec.[11], Subd. 7(i)

Appropriation Language:
As amended by ML 2008, Chap. 367, Sec. 2, Subd. 15 Carryforward

APPROPRIATION AMOUNT: $587,000

Overall Project Outcome and Results
Nitrate leaching to groundwater and phosphorus runoff to surface water are major concerns in sandy ecoregions in Minnesota. Some of these concerns can be attributed to agricultural crop management. This project was comprised of research, demonstration, and outreach to address strategies that can be used to minimize or reduce nitrate leaching and phosphorus runoff in agricultural settings.

Research evaluating slowed nitrogen transformation products, nitrogen application timing, and nitrogen rates was conducted on potatoes, kidney beans, and corn under irrigation on sandy soils. For potatoes, variety response to nitrogen rate, source, and timing was also evaluated. Results showed several nitrogen management approaches reduced nitrate leaching while maintaining economic yields. Based on these results, promising treatments were demonstrated at a field scale using cost share monies. In some cases, producers tested or adopted new practices without the cost share incentive.

- For potatoes, results show that at equivalent nitrogen rates, use of slow release nitrogen reduced nitrate leaching on average by 20 lb nitrogen per acre. Economically optimum nitrogen rates could be reduced by an average of 15 lb nitrogen per acre with slow release nitrogen. In addition, a primary advantage of using slow release nitrogen was that only one application was required instead of multiple applications, which resulted in lower application costs. As a result of this research, slow release nitrogen is being used on ~15,000 acres in the state or about 1/3 of the potato acreage. The reduction in leaching to groundwater based on these results is 300,000 lbs of nitrogen in the state for potatoes alone.
- For corn the slow nitrogen release product applied at planting resulted in a 29 bu/acre increase over the one time application of untreated urea at planting and also allowed eliminating a split nitrogen application. Nitrate leaching was also significantly reduced.
- Similar results were found for kidney beans. It was also shown that the kidney bean nitrogen rate could be reduced by one third when the coated urea was used at planting.

A number of best management practices for using polymer coated urea in irrigated potato, kidney bean, and corn production systems have been developed as result of this research.

The research and demonstration results were the basis for a number of educational programs for farmers and those that advise farmers to encourage implementation over a wide area with high risk soils and aquifers. In cooperation with the Minnesota Department of Agriculture, two surveys were also conducted in 12 counties with sandy soils and surficial aquifers to determine nitrate levels in private and municipal well water and the economics of treating water from them. The survey was targeted to sandy regions by

combining a zip code map with a soil association map or with nitrate probability maps from the Minnesota Department of Health. In the private well water survey about 6% of the wells were found to be above the USEPA drinking water standard of 10 ppm nitrate-nitrogen. The survey highlighted the economics of nitrate leaching and some of the options that municipalities and private well owners have taken to deal with high nitrate in their drinking water. The Minnesota Phosphorus Source Assessment Tool (PSAT) was developed to allow evaluation of phosphorus sources in small watersheds for educational and planning purposes. The PSAT is currently being used by water planners such as Soil and Water Conservation Districts, Watershed Districts, and Lake Associations. Six peer reviewed publications and three fact sheets have been produced based on the research conducted in this project.

Project Results Use and Dissemination

Presentations were made to various organizations and at various conferences throughout the project period. This included presentations to the Northern Plains Potato Growers Association, Soil Science Society of America, American Society for Horticultural Science, Minnesota Ground Water Association, and others. Additionally, hundreds of growers and grower consultants were contacted about the project and its findings. Hands-on demonstrations of the Phosphorus Source Assessment Tool (PSAT) were conducted across the state, and it is now being used by soil and water conservation districts, watershed districts, lake associations, and others. The tool, back ground information, and user manual are available at http://www.mnpi.umn.edu/psat.htm. Finally, the project findings were presented in numerous peer-reviewed articles and through numerous fact sheets available on the web.

Trust Fund 2008 Work Program Final Report

Date of Report: October 28, 2010
Date of Next Status Report: Final Report
Date of Work program Approval: June 24, 2005
Project Completion Date: June 30, 2010

I. PROJECT TITLE: Improving Water Quality on the Central Sands

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***** This project has several major components requiring multiple managers. The U of M has major responsibility for the research component. The CLC has major responsibility for the demonstration-implementation component.

Location: Sandy Ecoregions of MN (see map). Primarily: Becker, Benton, Cass, Crow Wing, Dakota, Hubbard, Itasca, Mille Lacs, Morrison, Ottertail, Sherburne, Stearns, Swift, Todd, and Wadena Counties.

Total Biennial LCMR Project Budget:	**LCMR Appropriation:**	**$587,000**
	Amount Spent:	**$586,358**
	Balance:	**$642**

Legal Citation: ML 2005 First Special Session, [Chap. 1], Article 2 , Sec.[11], Subd. 7(i) .

