FINAL REPORT

NOV - 7 2001

1999 Project Abstract
For the Period Ending June 30, 2001

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TITLE: Mesabi Iron Range Water and Mineral Resource Planning Project
PROJECT MANAGER: Ron Dicklich
ORGANIZATION: Range Association of Municipalities and School Districts
ADDRESS: Buhl School Building, Buhl, MN 55713
E-MAIL: rams@uslink.net
FUND: Minnesota Environment and Natural Resources Trust Fund
LEGAL CITATION: ML 1999, Ch. 231, Sec. 16, Subd. 7(k)

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APPROPRIATION AMOUNT: $650,000 ($400,000 DNR, $250,000 MGS)

<u>Overall Project Outcome and Results</u>

The Geological Survey (MGS) obtained 1,350 well records and 13,000 mining borehole records, verified their locations, and entered information into the County Well Index, an electronic database. The data was used to produce a topographic map of the bedrock surface. Bedrock topography and digital surface elevation data were used to determine thickness of overburden. Land surface data from 1899 was captured digitally and used to establish pre-mining drainage, and describe changes to the land surface.

Continuous water level measurements of the Canisteo Pit were recorded and hydraulic characteristics of the surficial overburden determined utilizing 18 wells. Maximum groundwater discharge from the pit is estimated at 0.91 cfs, well below the estimated average input of 5 to 8 cfs, indicating surface water discharge will occur. Models utilizing 83 years of historic climate data revealed the pit will fill and overflow in 4.5 to 8.5 years. Three possible outlet locations and downstream impacts are discussed.

Surface and mineral ownership research was completed for 232 stockpiles within two study areas containing 6,906 acres. Stockpile materials were examined for use by the aggregate and the iron mining industries. An electronic database was created consisting of 34 related tables and forms for browsing information on stockpiles' content, location and ownership.

Project Results Use and Dissemination

Bedrock topography maps were used to support ground water modeling of the Canisteo Pit. Electronic files of the maps are available at ftp://156.98.153.1/pub2/mesabi_w. The maps will be published in the MGS Miscellaneous Map series.

Map plates and a CD-ROM of stockpile data were provided to local units of government, the mining industry, Departments of Revenue and Transportation, Iron Range Resources and Rehabilitation Board, Iron Mining Association of Minnesota, and independent sand and gravel contractors on the Mesabi Iron Range for use in their land and resource use planning.

Hydrological data of the Canisteo Pit was provided to Taconite, Bovey, Coleraine, Grand Rapids, Itasca County officials and the West Range Planning Board. Results will also be provided to the mining industry as a watershed reclamation model. Results will be used in the siting and design of an outlet channel.

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Date of Report: July 1, 2001
LCMR Final Work Program Report
Date of Next Status Report: None
Date of Work Program Approval: June 16, 1999
Project Completion Date: September 30, 2001

I. PROJECT TITLE: Mesabi Iron Range, Water and Mineral Resource Planning

Project Manager: Ron Dicklich
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Total Biennial Project Budget:

$LCMR:	$650,000
- $LCMR Amt. Spent:	638,129
= LCMR Balance:	$ 11,871

A. The Legal Citation: ML 1999, Chap. 231, Sec. 16, Subd. 7(k)
Appropriation Language:(k) $200,000 the first year and $200,000 the second year are from the trust fund to the commissioner of natural resources. $125,000 the first year and $125,000 the second year are from the trust fund to the University of Minnesota to develop and assemble essential data on stockpile composition and ownership, complete hydrogeologic base maps, site and design an overflow outlet, and distribute results to local government and industry. This project is to be coordinated by the

Range Association of Municipalities and Schools. This appropriation is available until June 30, 2002, at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

B. Status of Match Requirement:
A match is not required. However, matching monies or in-kind services valued at $75,000 were provided to the project. Details of the match are contained in Section IV, Result 3.

II. & III. FINAL PROJECT SUMMARY

Overall Project Outcome and Results

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and gravel contractors on the Mesabi Iron Range for use in their land and resource use planning.

