I. Minnesota River Basin Water Quality Monitoring - Water 9

Program Manager: Wayne Anderson, Head (612)296-7323
Technical Support Unit
Nonpoint Source Section
Water Quality Division
Minnesota Pollution Control Agency

Program Cooperators: Greg Payne, U.S. Geological Survey (USGS)
Jack Arthur, EPA Environmental Research Laboratory (ERL)
Henry Quade, Mankato State University (MSU)
Jeff Nielsen, Bd. of Water & Soil Resources
Nick Pearson, Soil Conservation Serv. (SCS)

A. M.L. 91 Ch 254 Art. 1, Sec. 14, Subd:4(c) Appropriation: $700,000
Balance: $ - 0 -

Minnesota River Basin Water Quality Monitoring: This appropriation is from the Minnesota environmental and natural resources trust fund to the commissioner of the pollution control agency. This is the final two years of a multiagency four-year effort to identify the sources of nonpoint pollution threatening the water quality and uses of the Minnesota River. The results will be used to direct state and local implementation programs. Federal matching money is appropriated.

B. Compatible Data: During the biennium ending June 30, 1993, the data collected by projects funded under this section that have common value for natural resource planning and management must conform to information architecture as defined in guidelines and standards adopted by the information Policy Office. In addition, the data must be provided to and integrated with the Minnesota Land Management Information Center's geographic data bases with the integration costs borne by the activity receiving funding under this section.

C. Match Requirement: This is the second time this activity has received LCMR funding. The original funding was for the biennium ending June 30, 1991. The original funding required a dollar for dollar match. Funding for the biennium ending June 30, 1993 does not carry this requirement. To date the activity has received matching and cooperating funds that total approximately $1,450,000 over the four years of the project.

II. NARRATIVE

A. The Department of Natural Resources conducted a study of the Minnesota River in 1985. The study entitled "Biological Survey of the Minnesota River - March 1985" made the following conclusion; The Minnesota River constitutes a serious, negative, water quality impact on the Mississippi River system, particularly in respect to turbidity, sediment and nutrients. It is a major contributor to the problems of silting and eutrophication of Lake Pepin and important backwater areas above the lake. The Pollution Control Agency conducted a study of the Mn River in 1982 and publish a report entitled "Minnesota River Watershed Water Quality - An Assessment of Nonpoint Source Pollution - MPCA Sept. 1982". This study demonstrated that nonpoint source pollution is having a significant impact on the Minnesota River and it's tributaries. The MPCA also conducted a study entitled "Lower Minnesota River Waste Load Allocation Study MPCA - October 1985". This study made the following recommendation; implementation of a constructive and sustained basin-wide program dealing with surface runoff related sources of nonpoint source pollutants and soil erosion is critical to the ultimate achievement of water quality objectives.

B. The Minnesota River and it's tributaries are important recreational resources to the people of Minnesota, and are very under utilized according to DNR officials.

C. The Minnesota River is one of the most highly impacted water bodies in the state from nonpoint source pollution. The oxygen standard in the lower reach of the Minnesota is

5 mg/l and is frequently violated. The suspended sediment carried by the Minnesota river is higher than most other rivers in the state. During 13 years of record at Mankato, the USGS observed a median concentration of 92 mg/l and a load of 2,700 tons per day.

III. OBJECTIVES

A joint effort of federal, state, and local governmental units will assess the mainstem, major tributary, and ground water nonpoint source (NPS) inputs to the Minnesota River for the purpose of targeting future water quality management programs. A comprehensive monitoring network has been set-up in the Minnesota River Basin from the dam at Lac Qui Parle Reservoir to the mouth. (Because of the complexity and expense of accurately assessing a reservoir, it was decided by the steering committee to stop the study at the Lac Qui Parle reservoir outlet). The monitoring network includes 14 mainstem sites, ground water from 19 separate spring sites, and 17 tributaries, located at regular intervals between Lac Qui Parle and the mouth. The mainstem sites were chosen to be representative of the geographic and tributary reaches. The ground water stations were selected to assess the various aquifers feeding the system. The major tributaries monitored include the Chippewa River, Hawk Creek, Yellow Medicine River, Redwood River, Cottonwood River, Blue Earth River Watonwan River, Le Sueur River, Rush River, High Island Creek, Bevens Creek, Bluff Creek, Carver Creek, Credit River, Nine Mile Creek, Riley Creek, and Sand Creek.

Funding of this proposal by the LCMR will be used to study 12 mainstem sites, 15 ground water sites, and 10 tributary sites. Additional sites are monitored by the MWCC under separate funding.

The Minnesota River Assessment Project (MRAP) consists of representatives from U.S. Geological Survey, U.S. Environmental Protection Agency - Research Laboratory in Duluth, South Central Minnesota Counties Water Planning Project, Mankato State University, Minnesota Board of Water and Soil Resources, Minnesota Department of Natural Resources, USDA Soil Conservation Service, the Minnesota Department of Agriculture, Metropolitan Council, the Metropolitan Waste Control Commission, USFW, and U.S. Corps of Engineers. MRAP is the mechanism which has been established to carry out the assessment of the Minnesota River using the LCMR and related matching funds. For the purposes of management and coordination, MRAP is divided up into a Steering Committee and four main subcommittees. These subcommittees represent the three principal areas of investigation in addition to data management. The Steering Committee for this project meets on a monthly basis in order to insure proper project coordination. The subcommittees meet on an "as necessary" basis to work out specific details of the various areas on investigation.

Overall project leadership and responsibility rests with the Minnesota Pollution Control Agency (MPCA). The MPCA is providing the overall project coordination by the following:

- Budget and contract management
- Work plan preparation
- Project guidance
- Data synthesis and integration through modeling and GIS
- Coordination of monthly Steering Committee meetings
- Project tracking
- Reporting responsibilities

Individual Cooperators are responsible for;

- Monitoring design and data acquisition
- Work plan
- Overall coordination through Steering Committee participation
- Quality Control and Quality Assurance
- Data analysis
- Reporting data conclusions and recommendations

Currently, data from the first two years of this study is being used to guide the activities of years three and four. This information is also being used to identify cause and effect relationships and design individual studies to further assess them and develop best management practices (BMP's). Further intensive studies on specific subwatersheds can be targeted through the Clean Water Partnership and other ongoing programs subsequent to completion of the project.

A. Physical/Chemical Assessment (USGS and MPCA)

A1. Narrative

This portion of the study consists of the following objectives;

1. Identify sources and determine loadings of major nutrients, suspended sediment, BOD, and organic carbon in selected reaches of the Minnesota River and selected major tributaries and ground water to isolate the effects of specific sources on river quality.

2. Determine the relationships between suspended sediment and major nutrients, BOD, and organic carbon using regression techniques to define the relationship between these constituents in the Minnesota River.

3. Quantify the transport of sediment and associated pollutants between river reaches.

4. Attempt to identify areas of bank erosion and sediment deposition to determine whether in-stream loading might have a more adverse effect on river quality than nonpoint pollution.

A2. Procedures:

Sampling will progress downstream in an attempt to follow a parcel of water along the course of the river. Stream flow will be measured at ungaged stream sites at the time of sampling. Measurements of water temperature, specific conductance, pH, and dissolved oxygen will be made at the time of sampling. Raw surface water samples will be collected to determine the concentrations of suspended sediment (including determination of the percent finer than sand), total and volatile suspended solids, phosphorus, orthophosphate, ammonia plus organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, organic carbon, BOD, COD, chlorophyll a, and fecal-coliform and fecal-Streptococcus bacteria. Bacteria concentrations should aid identification of nutrient sources. Samples of both surface and ground water will be analyzed for dissolved concentrations of phosphorus, orthophosphate, ammonia plus organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and organic carbon by filtering through a 0.45um-pore-size filter. The difference in concentration between the unfiltered and filtered samples of surface water should approximate the amount of material attached to particles of suspended sediment and in colloidal complexes. Selected samples of suspended sediment will be analyzed using approved methods to determine recoverable concentrations of nitrogen and phosphorus actually carried by the sediment.

At the stream gaging sites on the Minnesota River near Montevideo and the Blue Earth River near the mouth, weekly samples will be collected from March-July and monthly during the rest of the year. These samples will be analyzed for the same suite of constituents (both dissolved and total) as listed above. This data should provide more detailed information about the loading of constituents from major subportions of the watershed.

Sediment loading to the lower reach of the river will be determined from data collected at the daily sediment and stream flow station already operating at Mankato. A local observer will collect daily samples of suspended sediment from the Blue Earth River near Rapidan. Sediment loading from the Minnesota River above the Blue Earth River will be determined by subtracting out loading from the Blue Earth River.

Samples of bottom material collected from the mainstem sites and tributary streams during low flow will be analyzed for particle size and the total concentrations of phosphorus, ammonia plus organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, and organic carbon. Samples of parent material at sites of active erosion will be analyzed for these same constituents to determine the composition of sediments introduced from the stream banks.

Three sets of samples during FY 92 and two sets in FY 93 collected at approximately the same sites will be analyzed for the same suite of constituents. These same sites will have been sampled a total of 7 times during FY's 90 and 91 and as the data from those runs is analyzed, the number of sites and sampling locations could be changed to more accurately assess certain portions of the basin which are contributing large amounts of pollutants.

Samples will be collected during snowmelt runoff in spring, during mid-range flow (based on flow-duration data), and during low-flow conditions in late summer or early winter. Because tributaries are more variable, they will be sampled two extra times during each of the years. Bottom-material samples will be collected and analyzed once each year. Ground water will be sampled only twice during each year because springs may be inundated during spring runoff.

Segments identified as being important sources of bank erosion or areas of deposition will be re-examined to determine estimates of the volume of sediment added to the stream or removed from it.

Stream flow and sediment discharge in ungaged tributaries will be approximated using basin-comparison or numerical modeling techniques. Ground water inflow will be estimated from seepage gain and loss measurements during periods of reduced flow between each of the mainstem sampling/measuring sites less tributary inflow. Sediment transport between reaches in the mainstem of the river will be determined from differences in concentration, particle size, and water quality at each of the 12 sampling sites.

All water samples will be collected and preserved by personnel from the USGS or the MPCA, using USGS techniques (depth integrated samples composted from multi-verticals) which are consistent with USEPA requirements. The samples will be packed in coolers, iced and than shipped via air freight to the USGS laboratory in Denver, Colorado.