Appropriation Language:
As amended by ML 2008, Chap. 367, Sec. 2, Subd. 15 Carryforward

(b) The availability of the appropriations for the following projects are extended to June 30, 2010: ((3) Laws 2005, First Special Session chapter 1, article 2, section 11, subdivision 7, paragraph (i), improving water quality on the central sands;

7 (i) Improving Water Quality on the Central Sands

$294,000 the first year and $293,000 the second year are from the trust fund to the commissioner of natural resources for agreements with the University of Minnesota and the Central Lakes College Agricultural Center to reduce nitrate and phosphorus losses to groundwater and surface waters of sandy ecoregions through the development, promotion, and adoption of new farming and land management practices and techniques. This appropriation is available until, June 30, 2010 at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

II. and III. FINAL PROJECT SUMMARY: Reduce nitrate and phosphorus losses to groundwater and surface waters of sandy ecoregions through the development, promotion, and adoption of new farming and land management practices and techniques.

Nitrate leaching to groundwater and phosphorus runoff to surface water are major concerns in sandy ecoregions in Minnesota. Some of these concerns can be attributed to agricultural crop management. This project was comprised of research, demonstration, and outreach to address strategies that can be used to minimize or reduce nitrate leaching and phosphorus runoff in agricultural settings. Research evaluating slowed nitrogen (N) transformation products, N application timing, and N rates was conducted on potatoes, kidney beans, and corn under irrigation on sandy soils. For potatoes, variety response to N rate, source, and timing was also evaluated. Results showed several N management approaches reduced nitrate leaching while maintaining economic yields. Based on these results, promising treatments were demonstrated at a field scale using cost share monies. In some cases, producers tested or adopted new practices without the cost share incentive. For potatoes, results show that at equivalent N rates, use of slow release N reduced nitrate leaching on average by 20 lb N per acre. Economically optimum N rate could be by an average of 15 lb N per acre with slow release N. In addition, a primary advantage of using slow release N was that only one application was required instead of multiple applications, which resulted in lower application costs. As a result of this research, slow release N is being used on ~15,000 acres in the state or about 1/3 of the acreage. The reduction in leaching to groundwater based on these results is 300,000 lbs of N in the state for potatoes alone. For corn, the slow N release product applied at planting resulted in a 29 bu/acre increase over the one time application of untreated urea at planting and also allowed eliminating a split N application. Nitrate leaching was also significantly reduced. Similar results were found for kidney beans. It was also shown that the kidney bean N rate could be reduced by one third when the coated urea was used at planting. The research and demonstration results were the basis for a number of educational programs for farmers and those that advise farmers to encourage implementation over a wide area with high risk soils and aquifers. In cooperation with the Minnesota Department of Agriculture, two surveys were also conducted in 12 counties with sandy soils and surficial aquifers to determine nitrate levels in private and

municipal well water and the economics of treating water from them. In the private well water survey about 6% of the wells were found to be above the USEPA drinking water standard of 10 ppm nitrate-nitrogen. The survey highlighted the economics of nitrate leaching and some of the options that municipalities and private well owners have taken to deal with high nitrate in their drinking water. The Minnesota Phosphorus Source Assessment Tool (PSAT) was developed to allow evaluation of P sources in small watersheds for educational and planning purposes. The PSAT is currently being used by water planners such as Soil and Water Conservation Districts, Watershed Districts, and Lake Associations. Six peer reviewed publications and three fact sheets have been produced based on the research conducted in this project.

IV. OUTLINE OF PROJECT RESULTS*:* The economy of the Central Sands region of Minnesota depends heavily on both agriculture and recreation. About 40% of the region is agricultural land. The remainder is largely covered by forests and lakes. While the agricultural economy depends on phosphorus and nitrogen applications for crop productivity, the recreational economy depends on keeping those nutrients out of lakes. A growing number of communities on irrigated sandy soils with shallow and vulnerable aquifers (Perham, Park Rapids, Cold Spring, Rice, and Hastings, for example) are experiencing increased levels of nitrate in their public water supply due, in part, to nearby farming operations. The coarse-textured soils are a special consideration in examining nutrient movement in the region. The results of this project aim to identify regionally appropriate land management alternatives for reducing nutrient losses to water, and to justify these alternatives by beginning to document their costs and benefits.

- The effectiveness of new farming techniques will be examined. Techniques include new generation of polymer coated controlled release nitrogen fertilizer, nitrogen rate recommendations, evaluation of newly released nitrogen efficient (eco-friendly) crop varieties, phytofiltration to remove ground water nitrate while providing income, and deep tillage on responsive soils.
- Phosphorus losses to lakes, which reduce recreational appeal, will also be addressed by creating a tool that quantifies the risk and identifies actions that reduce losses. The Minnesota Phosphorus Index (currently used by farmers) will be modified to address land use activities in proximity of lakes.
- Accelerated adoption of new farming techniques that reduce the risk of nitrogen loss is necessary to reduce nitrate losses to drinking water supplies. This will be accomplished by on-farm demonstration and outreach efforts based on results from the field studies. Demonstrations will be strategically located on sensitive soils and aquifers. Profitability and water quality impacts will be considered on a field scale.
- The costs of input expenses and yields associated with the various techniques will be measured. One benefit of these new farming techniques is the protection of drinking water quality. This benefit will be

estimated by documenting the potential costs of nitrate contamination incurred by municipal and private well-owners.