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IV. OUTLINE OF PROJECT RESULTS

Result 1 - Bedrock Contour and Glacial Thickness Mapping

LCMR Budget:	$155,000	Match:	$ - 0 -
Balance: (June 30, 2001)	$ - 0 -	Balance:	$ - 0 -

Tasks:

- Field verification, interpretation, and computer entry of water well log data

  Approximately 1,350 water well locations were field verified, and the geologic logs of those wells were interpreted and entered into the County Well Index database. These new logs supplement nearly 3,500 logs already in the system for this area. Geologists interpreted the well logs to determine the depth and elevation of the bedrock surface, and the type of bedrock present. The database is also an important source of information about the character of the overburden. The water wells are particularly important in the areas outside the interest of mining and exploration drilling.

- Development of and quality control checks on bedrock contour maps

  Bedrock elevation data was plotted from the well records, mine borehole records, and previously mapped bedrock outcrops. The data was contoured by hand at 1:24,000 scale and at a 20-foot contour interval. The mine borehole data includes holes drilled after overburden stripping, through waste rock piles, in mine bottoms, and in other situations that do not reflect the position of the pre-mining bedrock surface. These data were identified by the geologists by their incongruity with surrounding data and were not used in constructing the map. Contouring software cannot detect or ignore those inappropriate data. The resulting map reflects the pre-mining bedrock topography. That topography is the same today, except in those areas where bedrock has been mined. In many places, the topography reflects the nature of the underlying bedrock and the faults within it, and it will be useful in increasing the resolution of geologic maps of the area.

- Development of drift thickness maps using bedrock and surface contours

  The overburden thickness map is mathematically derived from the bedrock topography and the current land surface. After the bedrock topography contour lines were digitized, a grid with a cell size of 30 meters was created. Similarly, a digital elevation model of the land surface was obtained and re-sampled to a 30-meter cell size. Subtraction of the bedrock grid from the land surface grid yielded a third grid of values that represent the thickness of the material between the land and bedrock surfaces. That grid was divided into depth intervals of 50 feet and overlain with a township/range grid as a simple base to produce the map presentation. In most of Minnesota the material between the bedrock surface and the land surface is glacial sediment. On the Mesabi Range there are also significant components of mine tailings, stripped overburden, and waste rock distributed in basins and dump piles. These man-made features can be recognized on the overburden thickness map by unnaturally straight and geometric shapes.

- Production of contour maps as ArcView data files

  The bedrock topography, overburden thickness, and data distribution maps have been formatted as ArcView shape file themes. This makes it possible to view the data at a variety of scales (not to exceed 1:24,000) and in a variety of styles (contours, shaded-relief, 3-D, etc.). It is also possible to compare or overlay the data with other georeferenced data sets. The data files are available at the MGS anonymous ftp site ftp://156.98.153.1/pub2/mesabi_w. MGS will also publish these maps as part of the MGS Miscellaneous Map series for distribution.

Result 2 - Mine Borehole Data Compilation and Interpretation

LCMR Budget:	$ 95,000	Match:	$ - 0 -
Balance: (June 30, 2001)	$ - 0 -	Balance:	$ - 0 -

Tasks:

- Collection, evaluation, interpretation and computer entry of borehole data

  Data to support mapping in areas of mining were compiled from the records of boreholes drilled for mineral exploration or mine development. Such records were obtained from mining companies, and from public and private agencies that regulate mining or manage mining properties. Sources of mine borehole data included Minnesota Iron and Steel, Hibbing Taconite, U.S. Steel, National Steel, Eveleth Mines, Great Northern Iron Ore Properties, Meriden Engineering, Cliffs Mining Services, Geomines, Eveleth Fee Office, Minnesota Department of Natural Resources–Waters Division–Grand Rapids Office, Minnesota Department of

Revenue, and Minnesota Department of Natural Resources–Division of Lands and Minerals–Hibbing Office. Approximately 13,000 borehole records were compiled into the County Well Index for this project; they appear on the Database Map. Borehole density is greatest in areas where the Biwabik Iron formation is the first bedrock layer. As a result, the maps typically present a more detailed and accurate representation of that part of the bedrock topographic surface than elsewhere.