A3. Amount remaining: $ - 0 -

A4. Product Timelines

	July 91	Jan 92	July 92	Jan 93	July 93
Detail Design	****				
Fieldwork/Sampling	**				
Chemical Analysis	**				
Data Synthesis	**				
Final Report				*******************	

A5. Status: The Minnesota River Assessment Project was organized in 1989 to determine the causes of water quality degradation in the Minnesota River. To accomplish this goal, three major subcommittees were formed in 1989; Water Quality (USGS), Biological - Toxicological (U.S. EPA - MDNR), and Land Use (MSU-BWSR). The USGS, in cooperation with the MPCA and the LCMR, monitored selected physical characteristics and chemical constituents in the Minnesota River Basin. A two-fold surface water sampling approach was used to identify areas of the Minnesota River Basin that could contribute nonpoint source pollutants. The first approach consisted of water quality sampling at the mouths of 10 major tributaries. Sampling included measuring chemical concentrations and determining sediments loads so that each tributary could be ranked by the magnitude of its contribution to the Minnesota River. The second approach consisted of sampling the mainstem of the Minnesota River at 12 locations to determine the accumulated effects of all nonpoint source pollution and instream processes.

Ten data collection sites were established near the mouths of the following major tributaries: Chippewa River, Yellow Medicine River, Hawk Creek, Redwood River, Cottonwood River, Watonwan River, Le Sueur River, Blue Earth River, Rush River, and High Island Creek. Mainstem data collection sites on the Minnesota River were established at intervals ranging from 13 to 33 miles, beginning at the outlet of Lac Qui Parle Reservoir and extending downstream to Henderson, Minnesota.

Water samples were collected from a range of stream flow conditions to characterize the change in water quality as the streams responded to both dry and wet conditions. Accordingly, samples were collected at all sites during low flow in late summer 1989, in winter 1990, and in late summer 1990. Samples were collected during a short time period (2-3 weeks), progressing from upstream to downstream to obtain a synoptic appraisal of water quality during low stream flow. Samples were collected at selected sites during snowmelt (March-April) and during runoff from summer rainfall (May-July) to evaluate high flow conditions. The Minnesota River at Montevideo and the Blue Earth River at Mankato were sampled frequently throughout 1989-92 (weekly from March through July, and monthly from August through February) to more precisely determine short-term changes in water quality. From August 1989 through September 1992, 404 water samples from streams and 36 samples from springs and seeps were collected for chemical analysis. In addition, suspended-sediment samples were collected daily from March through November at the Blue Earth River at Mankato and at the Minnesota River at Mankato.

The sampling during 1989-1990 was designed to provide information about both areal and temporal variability in water quality. Sampling sites were added in the Blue Earth and Redwood River Basins, and the sampling schedule was modified during 1991-92 on the basis of findings during 1989-90. This was done to provide more detailed information about processes associated with the origin, transport, and transformation of problematic water-quality constituents.

A USGS report containing selected water-quality and basin- characteristics data has been prepared and is scheduled to be published and released July 1, 1993 (Winterstein et al. 1993). A second USGS report containing analyzes and an interpretation of the water-quality data is in preparation. A draft of this report is scheduled for completion by October 1, 1993. The interpretive report will describe the occurrence, distribution, and regional variability of nonpoint source pollution within the Minnesota River Basin. The interpretive report will document measured concentrations and loads of nonpoint source constituents in basin streams across a broad range of hydrologic conditions. Processes affecting the transport and transformation of nonpoint source constituents delivered from watershed source areas will be described and the contribution of instream processes such as deposition, resuspension, and bank erosion will be evaluated. Natural physiographic, geologic, and climatic variability within the basin, as well as human influences, will be compared and related to measured water quality as part of the interpretation.

Winterstein, T.A., Payne, G.A., Miller, R.A., and Stark, J.R., Selected Basin Characteristics and Water-Quality Data for the Minnesota River Basin: U.S. Geological Survey. Open File Report 93-164, 108 p.

Basin Geochemistry and Flow Systems

The Minnesota River follows the course of the glacial River Warren, which carved one of the deepest and longest valleys in Minnesota. The resulting valley is a hydrologically dynamic basin cutting largely through glacial sediments deposited by the Des Moines lobe of the Laurentide ice sheet. Moving west to east across the basin, precipitation increases with a corresponding increase in tributary flow. Furthermore, total dissolved solids (TDS), sulfate and the trace element boron are higher in the west. Eastward, the waters have lower TDS and become more dominated by calcium, magnesium and bicarbonate. Surface water impacts increase eastward, particularly with regards to the potential for nutrient and sediment loading (Magner and Alexander, 1991).

Subsurface movement of water has a significant buffering influence upon the hydraulics and water quality of the Minnesota River, during low flow periods. Deeper, more regional flow systems with longer residence times exhibit a relatively constant chemistry and flow rate. Drainage examples, such as the historic Mountain Lake wetland, illustrate the transition from enclosed catchments to regionalized flow systems (Magner, et al. 1993).

The deeply incised glacial river valley produced the vertical relief required for ground water to resurge as springs and fens. Recharge to the springs is provided by infiltrating water, with lakes and large wetlands representing large and relatively constant sources. Physically, the springs vary from discrete point sources to diffuse side hill seeps. Near the river they occur as sand boils in the river bed.

Springs fed by waters with long residence times, low redox potential and dissolved oxygen contain little or no nitrate-nitrogen. Conversely, short residence time springs that are more oxidized have a higher susceptability to nitrate-nitrogen. In addition to increased nutrient loading, the presence of pesticides in the shorter residence time springs was observed.

A6. Benefits

(a) Identify sources and determine loadings of major nutrients, suspended sediment, BOD, and organic carbon in selected reaches of the Minnesota River and the selected major tributaries and ground water to isolate the effects of specific sources on river quality.

(b) Determine the relationship between suspended sediment and major nutrients, BOD, and organic carbon using regression techniques to define the relation between these constituents in the Minnesota River.

(c) Quantify the transport of sediment and associated pollutants between river reaches.

(d) Attempt to identify areas of bank erosion and sediment deposition to determine whether in-stream loading might have a more adverse effect on river quality than outside sources of pollution.

B. Biological/Toxicological Assessment (EPA-ERL, DNR and MPCA)

B1. Narrative:

This portion of the study will assess the existing biological characteristics and the nature and extent of toxic gradients within the Minnesota River Basin. Through application of laboratory and field methods, meaningful linkages can be made among the river's biological resources, regulatory water quality standards, and intended designated uses. The overall goals are to recommend procedures for enhancing the biotic resources and identifying toxic conditions in the river basin.

This portion of the study is divided up into macroinvertebrate, fish, and toxic components. Specific objectives for the macroinvertebrate and fish studies are to define the existing biological communities, determine proportions of tolerant and intolerant forms, and further characterize impairment using biotic indices. The toxicity studies will further establish where the problem areas occur (in water and/or sediment column), general nature of the causative agents, and extent of contamination in the biota. The biological surveys will show the extent of degradation, the toxicity findings will assist in verifying and quantifying the problem areas. The locations of the primary assessment sites have been and will continue to be the determining factor in selecting additional sites for this part of the study.

B2. Procedures:

a. Bethic Macroinvertebrates:

i. Habitat Assessment: Evaluating habitat quality is an important part of any assessment of stream macroinvertebrate communities. A systematic assessment of habitat quality is being conducted at each macroinvertebrate sampling location. Each location will be assessed in terms of it's physical, water quality, local watershed, stream bank and instream characteristics. The habitat assessment techniques described by the Ohio Environmental Protection Agency (1987) will be used in this study. This procedure includes the calculation of a Qualitative Habitat Evaluation Index (QHEI) from information collected at each sampling site.

The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation, of the lotic habitat quality. The index consists of seven metrics, each of which is given an individual score, with a maximum possible site score of 100.

The following seven metrics will be used to compute the QHEI for each macroinvertebrate sampling site:

1) Substrate type and quality
2) Instream cover type and amount
3) Channel morphology
4) Riparian zone and bank erosion
5) Pool and riffle-run quality
6) Map gradient
7) Drainage area

The QHEI score is computed by adding the components of each metric to obtain the metric scores and then summing the seven metric scores (total max. 100pts).

ii. Field procedures: Three different techniques will be employed. Qualitative samples will be taken with a kick-net and by hand picking from natural substrates. Quantitative samples will be taken with Hester-Dendy samplers and Ekman grab sampler. A sampling information sheet will be completed for each sampling station on each sampling date. Specific information on the details for each method may be found in the Biology/Toxics workplan.

iii. Laboratory Procedures: All samples will be coded for easy reference purposes. Each sample will be assigned a log number and recorded in a log book. The sorting method will vary with sample type. Hester-Dendy and Ekman grab samples will be sorted and tabulated in a glass tray over a glow box. To reduce analysis time for samples containing large numbers of individuals of one taxonomic group, such as oligochaetes and chironomids, all other organisms will be removed first and then the remaining specimens will be thoroughly mixed in the tray, the bottom of which has been delineated into quarters. Two opposite quarters of the tray will then be sorted. Chironomids will have to be identified by mounting the larva on a glass slide and examining the head capsule under the microscope. The relationship between the number of specimens in the sample and the number of microscope slide preparations and identifications is given in the work plan for the Biology/Toxic work group. Kick-net and hand-picked qualitative samples will be sorted as a subsample as described by (Plafkin et. al.,1987). The subsample will be removed as a randomly selected group of individuals from the bottom of a gridded glass tray. For sorting, enumeration and identification, samples will be examined under a light-equipped magnifying lens. Final examination of each sample will be done with the aid of a stereomicroscope. Specimens will be identified to the lowest taxonomic level possible, usually genus or species. A reference collection of voucher specimens of the macroinvertebrates collected will be assembled.