Result 1: Evaluation of novel techniques

Description: Techniques such as new forms of nitrogen fertilizer, more efficient crop varieties, and deep-rooted rotation crops to improve water quality in vulnerable aquifers will be evaluated. Cost/benefit analysis will be achieved by characterizing crop response, profitability, and leaching losses of nitrate beyond the root zone. Individual landowner incentives through cost share will be used to establish and implement these new practices. Outreach meetings will be conducted in these ecoregions to disseminate results.

Summary Budget Information for Result 1:	**LCMR Budget:**	**$233,001**
	Spent:	**$232,757**
	Balance:	**$244**

Completion Date: June 30, 2010

Final Report Summary: A series of studies were conducted at the sand plain research farm at Becker Minnesota to evaluate the use of polymer coated urea as a source of nitrogen to reduce nitrate leaching and to evaluate several new and promising potato varieties for improved nitrogen use efficiency over the conventional variety Russet Burbank. Three peer reviewed manuscripts and one extension bulletin were published based on the results of this portion of the project: Wilson, M.L., C.J.Rosen, and J.F. Moncrief. 2009. Potato response to a polymer-coated urea on an irrigated, coarse-textured soil. Agron. J. 101: 897-905; Wilson, M.L., C.J.Rosen, and J.F. Moncrief. 2009. A comparison of techniques for determining nitrogen release from polymer coated urea in the field. HortScience 44:492-494. Wilson, M.L., C.J.Rosen, and J.F. Moncrief. 2010. Effects of polymer-coated urea on nitrate leaching and nitrogen uptake by potato. J. Environ. Qual. 39: 39:492-499. Rosen, C.J., and P.M. Bierman. 2008. Best management practices for nitrogen use: Irrigated potatoes. Univ. Minn. Extension Service:
http://www.extension.umn.edu/distribution/cropsystems/DC8559.pdf

In addition two proceeding reports from the 2008 and 2009 season were prepared.

Summaries of the findings are as follows:

Agronomic effects of using polymer coated urea:

Controlled release fertilizers, especially polymer coated urea (PCU), have been shown to reduce nitrate (NO_3) leaching while maintaining potato (*Solanum tuberosum* L.) yields, but cost has been prohibitive. A new type of PCU (ESN - Environmentally Smart Nitrogen; Agrium, Inc.) is less costly than previous PCUs, but its effectiveness on potato production has not been extensively studied. A two-year field study was conducted to evaluate the effect of this PCU on Russet Burbank tuber yield and quality and to determine if it is economically comparable to soluble N sources. A study was also done to determine the release rate of N from the PCU in the potato hill. The PCU applied at emergence at 90, 180, 270 and 360 kg ha^{-1} N was compared with two split applications of soluble urea applied at equivalent rates (45 kg N ha^{-1} of each rate was applied as diammonium phosphate). Two additional PCU treatments (270 kg N ha^{-1}) were applied approximately 1 week before planting (preplant) and at planting to determine the effect of timing. An additional urea/urea ammonium nitrate treatment of 270 kg N ha^{-1} was added to simulate fertigation. Petioles and midseason soil samples were collected to determine N status during the season. Release of N from the PCU was found to be a function of days after planting and growing degree days (base of 5^oC). Overall, total and marketable tuber yields and the proportion of tubers above 170 grams were significantly higher in 2007 than in 2006. The addition of N significantly increased yields compared with the 0 N control. At equivalent N rates, PCU and urea were found to have similar total and marketable yields. Petiole nitrate concentrations were typically higher with urea early in the season and higher with PCU later in the season. Soil NO_3 determined in samples collected in late June was found to be a better predictor of yield and potential N need than those collected in mid to late July. The addition of N significantly increased net monetary returns compared with the control and net returns were higher in 2007 than 2006. At equivalent N rates, there were no significant differences due to N source. The optimal N rate that resulted in maximum net returns was 251 kg N ha^{-1} of urea while the PCU N rate was lower at 236 kg N ha^{-1}. Overall, the weather during the two study years was drier and warmer than the 30-year average. Under the conditions of this study, PCU produced similar yields and net returns as soluble urea and may reduce the need for split applications of N on these coarse-textured soils. This is one of the first types of PCU that may be a viable option economically for potato producers in the upper Midwest.