Bedrock outcrops in the study area also provided information about bedrock elevation and depth to bedrock. Their locations were taken from mapping by Morey and others (1994a, b), Morey and Cleland (1996a, b), Jirsa and others (1998), Morey (1998a, b, c), and from the original U. S. Geological Survey field maps (Leith, 1903). Some outcrops were also mapped in the field for this project. This is by no means a thorough evaluation of bedrock outcrops on the western Mesabi Iron Range, as this project was not designed to support comprehensive field mapping. It does, however, provide a guide to areas of scattered rock outcrops.

- In addition to the tasks envisioned in the original work plan, MGS also digitized topographic mapping of the land surface of the western Mesabi Range that was created in 1899. The maps were initially used to establish the elevation of boreholes for which no elevation was recorded at the time of drilling. However, the maps also make it possible to establish pre-mining drainage, and the location and magnitude of changes to the land surface over the last century. This topographic data has also been made available as an ArcView theme on the MGS anonymous ftp site. The historical topography and associated cultural features will be compared with equivalent modern data, and the resulting maps will be published in the MGS Miscellaneous Map Series.

- Final Report

The Minnesota Geological Survey has written an explanatory text to accompany the maps and data created for this project titled: <u>Database map, shaded-relief map of bedrock topography, depth to bedrock map, and topographic shaded-relief map including cultural and geologic features derived from mapping by the USGS Survey 1899-1900, Mesabi Iron Range, Western Half</u>. Files of the text and maps can be obtained from the MGS anonymous ftp site at ftp://156.98.153.1/pub2/mesabi_w.

Result 3 - Canisteo Pit Pilot Project

LCMR Budget:	$300,000	Match:	$75,000
Balance: (September 30, 2001)	$ 11,871 (estimate)	Balance:	$ -0-

Budget Notes: The $11,871 balance is an estimate as state accounting reports follow behind expenditures by approximately two weeks. However, the estimate includes all projected expenditures through September 30, 2001, and is believed to be fairly accurate.

The match includes $60,000 in-kind services from the USGS for the development of the ground water model MODFLOW for the Canisteo Pit, $10,000 from the DNR Division of Waters for drilling ground water wells, and $5,000 from the Iron Range Resources Rehabilitation Board for the water quality study of the Canisteo Pit.

Tasks:

- Develop bedrock topography and drift thickness maps of the Canisteo area

Over 600 historic borehole logs were analyzed with respect to drift thickness and bedrock topography. This information was then used to site 16 water table wells in close proximity to the Canisteo Pit. Geologic logs from the16 new ground water wells were used to help interpret the final bedrock contours and glacial thickness maps for the Canisteo Pit area developed by the Minnesota Geological Survey (MGS), a project cooperator. These maps were subsequently used by the U.S. Geological Survey (USGS) for modeling groundwater flow from the pit.

- Install observation wells and begin ground water data collection

Water level measurements in 18 wells around the pit were taken a total of 54 times between June 1999 and July 2001. Even though the average depth to water in the wells varied from 1.8 feet to 70.0 below ground surface and hydraulic characteristics of the overburden varied, well hydrographics were very similar. The information from this monitoring was used by the USGS to develop a water table contour map around the Canisteo Pit.

Aquifer testing of the wells, to determine hydraulic characteristics of the glacial till, consisted of slug and pump tests. Hydraulic characteristics varied widely from 0.011 to 120 $ft \cdot day^{-1}$, typical for glacial till with its mixture of clay and sand lenses. The USGS extrapolated these results to the entire soil system around the pit to model ground water flow out of the pit.

Monitoring of water levels in these wells will continue at least until surface water discharge from the pit occurs. As more data is collected the surface water model (WATBUD) will be modified to include new data. Model results from additional data will be checked against predicted values used for this study.

- Model Canisteo pit watershed for outflow at static water level

A calibrated surface water model (WATBUD) was developed for the Canisteo Pit. This model produced a very good fit to observed water levels. The values in the submodels are realistic for the dynamic hydrologic system that exists in a pit filling with water. Applying the calibrated model from the pit to future conditions was necessary in order to simulate downstream impacts. The method used was to simulate daily discharge from Canisteo Pit through a five foot weir with a crest elevation of 1300 feet msl or 1315 feet msl. Elevation 1300 ft msl was chosen because that is the point at which ground water is predicted to begin outflowing from the pit. Elevation1315 ft msl was selected to represent a future elevation at which the pit water could be stabilized. Other elevations approaching the topographic low point of the pit runout level (1324 ft msl) could also be modeled. However, the volume and timing of outflow, and downstream impacts to receiving waters would remain relatively unchanged. With the pit rising 2.5 to 5 feet per year, an assumed outflow elevation of 1315 ft msl would allow about three years for planning, design, and construction of an outlet channel. Flow from Canisteo Pit averages 5 cfs to 8 cfs but can be as great as 60cfs or higher under individual storm events