Data from both the qualitative and quantitative samples will be used to calculate different metrics to compare sampling stations and assess the health of the macroinvertebrate community at a sampling station. The following metrics apply either to the whole community or to different taxonomic groups, some of which are pollution-sensitive and others pollution-tolerant. Richness, Diversity Index, Equitability Index, Community Similarity Index, Community Loss Index, Ratio of Insect Scraper and Filtering Collector Functional Feeding Groups, Macroinvertebrate Biotic Index (MBI), Ordination, and Taxonomic Group Metrics. The work plan for the Biology/Toxic work portion of this project should be consulted for specifics on these metrics.

b. Clam Studies:

Sphaeriid clams will be used as biological indicators of water quality, especially ammonia levels, at selected sites on the Minnesota River and it's tributaries. Sphaeriid clams are important components of the benthic community and serve as dietary constituents for many fish and diving duck species. Because of their high population densities and short life cycles, they are valuable as bioindicators of water quality. Fingernail clams (Musculium transversum) have been shown to be sensitive to increased concentrations of ammonia (Zischke and Arthur, 1987) and to long-term acidification (Sorvos et al., 1985). Clams (M. transversum) will be collected from clean-water areas, measured with an ocular micrometer, and placed into mesh cages for testing to determine growth rates and percentage survival. At the 6-8 week exposure periods, the clams will be removed from the cages and preserved in 10% neutral buffered formalin. Survival counts, length measurements, and counts of immature clams will be taken in the laboratory. Data on clam growth, survival and reproduction will be correlated with gathered water quality data. The study will consist of separate trials. Each trial will consist of growth/survival component and a reproductive component. Sites will be selected based on the available water quality data, with the intent of selecting sites in which a water quality (ammonia, in particular) problem is suspected and sites which may serve as reference areas. Three to five mainstem and tributary sites are proposed and coordinated with the Physical/Chemical portion of the overall study. Chemical and physical measurements will be made at the initiation of the study, during the exposure, and at the termination of the tests. These measurements will include total ammonia, dissolved oxygen, pH, turbidity, alkalinity, specific conductivity and temperature.

c. Fish Community Study: The objective of this portion of the study is to develop an extensive data base on the Minnesota River watershed fish community characteristics and utilize this information to establish water resource goals. These goals will be defined in terms of fish community health and will be related to fishable/aquatic life uses. These goals will allow evaluation of pollution impacts on the biological integrity of the Minnesota River and its tributaries by comparison to the best attainable conditions.

One of the most useful assessment methodologies for fish community analysis is the Index for Biotic Integrity (IBI). The IBI was developed to monitor water quality in streams and rivers of the midwest, primarily Illinois (Karr, 1981). It is considered a useful assessment tool because it is quantitative, provides a criteria to determine what is an excellent or poor fish community, and utilizes several characteristics of the fish community to assess health. The IBI is comprised of 12 fish community characteristics or metrics, six which express species richness and composition, three which summarize trophic composition information, and three which evaluate fish abundance and condition. Each metric is assigned a score of 5 (best), 3 or 1 (worst) depending on how the sample data being analyzed compares with the value expected at similar sites that are relatively undisturbed (Bertrand and Hite, 1989). The twelve metrics can then be summed to express an overall rating of fish community health. The IBI was chosen as the assessment methodology for fish community analysis for several reasons. It has accurately reflected habitat and water quality perturbations (point and nonpoint pollution problems) in various studies where known problems existed. The use of relatively undisturbed references for setting the attainable fish community health provides for reasonable water quality goals. Existing data, to some degree, can be used for developing the expected metric values. Fish collections previously taken from the Minnesota River and its tributaries (Kirsch et al., 1985; U. of M. Bell Museum) were used for establishing the metrics and proposing expected values for each. The actual metrics used in the project have been decided by members of the Biology/Toxics Committee, and Jim Underhill and Jay Hatch of the U. of M. Bell Museum. A list of watershed fish species was generated from th existing data. Ecological characteristics (feeding habits, tolerance/intolerance to perturbation) were determined for each species by reviewing the literature with final status decided by the above group. It is particularly important when using IBI methodology that the samples contain species in proportion to the waterbody and that the procedures are standardized for all locations.

The IBI methodology has been performed on approximately 50 sites in the Minnesota River Basin during the first 2 years of the overall project. These sites were chosen based on land use information, riparian cover, riffle-pool presence, avoidance of known pollution discharge points, and overall representation of other streams in the area. Habitat assessments were conducted in conjunction with fish sampling to help define "reference" habitat conditions. Values derived from this exercise are being compared to the expected metric values obtained from the existing data. Actual expected metric values were chosen by the best professional judgement of the committee as mentioned above.

d. Toxicity Testing:
Toxicity tests (bioassays) are useful for identifying problem areas and frequently correlate with elevated instream pollutant and downstream persistence (Ankley et al., 1989; IJC, 1989). Our

objective is to determine if ambient toxicity can be demonstrated in surface water and sediments in the Minnesota River system and associate these results with the chemical and biological findings of others to identify undisturbed and degraded watershed reaches. The International Joint Commission (IJC, 1989) has recently recommended bioassays as excellent assessment tools because of their "simplicity, practicality, interpretability, and reproductability", and also concluded that individual assays are usually insufficient to define problem areas, but better definitions can be obtained by employing a series of tests in a tiered fashion. Two standardized procedures are proposed for use in this study, with the microcrustacean, *Ceriodaphnia dubia* and the green alga, *Selenastrum capricornutum*. In addition, the application of two new cellular techniques, biomarkers and mitochondrial phosphorylation, are also being used (Spies et al., 1988; Blondin et al., 1989).

During the first two years of this project 27 sites were monitored using the techniques outlined above. Ten tributary sites, 4 reservoir sites and 14 mainstem sites. All these sites, with the exception of the reservoir sites, correspond to the Physical/Chem monitoring stations. During years three and four of this study additional sites will be assessed. The specific sites will be chosen based on analysis of the data generated from all components from the first part of this study.

Ambient water and sediment samples are collected away from shoreline disturbances. The sediment samples are initially screened for toxicity using centrifuged pore water. The water is collected offshore by either wading or casting a prerinsed polyethylene bucket into the mainstream channel. Sediment samples are collected with a Petite ponar grab sampler. The water samples are then transferred to 2 1/2 gal. cubic containers. Three or four sediment grabs are throughly mixed in a clean polyethylene container and transferred to precleaned polyethylene containers. All samples are chilled to 4^{o} C in ice chests for transporting to the laboratory. All toxicity tests are started within 10-14 days after sample collections are completed.

Samples are collected during five time periods, and represent all four seasons of the year. The actual time of sampling has been and will continue to be coordinated with the sampling conducted under the Physical/Chem portion of this study.

i. *Ceriodaphnia* Test:
The source of the *Ceriodaphnia* will be ERL-D lab. cultures of known parentage. The animals will be ≤ 24 hours old when the study is initiated. For the 48-hour acute tests, five individuals are placed into each of two, one-ounce polystyrene cups containing 15 ml of test water. Duplicate cups are used for each ambient sample. Daphnids are fed daily but the test solutions are not renewed during the 48-hour test period. Acute test results are expressed as 48-hour LC50 with a 95 percent confidence interval. For those ambient samples showing acute toxicity, chronic tests are then conducted. For each chronic test with the ambient samples, one animal will be placed into each of ten, one-ounce polystyrene cups containing 15 ml of test water. The same procedure is repeated for a set of ten control replicates containing demineralized water solution (DMW). Daphnids are fed daily, and test solutions changed (renewed) twice during the seven-day test. Survival and production of young during the 7-day period is analyzed for significant differences.

ii. *Selenastrum* Test:
The *Selenastrum* algal assay test is conducted according t Miller et al., 1978. Dilution water will consist of stock culture medium with EDTA. Water samples are filtered through a 0.45u millipore filter and fortified with media mineral salts to a concentration equal to the synthetic dilution water. Each test culture receives a starting inoculum of 10,000 cells per ml. Test containers are placed under continuous illumination at 400 $\pm$ 50 foot c, 24 C, and continuously shaken. Algal growth is determined at the 4- day (96 hour) interval with an electronic particle counter. Results are expressed as percent of control growth (test/control x 100 = % stimulation or inhibition).

iii. Biomarkers:
Chemical-induced immune suppression is a widely-accepted phenomenon for detecting presence of heavy metals and various organic pollutants. A promising biomarker for detecting the presence of xenobiotics is the liver cytochrome P450 assay (Spies et al., 1988). The objective for conducting this biomarker assay is to determine its connection and level-of-agreement with the associated instream toxicity tests and actual pollutant organic and metal tissue concentrations.

Cytochrome P450 concentrations have been determined at 10 sampling sites (5 mainstem and 5 tributaries) representative of bottom and column water feeders. All fish are transported alive to the laboratory at MSU for analysis. Standard centrifugation methods are used to determine liver and microsomal protein contents. Liver microsomal cytochrome P450 concentrations are determined by the difference spectrum of reduced-carbon monoxide spectrum versus oxidized microsomal preparation using the extinction coefficient. Aminopryrine N-demethylase activities are determined and induced by the presence of aryl hydrocarbons. Formaldehyde is also be measured as an end product.

Based on biological/toxicological results found during the first two-years (1989-1991) of the project, additional analyses will be conducted at the mainstem and tributary locations. Toxic sediments have been found at one upper, three lower mainstem and at several reservoir sites. Investigations will begin to determine properties causing the toxicity at these sites. Additional sites will be selected for application of biological procedures. Necessary physical/ chemical and land-use features will need to be first defined by others before enlarging the study area. It is anticipated that most of the biological work during 1991-1993 will be in subwatersheds (i.e. Blue Earth River drainage and other areas) with emphasis directed at refining the physical habitat, algal, and selected biotic methods for application in lower order watersheds. Ultimate goal for the biological/ toxicological studies will be to develop diagnostic procedures that can ascertain a variety of pollutant impacts (i.e. nutrients, pesticides, sediment runoff) in various scale watersheds, and later be useful in defining the "before and after" characteristics when remediation begins.

iv. *Hyalella Azeteca* Test:
Toxicity testing using *Hyalella Azeteca* will be performed at five sites during the summer of 1991. The sites will be chosen based on

either their past toxicity or lack of toxicity. Bulk sediment toxicity tests will be performed by the U.S. EPA ERL-Duluth laboratory using U.S. EPA approved methods.

e. Tissue Residue, Sediment, and Water Chemistry: The objective of this portion of MRAP is to provide chemical data on total and selected polychlorinated biphenyl (PCB) congeners and several heavy metals (Hg, Cd, Cr, and Pb) in fish, macroinvertebrates (three ridge and fingernail clams), suspended sediments and sediments collected from fish/benthos/toxicological sampling sites, and pore water from sediments collected at toxicological sampling sites. These data will be useful in assessing pollution impacts on biota of the Minnesota River and its tributaries, correlations between toxicological data and in-stream toxicant levels, and adequacy of current fish consumption advisory.

i. Fish and Macroinvertebrate Collections: The fish and macroinvertebrates will be collected by groups conducting the biota surveys. Sediment samples will be collected by USGS or benthos group and split between MSU and ERL-D for chemical analysis and toxicity testing. Dan Helwig, MPCA, will set out ten to twelve suspended solid traps at fish/benthos/toxicological sampling sites. Four fish species are to be collected by the MN DNR for analysis:

Walleye/Sauger	15-20 inches
White Bass	10-15 inches
Channel Cat	15-20 inches
Carp	20-25 inches

Ten individuals of each fish species will be collected at 10 sites, 5 sites in the main channel of the Minnesota River and 5 sites in tributaries. Five walleye and five carp will be selected for biochemical toxicological evaluation, and kept alive until delivery to Dr. Mercurio, MSU. The remaining fish will be used for a composite species site sample. The Minnesota River will be sampled at Montevideo, Granite Falls-Morton, Mankato, Jordan and Fort Snelling. He also suggested that three of the five tributaries sampled should include the Le Sueur, Lac Qui Parle and the Yellow Bank Rivers. Two or three composite fish samples from the metro area (Jordan, Fort Snelling) will be analyzed for 10-12 specific PCB congeners.