Environmental effects of using polymer coated urea

Growing concerns over increasing nitrate (NO_3) concentrations in groundwater in potato (*Solanum tuberosum* L.) production regions of central Minnesota have prompted the need to identify alternative N management practices that will increase fertilizer N recovery and reduce nitrate leaching. A new type of polymer coated urea (PCU), Environmentally Smart Nitrogen (ESN, Agrium U.S. Inc.), has a significantly lower cost than comparable PCUs, but its use in potato production has not been extensively studied, especially with respect to nitrogen (N) fertilizer recovery, use efficiency, and NO_3 leaching. Four rates of PCU from

80 - 360 kg N ha^{-1} applied at emergence were compared with equivalent rates of urea split applied at emergence and post-hilling during field studies in 2006 and 2007. A 0 N control was included, as well as two PCU timing treatments applied all at preplant or at planting. One additional urea treatment simulated fertigation by splitting the post-hilling application further into five applications of 50% urea + 50% ammonium nitrate. All treatments included 45 kg N ha^{-1} as diammonium phosphate. Soil water samples at the 120 cm depth were collected using suction samplers and analyzed for NO_3-N. Deep water percolation (past 120 cm soil depth) was determined by the water budget method, and NO_3 leaching was found as a product of water percolation and NO_3-N concentrations on the day of occurrence. Tuber and vine N content were determined post-harvest, and soil residual inorganic N samples were taken from the top 60 cm. Both 2006 and 2007 were considered low leaching years. The highest leaching occurred at the highest N rates, but NO_3 leaching with PCU (21.3 kg NO_3-N ha^{-1} averaged over N rates) was significantly lower than with two splits of urea (26.9 kg NO_3-N ha^{-1}). At the 270 kg N ha^{-1} rate, splitting soluble N into five applications to simulate fertigation resulted in similar leaching as PCU. Apparent fertilizer N recovery ranged from 45 - 76% of applied N. PCU averaged an N recovery of 65% (over 4 rates) which was significantly higher than two split applications of urea at equivalent rates (55%). Nitrogen use efficiency (NUE) and residual soil inorganic N were not significantly affected by N source. In the spring following potato harvest, plots previously fertilized with PCU and urea had similar soil water NO_3-N concentrations, which were generally higher than concentrations in the 0 N control plots. Under the conditions of this study, PCU significantly reduced leaching and improved N recovery over two splits of urea.

Varietal response to nitrogen rate:

Field experiments were conducted at the Sand Plain Research Farm in Becker, Minn. to evaluate the effects of nitrogen rate, source and timing on yield and quality of various processing russet potato varieties. The varieties tested include: Russet Burbank (standard), Umatilla Russet, Premier Russet, and Bannock Russet, and AOND95249-1Rus (Trail Blazer). Ten N treatments were evaluated. Six of the ten treatments were conventional N sources with the following N rates (lb/A): 30, 120, 180, 240 (early), 240 (late) and 300. Four of the ten treatments were ESN: 180 and 240 lb N/A preplant and 180 and 240 lb N/A at emergence. A starter N rate of 30 lb N/A as monoammonium phosphate was included in the total N rate applied. In general, marketable and total yields of all varieties increased with increasing N rate with optimum yield between 240 lb N/A and 300 lb N/A depending on timing and source. For conventional N at the 240 lb N/A rate, more up front N was optimum for all varieties. Russet Burbank had the highest yield potential and tended to be the highest yielding variety followed by Bannock, AOND95249-1Rus, and Premier, and then Umatilla. Premier, Bannock, AOND95249-1Rus, and Umatilla all had fewer misshaped potatoes than Russet Burbank with Premier having the fewest #2 potatoes. Tubers greater than 6 and 10 oz were highest for Premier and AOND95249-1Rus

followed by Bannock, Russet Burbank and then Umatilla. While tuber quality was improved with the newer varieties, their lower yield potential indicates that more research is needed before Russet Burbank can be replaced with more N efficient varieties.

Evaluation of phytofiltration techniques:

In cooperation with the Minnesota Department of Agriculture, a center pivot near Perham, Minnesota was instrumented with suction tubes to monitor nitrate leaching below the root zone. The cropping systems monitored were: Russet Burbank potato in 2000, soybean in 2001, Alturas potato in 2002, Alfalfa in 2003-2007, Umatilla potato in 2008, and edible bean in 2009. Reduced levels of nitrate in soil water were found with soybean, Alturas potato, and the first four seasons of alfalfa. During the winter of the fourth season, there was significant winter kill of the alfalfa. This resulted in an increase in soil water nitrate concentrations during the fifth season. High nitrate in soil water was also found in 2008 with potato and 2009 with edible bean, which was likely the result of nitrogen release from the decaying alfalfa crop and an excess of N fertilizer applied. The results of this demonstration indicate the challenges associated with reducing nitrate leaching in an irrigated cropping system on sandy soils.

Overall impact:

Use of enhanced efficiency fertilizers such as polymer coated urea for potato production was shown to reduce nitrate leaching especially when fertigation of conventional fertilizer is not possible. Use of these fertilizers is one of many practices growers can use to help reduce the impact of agricultural practices on groundwater quality. Overall impact is that many potato growers are now using enhanced efficiency fertilizers without cost share dollars in their nutrient management program to help improve nitrogen use efficiency. Results show that at equivalent N rates, use of slow release N reduced nitrate leaching on average by 20 lb N per acre compared with a two split conventional system. Economically optimum N rate could be reduced by an average of 15 lb N per acre with slow release N. In addition, a primary advantage of using slow release N was that only one application was required instead of multiple applications, which resulted in lower application costs. As a result of this research, slow release N is being used on ~15,000 acres in the state or about 1/3 of the acreage. The reduction in leaching to groundwater based on these results is 300,000 lbs of N in the state for potatoes alone. Efforts need to be continued to identify potato varieties more efficient in nitrogen use than the conventional varieties currently being grown. Research results in the form of presentations and proceedings were disseminated during the course of the project to potato growers at educational meetings in Becker, MN and Grand Forks, ND and to professional audiences nationally.