An examination of water table measurements from the wells around the pit indicate there are few areas around the pit where ground water could possibly discharge. Well water levels above 1324 feet msl, the topographic low point on the pit rim, will preclude ground water discharge towards those wells. When this information is combined with a knowledge of the hydraulic conductivity of the overburden, potential ground water discharge from the pit is limited to three small zones.

Estimates of ground water discharge using MODFLOW revealed a small amount of discharge from the pit towards Holman Lake beginning when the pit rises above 1302 ft msl. At 1315 ft msl ground water discharge to Holman Lake from the Canisteo Pit would be less than 0.01 cfs. Ground water discharge to Holman would reach 0.025 cfs at 1320 ft msl, the expected maximum pit level should the pit be discharged via this route.

Prairie River is also estimated to receive a minor amount of ground water contribution from the pit. Ground water discharge towards the Prairie River is not expected to commence until the pit reaches an elevation of 1315 ft msl. At 1315 ft msl the discharge is estimated to be 0.11 cfs and at 1320 ft msl 0.20 cfs.

The greatest opportunity for ground water flow is towards Trout Lake. At pit water elevation 1300 ft msl ground water is estimated to begin flowing to Trout Lake at a rate of 0.06 cfs. At 1320 ft msl ground water flow would reach 0.48 cfs.

The total discharge of ground water at pit water elevation 1320 ft msl, along all three ground water discharge routes, would be 0.7 cfs. Although this is a measurable amount, it is small compared to the expected surface water discharge from the pit.

- Model Trout Lake and Holman Lake watersheds with inflow from Canisteo Pit

The Department's WATBUD surface water model was calibrated and used to model impacts on receiving waters downstream from the Canisteo Pit. Three downstream routes were studied: Holman Lake, Trout Lake, and the Prairie River.

Trout Lake
The addition of Canisteo discharge will cause median monthly water levels to rise 0.25 to 0.7 feet above recently recorded levels in Trout Lake. The average rise would be 0.5 feet and can be compared to historic data, which reveals Trout Lake levels may rise higher than one foot. Even though the median monthly water level increase is 0.5 feet, under certain climatic conditions, it is possible lake water levels could exceed these values under extreme precipitation events during excessive wet periods. It is important to note, using the 83 years of climate record, the maximum simulated lake level is projected to be 1290.6 ft msl. Trout Lake has experienced water levels similar to this in 1950 when the lake was recorded to be 1290.01 ft msl on May 15. It is likely the lake has experienced even higher levels that have gone unrecorded. However, constantly maintaining water levels 0.5 feet higher than normal would likely have much greater impacts on shoreline erosion than isolated, extreme events.

It should be noted that it is possible to attenuate water level changes to Trout Lake if lake water could be discharged more efficiently. Trout Creek becomes choked with aquatic vegetation during certain times of the year causing lake levels to rise. Improvements to the efficiency of this channel would include clearing channel vegetation and straightening of the channel in some locations. Another option to consider is the excavation of an overflow channel on the southeast corner of Trout lake directly to Swan River.

Holman Lake
The results of the WATBUD model analysis indicate, on average, the Canisteo Pit will discharge 5.7 cfs to Holman Lake. The average discharge from Holman Lake, using empirical methods, is 2.7 cfs. Adding the two values together (8.4 cfs) and consulting the Holman Lake rating curve, suggests the increase in lake level from the addition of Canisteo Pit water will be approximately 0.6 feet. The ratio between average Canisteo input (5.7cfs) and average Holman Lake discharge (2.7 cfs) is 2.1. If this ratio is assumed across the range of discharges measured for the Holman Lake rating curve (1cfs to 12cfs), Holman Lake can be expected to rise by as little as 0.25 feet during very dry periods and more than 0.65 feet during wet periods.