Dependent on distribution and abundance, three ridge clams will be collected from 10-15 sites. After the clams have been collected and identified per benthos group procedures, they will be transferred to aquaria (one per sampling site) filled with filtered Minnesota River water, taken at Mankato, MN. The clams will be held in these tanks for 24-48 hours to allow for purging of their GI tract. After purging of GI tract, they will be harvested and the soft tissues digested and analyzed for Hg, Cr, Cd, Pb and 10-12 specific PCB congeners. In addition, the fingernail clams used in the instream toxicity studies will also be archived for chemical analyses.

ii. Sediments and Suspended Solids Collections: Sediments will be collected by USGS or the benthos group and split between ERL-D and MSU for toxicity testing and chemical analysis, respectively. Suspended solids samples will be collected from MPCA using suspended solid traps set out 2-4 weeks prior to sample collected. Sufficient sediments (1-2 gallons) should be collected to allow for pore water separation and analysis.

iii. Fish and Macroinvertebrate Tissue:
Benthic samples for mercury will be according to procedures by the U.S. EPA (1980). For fish, procedures intended for use are by the Minnesota Health Chemistry Laboratory. Cadmium, chromium, and lead concentrations will be determined per Minnesota Department of Health (1985) procedures and analyzed with a Perkin-Elmer graphite furnace.

Composite fish samples for total polychlorinated biphenyls (PCBs) will be with Minnesota Department of Health Chemistry Laboratory (1985) procedures. The three ridge and fingernail clams will be analyzed for 10-12 specific PCB congeners (using U.S. EPA (1980), Kuehl et al., 1987, and Swackhamer, 1988 procedures). Final selection of the specific congeners will be made after preliminary analysis and consultation with ERL-D.

iv. Sediments and Suspended Solids:
Sediments and suspended solids will be analyzed for mercury using procedures recommended by the U.S. EPA (1985). Mercury will be determined by Cold Vapor Method. The other metals will be determined using a Perkin-Elmer Plasma 40 ICP or Perkin-Elmer 5100 Atomic Absorption Spectrophotometer using procedures recommended by the U.S. EPA (1980, 1983, 1986). Sediment pore water will be prepared and analyzed by graphite furnace atomic absorption spectrophotometry per Minnesota Department of Health Chemistry Laboratory (1986) a, b, c) procedures. Sediments and suspended solids will be analyzed for the same specific PCB congeners as with the benthic tissues.

Surface Water:
Surface water samples will be collected from the same sites and times that the sediment samples are collected. The water samples will be collected away from shoreline disturbances. Samples will be transferred to 2 ½ gallon cubicontainers and transported in ice chests (< 4^{o} C) back to ERL-D. Samples will be analyzed for mercury, cadmium, chromium and lead using Minnesota Department of Health procedures. Contractor will be American Science International.

v. Other Analytical Procedures:
Performance standards will be purchased/supplied from a reliable vendor and traced to the NBS or EPA. These standard solutions will be used to check instrument performance, reproducibility, and sensitivity on a daily basis.

Calibration standards will be used to generate response factors or standard curves for quantitation. These standards will have the same composition as the performance standard, but may differ in total concentration. Concentrations of the calibration standards will be chosen based on the type of matrix being analyzed and the instrumental method of analysis. Surrogate standards will be used to monitor analytical recoveries. Dependent on analysis, one or more surrogate standards will be added to each sample and blank prior to digestion/extraction. A spiked sample shall be analyzed with every analytical batch or one in every 10 samples, whichever is the greater frequency. Each batch shall be accompanied by a reagent blank. The reagent blank will be carried through the entire analytical procedure. A known replicate will be analyzed with each analytical batch. NBS and/or EPA check samples will be included with each analytical batch (NBS oyster, NBS Buffalo River sediments, etc.).

All data will be stored on work sheets in a notebook per EPA guidelines (4.9). Each sample will have a unique laboratory number. Where possible, data will be organized on a computer information system. Statistical evaluation of data will include precision, accuracy, standard deviation, and analysis of variance. Should statistical comparison of replicates be unsatisfactory, the samples will be re-analyzed.

A 5100 Zeeman Atomic Absorption/Graphite Furnace system will be used to analyze the benthos and pore water samples. A Plasma 40 ICP will be used to analyze metals in the sediments and suspended solids samples. A high resolution gas chromatograph with electron capture detector will be used for PCB analysis.

A performance standard will be run prior to everyday's sample runs to monitor reproducibility, sensitivity, and where applicable, resolution. Changes in reproducibility or lower sensitivity should be addressed by proper instrument maintenance. If any instrument does not meet instrument performance checks, analysis will not proceed until corrections have been made.

Per EPA, quantitation of PCBs will be congener specific and done by the internal standard method. This method eliminates error due to variations in sample injection volume and is independent of final extraction volume. Quantitation of metals will be done by method of standard addition or by measuring absorption/emission intensity versus a standard curve.

The LOD is defined as the signal that is equal to 3 standard deviations of the baseline noise. The LOQ is defined as the signal that is equal to 10 standard deviations of the baseline noise and is determined in the same manner as LOD (4, 6, 9). Data shall be reported as the calculated value if concentrations are greater than or equal to LOQ. Calculated concentrations that are greater than or equal to the LOD but less than the LOQ will be reported with LOQ indicated in parentheses next to it.

f. Overall Assessment and Synthesis:
The project represents a consolidation of several approaches to assist in determining if regulatory directives (water quality standards and use designations) will accomplish intended purposes. Ambient laboratory and the <u>insitu</u> toxicity test results will be compared to the instream biosurvey, physical/chemical profiles, and the tissue residue information. Special efforts are being taken to coordinate the sampling locations and times among the macroinvertebrate, fish, toxicity testing and chemistry participants. The primary purpose for conducting the bioassays is to reveal potential problem areas. Toxicity needs to be correlated with elevated instream toxicant levels and downstream persistence. Since ambient bioassays are laboratory tests and not instream measures, the results can only be considered as surrogates for ecosystem health (the protection of aquatic life). Effectiveness of bioassay results can be shown where changes occur in instream taxa and abundance, water quality, and physical (habitat) measures. Plafkin <u>et al</u>. (1987) has summarized methods to integrate bioassay, biosurvey, water quality, and physical results. Discriminate analytical procedures have recently appeared to be a powerful tool to classify macroinvertebrate occurrence with associated water quality (Omerod and Edwards, 1987), and in

determining discrete physical/chemical (Cushing et al., 1980) and biological assemblages (Corkum, 1989) in both intra and inter river sites. Additional field response profiles can be done using statistical analyses such as Spearman's rank and the Mann-Whitney U-test.

This study is directed at identification and diagnosis of problem areas within the Minnesota watershed. The macroinvertebrate and toxicity test portions of the study will be limited to assessing existing conditions, while the fish investigation will first summarize results with previous river surveys to develop a data base on community characteristics, impacted sites, and water resource goals prior to beginning the field work. A recognition of the problem areas (in terms of water quality/habitat) can further be determined by merging the physical, chemical and biological information together. Past Minnesota River reports will be helpful in defining NPDES permittees, habitat problems, high and low water quality limited reaches, and the control strategies attempted. Concurrent results being gathered by the ongoing land use and physical/chemical studies will also bring the problem areas into clearer focus. Designating units of analysis (subwatersheds) for control allow further definitions of impairments on a more micro scale. Eventually a computerized information system can be attempted to portray subwatershed boundaries by use and impairment. Physical feature maps can be overlaid with dominant chemical factors and biological communities to further assess the relative of point, nonpoint, and inplace pollutant sources. Procedures such as given by Johnston et al. (1988) can be explored to determine descriptors that characterize water quality within the watershed. All of these procedures will define the stressors and impacted reaches to assist in the categorizing of high priority subwatersheds needing additional assessment for nonpollutant controls.

B3. Amount remaining: $ - 0 -

B4. Product Timelines

```
                       July 91    Jan 92     July 92    Jan 93     July 93
--------------------------------------------------------------------------
Detail Design      ****
Fieldwork/Sampling      *************************************
Chemical Analysis        ************************************
Data Synthesis               ***********************************
Final Report                                              ****************
```

B5. Status: The Minnesota River Assessment Project was organized in 1989 to determine the causes of water quality degradation in the Minnesota River. To accomplish this goal, three major subcommittees were formed in 1989; Water Quality (USGS), Biological - Toxicological (U.S. EPA - MDNR), and Land Use (MSU-BWSR). The biological/toxicological assessments were divided into three broad assignments:

Habitat
Chemical/Toxicological - water, sediment, and toxicological
Biological - fish and macroinvertebrate communities

Field work was conducted over a three-year (1989-1992) period. During the first biennium (1989-1991), sampling emphasis was focused on determining existing conditions in the river's mainstem, near the confluence of ten major tributaries, and in developing indices to characterize the river's biological resources. During the second biennium (1991-1993), efforts continued in defining conditions in upper watersheds serving as feeder streams to the major tributaries and to the Minnesota River's mainstem. A summary of the results by investigator are as follows:

Habitat Assessments and Diatom Communities: Habitat evaluations have become a common component for stream characterizations because of their importance as prime determiners of aquatic life quality. Habitat provides the living space for biological communities. Important aquatic habitat features addressed in this study are substrate, channel morphology and stability, and instream cover. An investigation was conducted on the influence of habitat on diatom communities.

Richards et al. 1993 - Habitat and Diatom Communities. Habitat and diatom community structure were evaluated in 16 streams in upper watershed areas of the Minnesota River Basin.

Habitats were found to be of generally poor quality, characterized by unvegetated riparian zones, and stream substrates dominated by fine inorganic particles (< 2 mm. diameter).

The diatom community taxa were found to have good to excellent pollution tolerance ratings. All stream sites showed moderate to severe impairment in terms of predicted species diversity from other midwestern prairie streams. Results indicated that suspended sediments and siltation were the major causes of impairment in the diatom biological community.