Result 2: Evaluation/Demonstration of new tillage techniques

Description: These techniques will provide a favorable crop environment but minimize the potential of nitrogen and phosphorus loss. Cost/benefit analysis will be achieved by characterizing crop response, profitability, risk of phosphorus runoff losses and leaching losses of nitrate beyond the root zone. Cost share and technical assistance provided to landowners will encourage adoption of these new methods. Outreach meetings will be conducted these ecoregions to disseminate results.

Summary Budget Information for Result 2: LCMR Budget: $235,046
Spent: $234,801
Balance: $245

Completion Date June 30, 2010

Final Report Summary: June 30, 2010
Deep tillage effects on irrigated kidney bean and corn production and leaching losses of nitrate on soils with restrictive horizons were evaluated. Two refereed publications were published describing the results. Wilson M.L., Moncrief J.F., Rosen C.J. 2008. Kidney bean (*Phaseolus vulgaris* L.) production on an irrigated, coarse-textured soil in response to polymer coated urea and tillage: I. Grain yields, disease severity, and a simple economic analysis. Journal of Environmental Monitoring and Restoration 5:78-93. Wilson M.L., Moncrief J.F., Rosen C.J. 2008. Kidney bean (*Phaseolus vulgaris* L.) production on an irrigated, coarse-textured soil in response to polymer coated urea and tillage: II. Plant N accumulation, nitrate leaching and residual inorganic soil N. Journal of Environmental Monitoring and Restoration 5:58-72. Results were presented at multiple locations annually to growers and those that advise them. A summary of the findings follow.

Kidney beans (*Phaseolus vulgaris* L.) in Minnesota are commonly grown on irrigated, coarse-textured soils that are susceptible to nitrate leaching. A dense Bt layer that is present in these soils restricts root growth and may increase severity of *Fusarium* root rot. Anecdotal evidence from local growers suggests that breaking up the Bt layer reduces the impact of root rot. This study was conducted to assess different tillage depths and the use of polymer coated urea (PCU, Agrium U.S. Inc. and WSPCU, Specialty Fertilizer Products) on grain yields, net monetary returns and disease severity. The study was conducted over three years as a split plot design. Whole plots were deep and shallow tillage (chisel plowed to an average of 47 and 29 cm, respectively) while N treatments were subplots. Three rates of PCU applied at emergence were compared with equivalent rates of urea split applied at emergence and prebloom for kidney beans. Also, one rate of each source, including WSPCU, was applied at planting and a 0 N control was included. Differences between tillage depths were not

found. Disease severity was not significantly affected by tillage depths or N treatment. Emergence applied PCU resulted in lower grain yields and monetary returns than split urea applications. PCU applied at planting, however, resulted in similar yields and monetary returns compared with split and planting urea, which suggests a more optimal N regime for kidney bean production. Planting applied WSPCU also resulted in similar yields and net returns as planting applied urea.

Differences between tillage treatments were not found except as interactions with N treatment. In dry years, emergence applied PCU resulted in reduced grain N uptake and more cumulative NO_3 leaching than split applied urea. In a wet year, however, emergence applied PCU resulted in similar plant N uptake and significantly less NO_3 leaching that split applied urea. Planting applied PCU resulted in similar plant N uptake and generally less NO_3 leaching compared with split applied and planting urea, regardless of leaching conditions. In dry years, planting applied WSPCU resulted in similar grain N uptake and NO_3 leaching as planting applied urea and PCU.

Evaluation of similar treatments on corn at Staples, MN, 2008 and 2009 was consistent with the kidney bean response. The PCU product and split applied urea showed consistently less nitrate leaching losses and higher grain yields than untreated urea applied at planting. The soluble polymer coated urea product (WSPCU) was worse than untreated urea at planting for nitrate leaching and yield.

Best Management Practices Based on Results 1 and 2

One of the main objectives of this project was to evaluate new fertilizer technologies to improve nitrogen use efficiency and reduce nitrate leaching on coarse-textured sandy soils. Polymer coated urea was evaluated in irrigated potato, kidney bean, and corn production systems. The following can be considered as best management practices for those systems:

Potatoes

- Polymer coated urea at planting or early side dress (at emergence)
- Untreated urea split applied at emergence and multiple fertigation (40% and 60% respectively)
- Recommended N rate should be targeted at 180 to 240 pounds per acre for late season processing varieties if a single application of polymer coated urea or if split applications of soluble N are used.