It appears from these estimates that the addition of Canisteo Pit water to Holman Lake will cause water levels to rise about the same as predicted for Trout Lake. These simplified estimates can be confirmed by modeling only if beaver activity at the inlet and outlet of Holman Lake is continuously controlled. Although there are currently no homes on Holman Lake, shoreline adjustment from wave and ice action, flooding of low areas, and channel scouring are likely consequences of higher lake levels. Near-shore vegetation would be affected, especially trees and other woody species. Aquatic vegetation in shallow water both in the lake and the upstream wetland may also be impacted with higher water levels.

<u>Prairie River</u>
The third potential outlet from Canisteo Pit would be directed out the southwest corner of the pit to Prairie River, which has an average water elevation of 1255 ft msl. Discharge could be accomplished by excavating a one mile channel to the West Hill Pit. However, a great deal of material would have to be excavated since elevations as high as 1350 feet msl would be encountered. Water currently flows from the West Hill Pit to the Lind Pit via a culvert and from the Lind Pit into the Prairie River through another culvert. Both culverts would have to be examined to determine if they can accommodate additional discharge from Canisteo Pit without negative consequences. Other considerations for directing Canisteo water to Prairie River include mineral rights in the West Hill Pit and private property ownership along the proposed route.

The Prairie River could easily accommodate discharge from Canisteo Pit. The watershed at this point on the river is approximately 450 square miles and has an average flow of about 230 cfs. Even during storm flow, the channel capacity of Prairie River would be adequate to accept flow from Canisteo Pit which is expected to be 5 to 8 cfs on average and about 60 cfs maximum.

For any of the three outlet routes a properly sized culvert could be installed at the outlet of the Canisteo Pit that would limit discharge but force the pit to accommodate greater fluctuating water levels. This "bounce" in the pit could limit extreme flows into receiving waters but large fluctuations in pit water level could increase the likelihood of excessive erosion in an already erosion-prone basin. With a 5 foot weir at crest elevation 1315 ft msl, the pit would rise a maximum of 2 feet above the crest. More restricted outlet control structures would force maximum water levels in the pit even higher. Even if a smaller outlet structure was used, the same total amount of water would have to be released from the basin to keep it from continually rising. Therefore, the average downstream impact will remain largely unchanged.

- Assess pit wall stability and make recommendations

A visual analysis of pit walls lead to the development of a map identifying 25 erosion-prone areas around the pit. These were areas of active erosion as well as areas with a high potential for future erosion. Measurements of the 25 erosion-prone areas revealed that unstable pit walls range in height from 23 feet to168 feet with slopes from 26° to 75° from the water surface. Although some of the pit walls have impressive height and slopes it is also evident that pit walls do not have to be particularly tall or steep to be unstable.

It is not uncommon for large boulders and rocks to cascade down to the pit water. Large blocks of soil sloughing off pit walls in one dramatic event are also fairly common. Anyone using the pit should be aware of these potential hazards and exercise caution. Development around the pit should be carried out with an awareness of the 25 identified erosion-prone areas. However, any area meant for development must have site specific data collected and analyzed by professionals to determine its suitability for the proposed activity.

- Survey of Canisteo Pit water quality

Although an assessment of water quality was not an original objective of this study, it became apparent that some water quality information was necessary when addressing the issue of downstream impacts. Therefore, a water quality assessment of Canisteo Pit was included to develop a baseline of information.

Water quality analyses did not indicate any water quality concerns. Results were comparable to those found by Pierce and Tomko (1989) in a survey of 13 mine pit lakes on the Mesabi Iron Range. Canisteo Pit water stratified and was oxygen-rich throughout its profile averaging 9.3 $mg \cdot l^{-1}$ at one meter depth. Chlorophyll a averaged 0.006 $mg \cdot l^{-1}$ and total phosphorous was always below detection limits. In addition, secchi disk readings ranged from 8.5 feet on 19 June 2000 to 34.5 feet on 28 August 2000. These results indicate nutrient poor water of very high quality.