Chemical/Toxicological Assessments: Standardized analytical procedures have become widely used for characterizing watersheds. This project represents the application of several approaches (water, sediment, tissue) in describing watershed quality. In addition, ambient bioassay and biomarker (cellular) tests are widely employed to detect the presence of harmful pollutant concentrations. Three standardized laboratory procedures and two cellular techniques were employed in the identification of problem reaches.

Proctor et al. 1993 - Sediment and Settleable Solids. Sediments, settleable solids, and water quality were evaluated at 11 to 23 locations. In addition, heavy metals and PCB congeners were analyzed from clams collected at 8 locations in the river basin. Zinc was the heavy metal found at highest concentrations, but all metals were within an expected normal range for the basin's geology. Total Kjeldahl nitrogen and total phosphorus were appreciably higher than other nutrients associated with settleable solids. Highest levels were found in the reservoirs and in the Yellow Medicine, Redwood and Cottonwood tributaries. Zinc, copper and nickel were the dominant heavy metals found in the clam tissues. Higher chlorinated PCB congeners were also recovered from clam samples. Storm water quality at 8 minor watersheds locations indicated a consistent pattern of elevated total suspended solids and nitrate-nitrite nitrogen, but levels of phosphorus and ammonia were variable.

Arthur et al. - Ambient Toxicity Testing. Toxicity tests were conducted from surface water and sediment pore water samples from 24 locations and from bulk sediments from 5 locations. None of the surface water samples were toxic.

Sediment pore water was toxic to water fleas, Ceriodaphnia, at two mainstem stations (in the metro area of the river's mainstem) and at three reservoir sites. Toxicity to the green algae, Selenastrum, was sometimes present at mainstem locations downstream from Morton and at two reservoir locations. Ammonia nitrogen appeared to be the suspected agent causing the observed toxicity. The mitochondrial test gave inconclusive results. None of the bulk sediment samples yielded toxic responses from the scud, Hyalella.

Scheld et al. - Fish Liver Enzyme Tests. The results of this test were inconclusive.

Biological Assessments: Fish and macroinvertebrate and algal communities are commonly measured in watershed investigations. Their composition is directly influenced by environmental factors such as water and sediment chemistry and habitat conditions. Healthy communities are distinguished by diverse and stable populations. In streams where environmental quality is adversely impacted, pollution-sensitive populations decline and are replaced by more pollution-tolerant forms. By monitoring biological communities, insights are gained as to the extent of watershed impairment.

Zischke et al. - Macroinvertebrate Evaluations. Benthic community status was evaluated at 41 locations: 9 mainstem, 10 individual tributaries, 10 Blue Earth watershed sites, and 12 upper watershed locations. Caddisflies, mayflies and midges were the most common taxa collected. Macroinvertebrate communities were compared to biocriteria developed for the Eastern Cornbelt Plains Ecoregion.

Most locations were severely degraded. Lowest quality ratings were present at the Lac Qui Parle Reservoir, Chippewa River tributary site, Frost and Minneota locations. Some of the tributary (Redwood, LeSueur), Blue Earth (at County Road 13) and minor watershed (Beauford, Camp Pope Creek) site community indices exceeded established macroinvertebrate biocriteria. Most locations were characterized as having macroinvertebrate communities responding to organic enrichment.

Bailey et al. - Fish Community Evaluations. Fish community status was evaluated at 116 sites. Information at 54 of the less impacted locations and historical data were used to develop expected values for an index of biotic integrity (IBI). An IBI score of 30 or higher is recommended as meeting an exceptable level for the Minnesota River Basin fish biocriteria. Individual IBI site scores ranged from 12 to 60, 37 sampled sites did not meet the established biocriteria, with the majority of these locations occurring in smaller streams (< 100 mi^2 drainage areas). Poorer fish quality was especially found in the Blue Earth tributaries. Habitat degradation due to ditching and sedimentation appeared to be the factors impairing the fish communities. Higher fish quality was present near the Minnesota River's mainstem.

Summary of Biological/Toxicological Findings: Comprehensive evaluations, as shown in the Biology/Toxics MRAP reports, supply descriptive information on the integrity of several components in the Minnesota River Basin. The most important stressors affecting the basin's biological integrity were shown to be excessive inputs of sediments and nutrients, and habitat modification due to channelization and reaffirms conclusions by recent studies (King, 1985; Kirsch et al. 1985; Bright et al., 1990) as to continuing dominance and role of these same stressors in degrading the basin. Dominant physical habitat characteristics were a general lack of substrate heterogeneity, high substrate embeddedness by fine particles, and a general absence of vegetative riparian areas. The dominance of more tolerant fish species and a lack in numbers of top carnivore species, together with a scarcity of important insect groups (stoneflies, megalopterans) further revealed an impacted biological community. For most biological sites, calculated fish and macroinvertebrate indices of biotic and community integrity fell below established biocriteria. The lowest biocriteria scores were found in the minor watershed sites. Where toxicity was found, a degraded biological community was also present. Few reference or unimpacted reaches were demonstrable, and where present, were largely limited to river areas upstream from Mankato. Of the evaluated sites, the least impacted biological communities on the river's mainstem, principal tributary, and minor watershed locations were between Courtland and Granite Falls, the Yellow Medicine watershed, and at Camp Pope Creek near Redwood Falls, respectively.

References Cited

Bright, R.C., C. Gateby, D. Olson, E. Plummer. 1990. A Survey of the mussels of the Minnesota River, 1989. July. Bell Museum of Natural History, University of Minnesota, Minneapolis, MN 55455.

King, K. 1985. Longitudinal zonation in the Minnesota River. Water Resources Center, University of Minnesota Graduate School, WRRC Report No. 6, March, St. Paul, MN 55108.

Kirsch, N.A., S.A. Hanson, P.A. Renard and J.W. Enblom. 1985. Biological Survey of the Minnesota River. Minnesota Department of Natural Resources, Special Publication No. 139, March, St. Paul, MN 55148.

Richards, C., Host, G.E. and J.W. Arthur. 1993. Identification of predominant environmental factors structuring stream macroinvertebrate communities within a large agricultural catchment. Freshwater Biology 29: 285-294.

U.S. EPA 1992. Research plan for midwest agrichemical surface/subsurface transport and effects research (MASTER). U.S. EPA Office of Research and Development, Office of Environmental Processes and Effects Research, Washington, D.C. 20460.

The following individuals are acknowledged for their enthusiastic contributions to the project and were active members of the MRAP Biology/Toxics group.

A description of the biology/toxics methods, results obtained and a much more complete discussion of the findings is contained in the individual biological/ toxics investigative reports.

Biological/Toxics Reports

Arthur, J.W., J.A. Thompson, C.T. Walbridge, and H.W. Read. 1993. Ambient Toxicity Assessments in the Minnesota River Basin. U.S. EPA, Environmental Research Laboratory - Duluth, Internal Report. 2737, Duluth, MN 55804.

Bailey, P.A., J.W. Enblom, S.R. Hanson, P.A. Renard, and K.S. Schmidt. 1993. Fish Community Analysis in the Minnesota River Basin. Minnesota Pollution Control Agency, St. Paul, MN 55155.

Proctor, B. 1993. Characterization of Sediments, Settleable Solids and Water Quality of Stormwater Runoff in the Minnesota River Watershed. Water Resources Center, Mankato State University, Mankato, MN 56001.

Richards, C. and F. Kutka. 1993. Diatom Community Structure as an Indicator of Stream Habitat Quality in Headwater Streams of the Minnesota River Watershed. Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811.

Scheld, J., T. Froehlig, C. Chaffee, T. Goldenstein, J. Kassen, J. Ellstrom, A. Schmidt, M.G. Fairchild, M.A. McCormick, S.J. Schmisek, L.S. Childs, B. Arulanandam, E. Mott, D. Stein, T. Kleist, B. Miller, T. Kujawa, T. Marks and S.D. Mercurio. 1993. Assessment of Impact of Organic Pollutants on Fish in the Minnesota River Watershed by Hepatic Aminopyrine N-Demethylase Activity. Water Resources Center, Mankato State University, Mankato, MN 56001.

Zischke, J.A., G. Ericksen, D. Waller, and R. Bellig. 1993. Analysis of Benthic Macroinvertebrate Communities in the Minnesota River Watershed. Department of Biology, St. Olaf College, Northfield, MN 55057.

B6. Benefits:

(a) evaluate the biological communities at the various sampling sites in order to determine the health of the biological communities and possible relationship between that health, quality of the water and the land-use.

(b) assess types and magnitude of selected in-place toxics which exist in the study area.

C. Land Use Evaluation (MSU, BWSR and SCS)

C1. Narrative:

Major U.S. Geological Survey designated hydrologic units for the Minnesota River Basin include major watersheds on the order of the Blue Earth, Cottonwood, and Chippewa Rivers. These major watersheds are represented by the USGS 8-digit hydrologic unit code. This eight digit system has been expanded by adding the CNI numbering system 3-digit code to make an 11-digit code (USGS/CNI unit code). The CNI watersheds have been further subdivided by the Department of Natural Resources numbering system into watersheds averaging 8,000-10,000 acres each. These watersheds are hereinafter referred to as subwatersheds. There are 1,114 of these subwatersheds in the entire Minnesota River Basin.

In order to understand the nature and extent of nonpoint source pollution in the Minnesota River Basin, it is necessary to conduct assessments at the subwatershed level. The Land-Use subcommittee of this project has developed four methods for accomplishing this. The four methods are termed "levels" and are;

Level I - Subwatershed characterization using on a map overlaying technique based on the U.S.EPA ecoregion concept,

Level II - Individual subwatershed assessment using modeling, GIS, Resource Management System (RMS), and Best Management Practices (BMPs),

Level III - Individual subwatershed assessment using intensive field work to identify small point and nonpoint sources of pollution,

Level IV - Individual subwatershed assessment using color-infrared photography remote sensing to identify small point and nonpoint pollutant sources.

These four levels are being worked on independently for the first two years of this project. During the second two years it is the goal of the land-use portion of this study to expand the assessment to develop a technically comprehensive yet economical methodology for broad scale application not only in the Minnesota River Basin but also across the state. This method will have the resolution necessary to pinpoint pollutant sources accurately enough to make specific management recommendation on the subwatershed level. The method may be one of the assessed levels or a hybred of two or more levels. It is also the goal of the land use portion of the study to be able to accurately predict the amount of resources necessary to address nonpoint source pollution control in the Minnesota River Basin.