Kidney Beans

- Polymer coated urea applied at planting
- Untreated urea split applied at planting and emergence (40% and 60% respectively)

- The recommended rate of N is 60 pounds per acre when BMP approaches are used.

Corn

- Polymer Coated Urea applied at planting or early side dress (V2).
- Untreated urea split applied at planting and late side dress-V6 (40% and 60% respectively).

Result 3: Modification of Minnesota Phosphorus Index

Description: This is a tool to quantify risk of phosphorus losses to nearby lakes. It will be modified to include land use practices such as nutrient management, vegetated buffer zones, and changes in surface water storage in proximity to lakeshore environments. Workshops on the use and interpretation of the P Index will be delivered to end-users.

Summary Budget Information for Result 3: LCMR Budget: $78,893
Spent: $78,944
Balance -$51

Completion Date: June 30, 2008

Final Report Summary: A review of literature related to P loss from non-agricultural land was completed. Based on this review a phosphorus index for the mixed land uses of the Central Sands was designed. The SLAM (Source Loading and Management) Model was the most appropriate compilation of runoff data related to developed land. This model was used to estimate factors and weightings for P loss risk factors on non-agricultural, non-forested lands. Recent data on P loss from pastures were used to improve the existing agricultural P Index. To help users rank the risk of P loss from diverse P sources, existing P load estimates from point sources such as individual sewage treatment systems were compared to modeled and measured losses from non-point sources.

Data from regional research sites were used to develop Minnesota-specific factors for use in the Watershed Treatment Model (WTM). The WTM was developed by the Center for Watershed Protection as a low cost model for comparing P loss loads from diverse sources. SLAM was used to assess these factors and field tests of the model were performed. Modifications to the WTM were completed to make it more appropriate for use in rural central Minnesota. It was renamed the Phosphorus Source Assessment Tool (PSAT). Workshops were conducted in St. Cloud, Alexandria, Park Rapids, and Brainerd. The sessions were well-promoted and attracted 101 attendees. Participants learned the basics of P loss risk, and learned how to use the PSAT. Final revisions to the were made in response to evaluations of training workshops in June. The PSAT can be used for education and for initial watershed assessments or screenings.

The main barrier to the use of PSAT is the need for land use data. PSAT and support materials are available at www.mnpi.umn.edu/psat.htm. At this site you can download the user's guide, Power Point presentations of soil P basics and PSAT use and interpretation. A poster was presented at the Minnesota Water Resources Conference in Brooklyn Center October 23-24, 2007.

Result 4: **Economic impacts**

Description: Surface and ground water degradation will be assessed from an economic standpoint. The economic value of high quality drinking water will be determined by conducting a series of studies with rural homeowners and public water suppliers.

Summary Budget Information for Result 4: LCMR Budget: $40,060
Spent: $39,856
Balance: $204

Completion Date: June 30, 2008

Final Report Summary:
Survey of private well owners: We reviewed previous Minnesota research of private well water quality and nitrate remediation practice and a draft survey of private well owners was developed in cooperation with Bruce Montgomery of the Minnesota Department of Agriculture. The survey was targeted to sandy regions by combining a zip code map with a soil association map or with nitrate probability maps from the Minnesota Department of Health. In developing a mailing list, we worked with county E-911 officials to avoid sending surveys to people on public water systems. The Minnesota Center for Survey Research finalized the design of the survey and sampling methodology. Questionnaires were sent to 800 property owners in 11 counties on June 6, 2006 and return rate approached 60%. Nitrate test kits were mailed to people who returned the surveys. Of the 60% returned, 77% returned a water sample for a nitrate test. Of the wells tested, 6% had nitrate-N levels >10ppm, and another 5% were between 5 and 10 ppm. Ten percent of respondents owned or leased a nitrate removal system at a cost of nearly $1000 to install and $100/yr to maintain. Average remediation costs were $190/yr to buy bottled water, $800 to buy a nitrate removal system plus $100/yr for for maintenance, and $7,200 to install a new well. Of well owners with NO_3-N over 10 ppm, 24% bought bottled water, 21% installed treatment systems, and 24% installed new wells. Water resource planners can compare the costs described in this study to the costs of preventing aquifer contamination through education and technical and financial support. This study also demonstrates a method for representative sampling of private wells without on-site visits, and the continued need for educational programs related to routine testing.

A poster reporting results was presented at the Minnesota Water and Water Resources Conference in October 2006. Details of this study were published in the Journal of Soil and Water Conservation. Lewandowski AM, Montgomery BR, Rosen CJ, Moncrief JF. 2008. Groundwater nitrate contamination costs: A survey of private well owners. Journal of Soil and Water Conservation 63: 153-161. A two-page summary was also prepared for those interested in a summary version.