C2. Procedures:

a. Level I Assessment - The ecoregion concept on which this portion of the study is based is a map overlaying technique which has been used to define ecoregions for the entire country. There are portions of seven ecoregions in the state of Minnesota and portions of three ecoregions in the Minnesota River Basin. The layers which went into the ecoregion development include; soil type, potential natural vegetation, topography, and current land uses. In Minnesota the ecoregion concept was expanded by the following method. Ecoregions were defined along MDNR 1979 minor watershed (subwatershed) boundaries. Land Management Information Center land use, geographic information, and MPCA water quality data were summarized for each ecoregion. Using the ecoregion data summaries, maximum R-square improvement stepwise regression models were developed. Based on these models, ecoregion characteristics were identified that were reasonable predictors of water quality. The predictors of water quality used were: forest and cultivation land uses; silt and sand soil types;

slopes of 3-6 percent; greater than 6 percent slopes; stream orientation; lake orientation; urban land use. This expanded method was then used to characterize the entire state at the subwatershed level, using information currently available at the Land Management Information System (LMIC). This method was used to rank subwatersheds for their potential for nonpoint source pollution susceptibility within ecoregions and on a state wide bases.

Under the direction of professor Henry W. Quade at Mankato State University work is being done to rank all subwatersheds in the Minnesota River Basin one to another for NPS potential, regardless of which ecoregion the subwatershed is in. This methodology is based on the expanded ecoregion assessment mentioned above and on classical stream geomorphology techniques. The goal of this work is to determine if a ranking system can be developed which can accurately predict NPS potential. And then to develop such a system for the Minnesota River Basin.

b. Level II Assessment - This portion of the land-use evaluation is being carried out by the U.S. Department of Agriculture Soil Conservation Service (SCS). This work is being conducted by the SCS Watershed Planning and Evaluation Team led by Nick Pearson. The funding for this portion of the study is directly from the USDA, and totals approximately $650,000. The work carried out under this level is being conducted in the Blue Earth, Le Sueur and Watonwan Rivers. These rivers make up the Blue Earth River watershed which has been shown to be a major contributor of NPS pollution to the Minnesota. Ten subwatersheds (about 100,000 acres total) have been selected for this portion of the study. The selection was done using the expanded ecoregion ranking method discussed above, with an attempt to select watersheds having varying NPS pollutant potentials. These ten subwatersheds are a subset of the 32 subwatersheds being assessed in Level III. The Soil Conservation Service participation will provide resource problem evaluation leadership on agricultural lands from nonpoint source pollution. This portion of the study will assist counties, the state and other federal agencies to identify local NPS water quality problems. The SCS will utilize the Agricultural Nonpoint Source Pollution (AGNPS) model and other models to in this identification process. The AGNPS model was developed by the USDA Agricultural Research Station in Morris, MN under a previous LCMR funded project. The SCS will train local sponsors in how to gather the appropriate data, to run AGNPS, and to interpret the data.

The SCS will identify and analyze Resource Management Systems (RMSs), Best Management Practices (BMPs), and make alternative proposals for solving water quality problems from agricultural lands within each of the subwatersheds. Economic procedures will be used to identify the most economically viable alternatives for water quality protection and enhancement.

The GLEAMS model will be run on alternative BMPs or combinations of BMPs to evaluate their effect on reducing nutrients and chemical pollutants to the ground water. Results of GLEAMS runs will be used by local SCS field offices to determine the best combinations of practices in developing RMSs for individual land users.

Geographical Information Systems (GIS) will be used to analyze the effects of land-use, soils, and topography on water quality.

The ten subwatersheds assessed by this method will have water quality monitoring conducted at their outlets. This monitoring will be event (spring runoff and precipitation) based and will be conducted for at least 4 to 5 events. The parameters to monitored include flow, Total and volatile suspended solids, total and dissolved Phosphorous, chemical oxygen demand, pH, alkalinity, ammonia-Nitrogen, and Nitrate + Nitrite - Nitrogen. This information will serve to calibrate the AGNPS model which is a watershed delivery model that predicts expected NPS loadings for particular storm (event) intensities.

c. Level III Assessment - This method of assessment is an approach which begins at the riparian (stream shore) and leads back to the source of individual point and nonpoint sources of pollution. Information is gathered which will led to a better understanding of how these pollutant sources are impacting the waters of the Minnesota River Basin. The methodology involves three steps.

Step 1 - A working copy of the watershed map is developed. Points of interest such as farmsteads, various types of wells, feedlots, septic tank outlets, tile inlets and outlets, conservation practices, culverts, windbreaks, dumps etc., as well as water bodies, are located on this map.

Step 2 - The stream is walked and notes are taking as accurately as possible to locate all real and potential pollutant sources.

Step 3 - A personal interview is conducted with each land owner/occupier. A questionnaire is filled out and the information added to the map. The questionnaire is appendixed. In addition the MDA's pesticide questionnaire is completed. This method of assessment is being carried out on 32 subwatersheds in the Minnesota River Basin or about 300,000 acres. The work is being performed by Soil and Water Conservation District (SWCD) personnel. The 32 subbasins were chosen in the same fashion that the subwatersheds assessed under level II.

d. Level IV Assessment - This level of assessment will be conducted on the same exact 10 subwatershed as level II which are also a subset of those being analyzed by level III. (Although the same 10 subwatersheds are being analyzed by three different methods the investigators are different. No information transfer or sharing will take place between assessment methods until the study is complete). This assessment involves remote sensing interpretation using color infrared photography. The DNR Remote Sensing Unit - Grand Rapids conducted the flights and photography used in this assessment. The flight coverage was spring (leaf-off) for the following purposes;

i. Assessment of ground surface prior to leaf-out, allowing for the identification of promiscuous dump sites, evaluation of slopes and erosion features, and characterization of the riparian zones.

ii. Evaluation of early enhanced vegetation associated with septic system failure, feedlot drainage, and inlets to lakes and streams.

iii. Identification of drainage patterns including tile lines, tile line outlets, and drainage ditch maintenance is being attempted.

iv. Determine the level to which information gained by Levels I, II, and III above can be obtained by aerial photography interpretation.

The method involves 5x7 prints of 35mm color infrared film (CIR) at a scale of 1:8000. The photographic coverage includes stereoscopic overlays of each successive photograph. An index mosaic for each of the ten subwatersheds will be assembled by piecing together adjoining photographs along the flight lines. Polygon maps will be made by tracing the boundaries of various land use and land cover types onto a sheet of mylar that overlays the index mosaic. The boundaries of additional features related to nonpoint source impacts will be drawn on successive overlay mylar sheets. Ground verification will not be used, however, USGS 7 1/2 minute quadrangles will be used to aid interpretation.

The position of the Public Land Survey section corners will be located onto the polygon map sheet using USGS 7 1/2 minute quadrangles as location guides. These points will serve as a geodetic reference that corresponds to the UTM coordinate system. The digitized format will be obtained from LMIC to insure compatibility. The mylar maps will be mounted onto a Calcomp 9100 digitizing table and the polygon boundaries will be manually digitized and processed by the AutoCAD system. The data will be stored on a Sun 386i computer, with the modeling done by the Arc Info System.

C3. Amount remaining: $ - 0 -

C4. Product Timelines

```
                         July 91    Jan 92     July 92    Jan 93    July 93
Detail Design          ***********
Fieldwork/Sampling               ***************************
Land Use Analysis                         **************************
Data Synthesis                                     ******************
Final Report                                               *****************
```

C5. Status: The Minnesota River Assessment Project was organized in 1989 to determine the causes of water quality degradation in the Minnesota River. To accomplish this goal, three major subcommittees were formed in 1989; Water Quality (USGS), Biological - Toxicological (U.S. EPA - MDNR), and Land Use (MSU-BWSR). The primary objective of the Land Use Subcommittee was to obtain data on land use at the minor watershed level. Four methods were developed and utilized to assess land use in the main watersheds.

- Level I involved an analysis of all minor watersheds using nonpoint source pollution potential modeling.

- Level II involved an intense SCS modeling of ten minor watersheds.

- Level III involved a detailed inventory and a questionnaire conducted by SWCDs in 37 minor watersheds. From this information a database and GIS system have been established at MSU.

- Level IV involved MSU and the DNR conducting aerial photography and interpretations in 10 minor watersheds.

Work on these methods was conducted during the 1989-1991, 1991-1993 bienniums. The information obtained will be used in future modeling by the MPCA and correlated to water quality and biological characteristics. A summary of the Land Use Assessments are as follows:

MRAP: LEVEL I - MSU

The land use component of the Minnesota River Assessment Project concentrated on developing methods for estimating nonpoint source pollution potential from major and minor watersheds within the basin. The Minnesota River Basin has a total of 1,208 minor watersheds in 12 major watersheds. Minor watersheds total 1,113 in Minnesota, 18 in Iowa, and 77 in South Dakota.

The Nonpoint Source Pollution Potential (NPSPP) for each of the 1,113 minor watersheds was calculated by a model developed at the Minnesota Pollution Control Agency. Total minor watersheds, Weighted NPSPP, and Average NPSPP values were used to compare the 12 major watersheds. Cumulative number minor watersheds, cumulative weighted NPSPP, and cumulative average NPSPP were used to show potential effects on the mainstem of the Minnesota River. Results indicate that the Lac Qui Parle River and Hawk Creek - Yellow Medicine River Watersheds have a high vulnerability for nonpoint source pollution based on the parameters used in this model.

Two reports and an electronic data base have been produced for Level I:

1) Nonpoint Source Pollution Potential Model of the Minnesota River Basin Watersheds, MRAP Level I-Land Use by Charles Peterson and Henry Quade, MSU Water Resources Center, June 1993, 104 pp.

2) An atlas of the Nonpoint Source Pollution Potential in the Minnesota River Basin by Charles Peterson, MSU Water Resources Center, June 1991, 29 pp.

3) Watershed diagrams of the 12 major watersheds have been digitized, and are available on floppy disk or in magnetic tape format.

MRAP Level II: USDA-SCS MODELING

The primary potential pollutants that were evaluated included sediment and nutrients (nitrogen and phosphorus). Cropland fields were analyzed using Soil and Water Conservation District inventories and by the use of computer modeling. Present conditions were evaluated and goals for nutrient and soil loses were established for each watershed and field.

Sediment - The majority of the acres in the ten evaluated minor watersheds are estimated to be eroding at 5 tons per acre per year or less. The 5 ton level is what is known as the tolerable level above which crop productivity can be affected. This level does not address other concerns such as water quality or other potential concerns.

Modeling runs predicted that significant reductions in sediment and phosphorus delivery from these minor watersheds may be realized through the application of conservation practices (20% - 45% for sediment yield, and 24% - 76% for phosphorus yield). Model predictions also indicated the potential for reducing nitrogen loses were comparatively lower and in some cases nitrogen yield could have a small increase.

The sediment management best management practices (BMPs) used in the predictive models included practices using residue management ranging from those necessary to achieve "tolerable soil loss" to those leaving up to 40% residue on all crop land. For nutrient management, BMPs recommended by MDA and U of M related to fertilizer rates and timing were used in the modeling.

Within the ten watersheds that were studied, there are not widespread areas that have levels of erosion that exceed soil loss tolerance limits. Priority areas do not appear to be readily apparent. Instead, priority areas may indeed be related to the distance to waterbodies and targeting treatment levels below traditional soil loss tolerance levels. It appears that small amounts of sediment and nutrients lost from cropland when compounded on thousands of acres could indeed cause off-site pollution problems.

Other practices, land uses and landscape features were not included in the modeling evaluation, but need to be considered when planning and implementing a total resource management system.

MRAP Level III: SWCD - METHOD

The SWCD Method of Land Use Assessment has been developed as a means of assessing nonpoint source (NPS) pollution in minor watersheds. The method is intended to provide a comprehensive view of land use and management in a minor watershed and could be adapted to fit a variety of small watersheds. Development of the method included input from Soil and Water Conservation Districts (SWCD), Water Resources Center, Mankato State University (MSU), Minnesota Board of Water and Soil Resources (BWSR), and various other local, state, and federal natural resource management agencies.

During the 1989-1991 biennium, thirty-two minor watersheds were inventoried utilizing the SWCD Method as outlined in the preliminary report titled "MRAP - Land Use Level III SWCD Methodology" (June 1991). Upon completion of the original thirty-two minor watersheds, a method evaluation showed the need for revision of portions of the method. These revisions improved the database handling and greatly increased the ability to develop a meaningful geographic information system (GIS). Five additional minor watersheds were inventoried utilizing the revised SWCD Method.

The SWCD approach begins at the riparian zone (water's edge) and leads back to the sources of pollution. The approach includes six steps:

1. Visual assessment of the waterbody.
2. Landowner interviews
3. Land use map development (aerial photo base and mylar)
4. Data base and query development
5. GIS development
6. Implementation plan development

Conclusions:

The SWCD Method of Land Use Assessment provides a comprehensive view of land use and various management practices that potentially affect water quality. The method has undergone considerable revision from its original format as outlined in our preliminary report prepared in June of 1991. The revised method maintains its original intent but has been revised to allow for better database management and improved GIS capabilities.

The current report identifies the strengths and weaknesses of the method, as well as the inventoried data and procedures for accessing the data. Assessment of this information to identify BMP needs is necessary.

Four reports and an electronic data base have been produced for Level III:

1) SWCD Methodology of Land Use Assessment, Mary Mueller and Gary Wehrenberg, 1993, 128 pp.

2) MRAP - Land Use Level III SWCD Methodology, Mary Mueller, Gary Wehrenberg and Debi Menk, 1991, 65 pp.

3) Database Training Materials for MRAP databases, Julie Doherty, MSU Water Resources Center, June 1993, 270 pp.

4) Database Documentation for Minnesota River Assessment Project (MRAP) Land Use Assessment Questionnaire, MSU Water Resources Center, 380 pp.

MRAP Level IV: AERIAL PHOTOGRAPHY METHOD

The MRAP Land Use Level IV Study uses large scale color infrared (CIR) aerial photography to obtain land cover/land use information which assists in the assessment of point source and nonpoint source pollution impacts within the minor watershed study areas. This methodology uses photo interpretation to identify, classify and delineate landscape features for manual map production of each minor watershed area.

The value of CIR aerial photography in the assessment of landscape features based on the ability of infrared-sensitive film to record gradations of energy not visible to the eye. For example, vegetation grades in color from light pink to dark magenta due to its reflectance of near infrared energy, resulting primarily from the internal structure of plant leaves and non-woody stems. Important components of vegetation assessment affecting color include density of vegetation, species of plant, enhanced growth correlated to available nutrients, and stressed growth due to disease, lack of moisture or excess moisture.

Since water absorbs infrared radiation, waterbodies appear black or blue black on false-color film. The high contrast of black with the surrounding landscape is useful in delineating water. Consequently, waterbodies as well as natural drainage and wet soils and readily identified. The black color of water is modified by the presence of substances such as algae or suspended particles, allowing delineation of impacted areas of lakes and streams.

Level IV land use assessment uses CIR aerial photography flown in the spring to evaluate the ground surface prior to leaf-out allowing the evaluation of slope, drainage and erosional patterns, early enhanced vegetation, and identification of agricultural best management practices. Vegetation, erosion, drainage, and associated land use practices will help to define the integrity of the riparian zones. Identification of land use/land cover, feature distance to water, best management practices, and area and type of buffer zones will allow characterization of probable NPS impacts.

Ten minor watersheds evaluated by this method correspond to the minor watersheds evaluated under Level II.

Aerial photography and interpretation has been completed, mylars developed, and digitization begun. The final report discusses advantages and limitations for this method.

The report for MRAP Level IV is:

1) MRAP - Land Use - Level IV Aerial Photography Methodology, Cis Berg, MSU Water Resources Center, June 1991, 25 pp.

C6. Benefits:
The detailed land use evaluation is vital to the other components of this study and will be invaluable to local resources managers and officials as they strive toward reaching water quality goals.

D. Data Management, Coordination and Modeling Support (MPCA)

D1. Narrative
MRAP has set up a data management subcommittee to insure that data is compatible, accessible, complete and accurate. All water quality data is entered into STORET. All cooperators have access to all data. The principal investigators are conducting their own individual study and will complete a report. A final summarization report will be compiled by the MPCA.

In order to deal with final report preparation, the following steps are being taken:

- As specified in the individual contracts between the MPCA and the various investigators, those investigators will be responsible to prepare individual interim and final reports.

- In the case of the USEPA and the USGS, those final reports will go through internal peer review prior to being submitted to the MPCA. Scheduling has been changed in the work plan to reflect this.

- The MPCA will prepare a final summarization report. Specific components of that report will be prepared throughout the project. The work has been changed to reflect this.

The data collected by this activity that has common value for natural resource planning will be made available for integration into the Minnesota land management information system's geographic and summary data bases according to published data compatibility guidelines. Costs associated with this data delivery will be borne by this activity.

The modeling exercise will be useful in evaluating the existing monitoring network, for guiding the establishment of expanded monitoring within portions of the overall project. Modeling will provide an effective analytical tool for predicting the effectiveness of various mitigative measures to improve water quality.

D2. Procedures.
Data synthesis by the various components will be an ongoing process which begins at the start of the project. The integration and assessment of the data will be done by three main processes which are:

- The running of the Hydrological Simulation Program - Fortran (HFPS), the Water Quality Analysis Simulation Program (WASP), and the Agricultural Nonpoint Source (AGNPS) models.

- By entering all data in the STORET data base so all the data is available for statistical manipulation.

- The Geographic Information System (GIS) activities from the various investigators will be compiled on one central GIS system at LMIC for integration.

It is planned at the present time to choose at least two models, in addition to AGNPS, which will be used to model contaminant fate and transport in surface waters within the Minnesota River Basin. The models chosen for use in this project are supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) which was established to meet the scientific and technical environmental assessment needs of the federal and state agencies. The two models which are currently being looked at for application in this project are:

1. The Hydrological Simulation Program - FORTRAN (HSPF) which is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates runoff models into a basin-scale analysis framework that includes fate and transport in one-dimensional stream channels. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions.

2. The Water Quality Analysis Simulation Program, (WASP4) is a generalized framework for modeling contaminant fate and transport in surface waters. The WASP4 system is based on the flexible compartment modeling approach, and can be applied in one, two, or three dimensions. It is designed to provide the generality and flexibility necessary for analyzing a variety of water quality problems in a diverse set of water bodies.

   Problems which have been studied using the WASP framework include biochemical oxygen demand and dissolved oxygen dynamics, nutrients and eutrophication, bacterial contamination, and organic chemical and heavy metal contamination.

D3. Amount remaining: $ - 0 -

D4. Product Timelines

```
                    July 91     Jan 92    July 92    Jan 93     July 93
Detail Design     ****
Model Selection    **********
Data Synthesis              ****************************************
Final Report                                        *******************
```

D5. Status: Mathematical modeling activities used hydrological, land use, and water quality data collected in the Minnesota River watershed to develop an analytical tool for evaluating the spatial and temporal loadings from nonpoint source pollution and its effect on water quality in the Minnesota River. The objective was to use an existing mathematical modeling framework, structured to efficiently evaluate the cumulative impacts of nonpoint source loadings, pollutant transport from surface runoff through the river system, pollutant interactions, biochemical transformations, and the resultant effect on a river's water quality. Modeling activities were supported by basic meteorological and hydrological data, geographically referenced watershed characteristics, and water quality data collected during the assessment project.

The work program indicated that plans were to evaluate two existing modeling frameworks, HSPF and WASP, for potential use in modeling contaminant fate and transport in surface waters within the basin. The Hydrologic Simulation Program - Fortran (HSPF) was selected for the watershed assessment project. HSPF is a comprehensive program for simulating watershed hydrology and surface water quality that integrates runoff processes with the river dynamics. The program offers flexibility in structuring simulations by involving only those subroutines necessary to address specific objectives or to accommodate existing databases. The Water Quality Analysis Simulation Program (WASP) is a well-documented program for addressing water quality problems in detail for a diverse set of waterbodies. The program does not generate surface runoff analysis as does HSPF so it must be linked with another model to be useful as a general watershed assessment tool. WASP should be considered for future applications in the Minnesota River watershed wherever high resolution analysis of in-stream loading is warranted and where complex physical-chemical interactions occur.

The HSPF model is a continuous simulation program that requires time dependent input data, structured as time series, which cover the periods of interest. For any continuous simulation project, a major work effort is needed to acquire, assemble, and format the required data into proper input structure. The development and use of stand-alone data reformatting programs for this project was essential for efficient application of the model. Future work efforts should be directed at improving automation of input/output capabilities of the HSPF model. For example, a graphics analysis post-processor would greatly enhance the model's utility.

The model simulates stream flow through user-defined reaches that have similar channel geometry and hydraulic characteristics which must be defined and input to the model. These stream characteristics must be generated by an auxiliary program supplied by the user that will calculate stream hydraulics as a function of flow. For this project, the Army Corps of Engineers program HEC-2 was selected because there have been substantial channel and floodplain cross-sectional measurements obtained on much of the Minnesota River mainstem for flood insurance studies which used HEC-2 analyses. Provided that adequate field data are available, HEC-2 is an effective program to develop water surface profiles and channel hydraulic parameters as input for HSPF.