Survey of municipal well managers: A plan for a municipal survey was developed that builds off of previous surveys such as the MDA/MDH 2004 study and the MDH "Assessment of Groundwater Contamination Costs to Public Water Suppliers" from 1994. In cooperation with the MDH, we identified seven municipalities with elevated, but not excessive, nitrate levels. A questionnaire was developed that was mailed to well managers in advance of an in-person interview. Results show that nitrate removal systems increase the cost of water delivery by fourfold or more. Initial installation costs are $400,000 or much more. Even before a treatment system is installed, cities pay for elevated groundwater NO_3 levels through increased costs of siting a new well, more frequent NO_3 testing, and time spent blending water from multiple wells. Because of the small sample, costs were not summarized, but were presented as examples of costs that could be incurred. This will help municipalities interpret the numbers for their unique situation. The interviews also addressed costs of and barriers to wellhead protection. Challenges of wellhead protection generally relate to the wide range of stakeholders, uneven distribution of costs and benefits, and the limited set of tools that cities have to influence land use and management in the well recharge area. Two write-ups of the results were completed and reviewed by stakeholders

V. TOTAL LCMR PROJECT BUDGET:

See attachment A for details.

TOTAL LCMR PROJECT BUDGET: $587,000

Explanation of Capital Expenditures Greater Than $3,500: N/A

VI. OTHER FUNDS & PARTNERS:

A. Project Partners:

Central Region Partnership - Sharon Rezac-Anderson - $0
Minnesota Department of Agriculture - Bruce Montgomery and Don Sirucek - $0
Soil and Water Conservation Districts (Todd County District-Lead) - Kitty Teply – $87,500
Natural Resource Conservation Service - $0
University of Minnesota and Minnesota Extension Service - Carl Rosen and John Moncrief $387,000
USDA Agricultural Research Service - Michael Russelle $0

B. Other Funds being Spent during the Project Period: $0

C. Required Match (if applicable): N/A

D. Past Spending:
Central Region Partnership to evaluate alternative farming practices $44,500 (matching funds to start the field studies);
Environmental Quality Board for development of P Index for farmers $90,000;
Two LCMR projects in the early 1990s were funded to evaluate nitrate leaching potential and management practices on sandy soils. This current proposal builds upon those projects and introduces new techniques that were not available or known 10 years ago.

E. Time: April 2005 to December 2007. If this project is selected in the initial screening process, we will seek additional support from the Central Region Partnership to start the project during the spring 2005 growing season. Extending the project to December of 2007 will provide three full growing seasons with additional time for information dissemination.

VII. DISSEMINATION: posting on web sites (http://www.soils.umn.edu/, http://www.mnpi.umn.edu/), workshops for grower organizations and agency field staff, as well as publication in popular and peer reviewed journals.

Outreach Effort

Result 1.
Results from this research were presented to the Area II potato growers associate and and the Northern Plains Potato Growers association in 2006, 2007, 2008, 2009 and 2010. A total of 220 grower and grower consultants were contacted each year through these programs. Additional presentations were made in 2006, 2007, 2008, 2009, and 2010 at the annual Soil Science Society of America meetings. Two additional presentations were made on strategies to reduce nitrate leaching from irrigated potatoes at the annual American Society for Horticultural Science meeting and Minnesota Ground Water Association's Conference in 2010.

Result 2.
The research and demonstration results from this effort were presented each year of the study at multiple locations in relevant biomes.

Result 3.
“Hands On” demonstrations of the Phosphorus Source Assessment Tool (PSAT) were conducted across the state. The usefulness of this tool was rated 4.1 out of a possible 5.0 by attendees. It is being used by water planners such as Soil and Water Conservation and Watershed Districts as well as lake associations and

others. The PSAT was also presented at the Minnesota Water Conference. The tool, back ground information, and user manual are available at http://www.mnpi.umn.edu/psat.htm.

Result 4.
Informational meetings were held where water samples were submitted for nitrate analysis and surveys completed on well characteristics and water treatment situation. Several fact sheets were developed and made available on several web sites.

1. *What communications and outreach activities have been done in relation to your project? For example: have tools or techniques developed through your project been adopted by a group; presentations relating to the project been made; has work pertaining to the project been published?*

Copies of presentations, fact sheets, and peer-reviewed articles are attached.

Peer reviewed:

1. Effects of polymer-coated urea on nitrate leaching and nitrogen uptake by potato
2. Groundwater nitrate contamination costs: a survey of private well owners
3. Potato response to a polymer coated urea on an irrigated coarse-textured soil
4. Kidney bean (Phaseolus vulgaris L.) production on an irrigated, coarse textured soil in response to polymer-coated urea and tillage: I. Grain yields, disease severity, and a simple economic analysis
5. Kidney bean (Phaseolus vulgaris L.) production on an irrigated, coase textured soil in response to polymer-coated urea and tillage: II. Plant N accumulation, nitrate leaching and residual inorganic soil N
6. A comparison of techniques for determining nitrogen release from polymer-coated urea in the field

Fact sheets, bulletins, user guides, proceeding reports

1. Costs of groundwater nitrate contamination: A survey of private well owners in central Minnesota
2. Costs of groundwater nitrate contamination: Municipal water suppliers (fact sheet)
3. Costs of nitrate contamination of public water supplies: A report of interviews with water suppliers
4. Survey of well owners about drinking water quality
5. Minnesota phosphorus source assessment tool: User guide and documentation