Capabilities to electronically analyze the spatial distribution of natural land characteristics and land management uses are essential to successful application of HSPF in large watersheds. Land characteristics are incorporated into the model using appropriate simulation parameters that affect the quantity and quality of runoff. An efficient geographic information system (GIS) with access to supporting databases is critical. For this project, the Minnesota Land Management Information Center's (MLMIC) EPPL7 program was used successfully to aggregate and evaluate large geographically indexed databases maintained by MLMIC. This project used geographic coverages available from LMIC as spatially registered 100-meter county files which were then aggregated into a project watershed file. The data collection unit for most variables is the 40-acre parcel which produces a spatial representation appropriate to regional studies. For possible future application of HSPF to minor subwatershed analyses, higher resolution, site-specific data would need to be developed. As future improvements in the currency and resolution of the reference databases used in this project become available, their impact on watershed simulation results should be evaluated and incorporated whenever appropriate.

Summary results of final HSPF model application and analyses are not available for this summary document, but will be included in the final technical report.

D6. Benefits

a. Guide the overall project by identifying any gaps in the current monitoring network in regard to site location or parameters monitored.

b. Guide the expansion of the project as identified "hot spots" are assessed.

c. Predict the effect that various land-use mitigative measures will have on water quality.

d. Evaluate the various components of the project and relate them to one another.

e. Insure that the data collected as part of the project will be electronically compatible and easily integrated.

f. Establish criteria (policies) so that data are stored, edited and corrected in a manner which insures quality assurance and quality control.

IV. EVALUATION:

All water quality and biological data collected in connection with this project is being stored in STORET. STORET is a computerized data base system maintained by the U.S. EPA for the storage and retrieval of data relating to the quality of the waterways within and contiguous to the United States. The data from not only this study but also data from previous studies conducted by all STORET users (U.S.EPA, USGS, MPCA and others) will be available for interpretation.

All land-use data collected will be compatible with and available to the Land Management Information Center at State Planning.

The data will be statistically analyzed and evaluated by the MPCA, the USGS, the U.S.EPA and others. The specific methods of analysis will include, the application of statistical regression techniques, and the running of various water quality models which may include the HSPF, WASP, AGNPS, and GLEAMS models.

V. CONTEXT:

A. Up to the start of this study the Minnesota River Basin has been monitored by the MPCA on a routine basis at approximately 12 sites located throughout the basin. The Metropolitan Waste Control Commission (MWCC) has also maintain routine monitoring at selected sites in the Metro. reach of the Mn River. In addition, the USGS has some routine monitoring data at selected sites within the basin. This routine monitoring network does provide some good back ground data. However, historical monitoring was set-up to evaluate point source pollution and to make some general observations on the quality of water in the system. This historic data did not provide detailed information on the sources and nature of the nonpoint source pollution in the system. This study is design to define the sources, nature and extent of nonpoint source pollution in the Minnesota River Basin in a comprehensive fashion.

Several previous studies have been conducted on the Minnesota River Basin. The Steering Committee used some of the recommendations from those studies as a guide when setting-up this study.

B. This project has been designed to answer questions on the sources, nature, and extent of NPS pollution in the Minnesota River Basin. This study will provide the scientific information necessary to SET WATER QUALITY GOALS and DEFINE POLLUTANT REDUCTION NEEDS, for the assessed portions of the Minnesota River Basin. This information can then be used to guide the implementation of "clean-up" efforts necessary to attain the defined goals. The information gained in this study will be incorporated into State and Local Water Plans in addressing the Minnesota River and tributaries.

C. This study represents the final two years of a four year project. The first two years were also funded by the LCMR. The project entitled the Minnesota River Basin Water Quality Monitoring, was funded at the $700,000 level. The FY 90-91 funding required a dollar for dollar match. To date the project has received matching funds totaling about $1,450,000. The project should complete that assessment. An implementation strategy for mitigating nonpoint source in the Minnesota River is currently being developed with separate funding from the U.S. EPA under section 319 of the Clean Water Act.

D. In resource improvement projects, such as this study, there are two basic phases. The first phase is the project development which includes a "diagnostic" or scientific investigation component, which is what the present study represents, and a complementary component of implementation planning. The second phase is the "implementation" phase which is guided by the findings of the "diagnostic" phase.

The work which will be carried out with LCMR funding through the Minnesota River Basin Water Quality Monitoring study, will provide the scientific information necessary to SET WATER QUALITY GOALS and DEFINE POLLUTANT REDUCTION NEEDS, for the assessed portions of the Minnesota River Basin.

This information can than be used to guide the implementation planning component and "clean-up" implementation phase. The implementation planning component is not funded by the LCMR at this time but some work has begun using separate funding as described below.

MINNESOTA RIVER IMPLEMENTATION PLANNING

Minnesota River Implementation Planning (MRIP) is a coordinated implementation planning strategy designed to complement Minnesota River Assessment Project (MRAP) and address the institutional, programmatic, and resource issues, and to facilitate public involvement necessary to accomplish the goal of restoration of the water quality of the Minnesota River.

MRIP coordination is funded through a grant from the U.S. EPA (Clean Water Act Section 319). In its formative stage, current progress consists of a draft work plan identifying goals, objectives, coordinative mechanisms and proposed participation. Initial work plan review is occurring through the 13 agency nonpoint source project coordination team and the MRAP cooperators. MRIP is being designed to be broad based, coordinating federal, state, and local policy makers, as well as planning, education and implementation agencies. In addition, broad citizen representation will be solicited from the Minnesota River Basin including representatives of agriculture, industry, environmental and conservation groups, and community leaders.

The draft work plan emphasizes evaluation of current authority and resources with special emphasis on local water planning and implementation, educational programs, incentives programs, and local controls. The need for further authority, financial and technical assistance will be recommended as necessary.

The final report will be an implementation strategy or "road map" to accomplish the water quality goals as identified by MRAP.

D. LCMR 'Minnesota River Assessment Project'

	FY 90	FY 91
Salaries/Fringe 2FTE	80,000	80,000
Consultant Contracts	241,500	241,500
Travel	6,000	6,000
Supplies and Materials	5,000	5,000
Equipment	16,000	16,000
Communications	1,500	1,500
Totals	350,000	350,000

E. LCMR 'Minnesota River Assessment Project' Proposed budget.

	FY 92	FY 93
Salaries/Fringe 2FTE	83,000	85,000
Consultant Contracts	235,000	222,000
Travel	6,000	6,000
Supplies and Materials	5,000	5,000
Equipment	20,000	5,000
Communications	5,000	5,000
Prof. Tech. Service	2,000	2,000
Printing	4,000	10,000
Totals	362,000	340,000

VI. Qualification:

1. Program Manager:

Wayne Anderson, P.E.
Nonpoint Source Supervisor
Nonpoint Source Section
Water Quality Division
Minnesota Pollution Control Agency

Bachelor of Agricultural Engineering, University of Minnesota - 1973

The program manager has been involved in all aspects of nonpoint source control work in Minnesota since 1984 as supervisor of nonpoint source control in the Water Quality Division. Activities have included assessment, planning, watershed modeling, Best Management Practice development, and watershed implementation. Mr. Anderson's role will be program manager and oversight of overall project.

2. Major Cooperators

A) Greg Payne
Senior Hydrologist
U.S. Geological Survey
St. Paul, Minnesota

B.S. Wildlife Biology and Management, University of Minnesota - 1969

Greg has served with the USGS for seventeen years, and his duties have included; conducting several time-of-travel studies on major river systems, water quality studies of urban lakes and Voyageurs National Park, and flood stage modeling on large rivers. Greg has served as Project Chief on a large sediment runoff study of Garvin Brook, Minnesota, and has experience in statistical analysis of data.

B) Jack Arthur
Aquatic Biologist
U.S. EPA - Research Laboratory - Duluth
Duluth, Minnesota

M.S. Public Health, University of Minnesota, 1964
M.S. Zoology, Washington, 1961
B.S. Biology, Gustavus Adolphus College - 1959

During his 26 years with EPA, Jack has conducted numerous studies. He had a major role in assessing artificial streams at Monticello, Minnesota for the purpose of testing the validity of water quality standards. Jack has conducted studies in various parts of the upper midwest, testing for correlations between sediment toxicity and water column effects. Jack's interests are in developing diagnostic procedures which can be applied to various size watersheds, for the purpose of guiding and assessing mitigation efforts.

C) Henry W. Quade, Ph.D.
Professor, Department of Biology, Mankato State Univ.
Director, Water Resources Center, Mankato State Univ.

Ph.D. University of Indiana - 1973
M.S. University of Minnesota - 1969
B.S. University of Wisconsin - 1962

Professor Quade has a wide range of interests in the areas of natural resources assessment and management. His interests range from limnologic, biologic, hydrogeologic and land-use investigations. He has authored numerous publications and has received more than two dozen grants from local, state and federal sources.

D) Jeff Nielsen
Regional Conservation Supervisor
Board of Water and Soil Resources
New Ulm, Minnesota

B.S. Soil and Water Resources Management, University of Minnesota - 1975

Jeff has served with the BWSR for 12 years. He has extensive knowledge of the soils and water resource needs of the Minnesota River Basin. He has a very good working relationship with the Natural Resource Managers, Soil and Water Conservation District (SWCD) employees and Supervisors, and Farmers in his area.

E) Nick N. Pearson
Water Resources Staff Leader
USDA Soil Conservation Service
St. Paul, Minnesota
B.S. Natural Resources and Soils, University of Wisconsin - Stevens Point - 1968

Started with the USDA SCS in 1968 in Oregon. Has been a soil scientist, and a District Conservationist in two locations. Served as an Assistant Head of Training for the Western United States out of the West National Technical Center. During his career, he has received numerous USDA-SCS performance awards in addition to the USDA Superior Service Award - the highest USDA recognition; Portland Federal Executive Board - Professional Employee of the Year, Mushaw Foundation's - Government Employee of the Year, as well as various other recognitions.

F) Tim Larson
Project Coordinator
Minnesota Pollution Control Agency
St. Paul, Minnesota

B.A. Biology and Chemistry, Mankato State University - 1974
MA. Biology, Mankato State University - 1982

Tim has served with the MPCA for 12 years. He has much experience in point and nonpoint source water pollution control and abatement. Activities at the MPCA have included working with both municipal and industrial point source generators in the areas of permitting and pollution control methodology development. In addition, he has worked in the area of nonpoint source control throughout the development of the state's current program.

VII. Reporting Requirements:
Semiannual status reports will be submitted no later than Jan. 1, 1992, July 1, 1992, Jan. 1, 1993, and a final status report by June 30, 1993.