6. The phosphorus source assessment tool: A tool for education and watershed planning
7. Best management practices for nitrogen use: irrigated potatoes (note– funded by fertilizer check off money, but slow release N data included from this project)
8. Response of processing potato varieties to nitrogen and enhanced efficiency fertilizers: 2008
9. Response of processing potato varieties to nitrogen and enhanced efficiency fertilizers: 2009

REPORTING REQUIREMENTS: *:* **Periodic work program progress reports will be submitted not later than** December 31, 2005**,** June 30, 2006, December 31, 2006*,* June 30, 2007, December 31, 2007, June 30, 2008, December 31, 2008, June 30, 2009, December 31, 2009, June 30, 2010, December 31, 2010**. A final work program report and associated products will be submitted by:** June 30, 2010*.*

VIII. RESEARCH PROJECTS:

A. Evaluation of the New Nitrogen Fertilizer Guidelines for Corn Grown on Coarse-textured Soils. Carl J. Rosen, John A. Lamb, and John F. Moncrief. $45,000 2008-2009

A two year study will be conducted at the Sand Plain Research Farm in Becker, Minnesota to determine the effects of nitrogen fertilizer rate and source on corn grown on irrigated and nonirrigated coarse-textured soils. For each irrigation treatment, eight N fertilizer treatments will be evaluated which include a zero nitrogen control, five conventional nitrogen fertilizer sources ranging from 60 to 300 lb N/A and two polymer coated urea treatments (ESN) at 120 or 180 lb N/A. Delta yield will be calculated for each irrigation treatment to determine how moisture stress affects N availability. Data from this study will be used to help fine-tune N BMPs for irrigated and nonirrigated coarse-textured soils.

B. Evaluation of the Slow Release Nitrogen Fertilizer for Irrigated Corn Grown on Coarse Textured Soils
Del Lecy, John F. Moncrief, Carl J. Rosen. $40,000 2008-2009

A two year study will be conducted at the Central Lakes College Agriculture Center, Staples, MN. Two treated urea-nitrogen fertilizers will be compared to untreated urea for corn response and nitrate leaching losses under two irrigation regimes on a coarse textured soil. This will be done at two scales (plot and field). Results will be disseminated through web based and printed publications as well as outreach meetings.

C. Nutrient Management Studies on Irrigated Potatoes. Carl J. Rosen. $32,000 2008-2009

Two comprehensive nitrogen (N) management studies with various potato cultivars/selections are proposed. Both studies are extensions of previous N management studies conducted with 'Russet Burbank'. The first proposed study is to compare N response of the recently released russet cultivars: 'Umatilla', 'Premier', and a promising NDSU selection (AOND95249-1Rus) with 'Russet Burbank'. 'Umatilla' and 'Premier' are cultivars released from the Northwest breeding program. Treatments will compare N rate and timing from conventional N sources and ESN.

Attachment A: Budget Detail for 2008 Projects - Summary and a Budget page for Todd County SWCD

Proposal Title: Improving Water Quality on the Central Sands

Project Manager Name: John Moncrief

87,000

1) See list of non-eligible expenses, do not include any of these items in your budget sheet
2) Remove any budget item lines not applicable

2005 LCMR Proposal Budget	Result 1 Budget	Beginning Balance	Current Invoice 1/1/10-6/30/10	Ending Balance 6/30/10	Result 2 Budget	Beginning Balance	Current Invoice 1/1/10-6/30/10	Ending Balance 6/30/10	Project Total			
	Evaluation of New Techniques				*Evaluation of New Tillage Techniques*				Budget	Beginning Balance	Current Invoice 1/1/10-6/30/10	Ending Balance 6/30/10
BUDGET ITEM												
*** PERSONNEL: Staff Expenses, wages, salaries SWCD Manager***	4000	1,758.81	1,758.81	0.00	4,000	1758.81	1758.81	0.00	8,000	$ 3,517.62	$ 3,517.62	$ -
PERSONNEL: Staff benefits	1000	995.22	995.19	0.03	1,000	995.23	995.19	0.04	2,000	$ 1,990.45	$ 1,990.38	$ 0.07
Other contracts, Farmer Cost Share	36750	7,384.68	7,384.50	0.18	36750	7384.68	7384.50	0.18	73,500	$ 14,769.36	$ 14,769.00	$ 0.36
Web Site Development	1,250	1,250.00	1,249.25	0.75	1,250.00	1250.00	1249.25	0.75	2,500	$ 2,500.00	$ 2,498.50	$ 1.50
Mileage	500	167.49	0.00	167.49	500.00	167.49	0.00	167.49	1,000	$ 334.98	$ -	$ 334.98
COLUMN TOTAL	43,500	11,556.20	11,387.75	168.45	43,500.00	11,556.21	11,387.75	168.46	87,000	$ 23,112.41	$ 22,775.50	$ 336.91