On two occasions, water samples were analyzed for gas range organics (GRO), diesel range organics (DRO), polychlorobiphenyls PCB's, and mercury (Hg). Results from these analyses were only available for one of the sample times at the time of this report. GRO, DRO, and PCB's were all below detection limits at both sample locations in the pit. One sample had a Hg level of 0.71 $ng \cdot l^{-1}$ while the second sample had a level of 1.24 $ng \cdot l^{-1}$. Sorenson, et al. (1990) determined an average of 2.47 $ng \cdot l^{-1}$ and a range of 0.9 to 7 $ng \cdot l^{-1}$ for 77 lakes in northeastern Minnesota. Mercury levels in Canisteo Pit are at the low end of these data but are typical for open water bodies in this area.

- Final report with recommendations

A final report titled The Canisteo Mine Pit Water Balance Study 2001 was prepared by the Department of Natural Resources on this project. The only unresolved problem of note is the staff turnover experienced during the course of this study. Two thirds of the way through the study a project hydrologist resigned to take another professional position with a consulting firm. Then with three months left the replacement hydrologist also resigned to take another position. It appears that staff turnover problem is a result of these being non-permanent, entry level positions. Individuals in these positions are given extensive training and a high level of responsibility. They then become marketable and quickly become good candidates for consulting firms or other agencies.

Result 4 - Stockpile Composition, Ownership, Use.

LCMR Budget:	$100,000	Match:	$ - 0 -
Balance: (June 30,2001)	$ - 0 -	Balance:	$ - 0 -

Tasks:

- Surface and mineral ownership research was completed for 2,839.32 acres in the Virginia study area. A total of 4,067.02 acres were researched in the Calumet study area, with an additional 2,498.99 acres, which were previously researched and checked for ownership changes. Parcels within the study areas which were platted into city lots and blocks were not researched due to their small acreage and complicated ownership. Stockpile ownership was determined for a majority of the stockpiles located within the study areas. However, many stockpiles still have undetermined ownership. This is due to the fact that most of the documents necessary to determine stockpile ownership are not available for public review and the mineral owner of the materials could not be determined. This project made an effort to locate such documentation and to trace the mineral owner of the stockpiled materials.

- A total of 232 stockpiles were inventoried in the two study areas. The stockpile inventory involved gathering information regarding material composition, material classification, sample analysis, and volume estimation. Material was classified into ten material types based upon geology and iron content. The footprint of each stockpile was digitized to capture the location of the stockpile.

- Eighty-two grab samples were collected from stockpiles. The samples were tested for aggregate and iron ore. Aggregate tests included: specific gravity, absorption, soundness, and gradations. The test results were compared to the Minnesota Department of Transportation specifications for general aggregate use. Iron ore testing was comprised of chemical assays of the eight most common oxides.

- A relational database was designed to store the information gathered for this portion of the project. This is the first known attempt to model and develop a database which would accommodate the complexities of stockpiles and ownership on the Mesabi Iron Range. The database consists of 34 related tables and forms for browsing the information.

- Vegetation covers on the stockpiles were determined through aerial photography interpretation and field checked. The current transportation infrastructure, which includes major roads and railroads, and private mining roads and old railroads, was mapped.

- The stockpiles were examined for use in the aggregate industry and the iron mining industry. Generalizations can be made about each material type based upon qualitative and quantitative data. The material type with the highest potential for aggregate use was glacial overburden. Cretaceous ore and natural ore fine tailings have a high potential for iron.

- The method by which the information for this portion of the project was organized and mapped was customized for aggregate and iron ore potential. The methodology used for this project could be expanded to other geographic areas; however, modifications would be needed in the database and in stockpile classification. The information collected represents what was known in the two study areas during the term of this project (1999-2001). Currently, there are no plans to update the database to reflect changes which may occur after June 30, 2001.

- The final products produced were: 1) a report entitled "Stockpile Ownership, Composition and Use," detailing the data collected and the collection methodology; 2) four map plates summarizing surface, mineral, and stockpile ownership; and material type, vegetation and transportation for the two study areas; 3) and a CD-ROM containing the relational database in Microsoft Access, ArcView shape files of stockpiles, vegetation and transportation, metadata, and the final report. Copies of this report and associated products area attached to this final work program.

V. DISSEMINATION

The maps for Results 1 and 2 were delivered to project cooperators to support ground water modeling of the Canisteo Pit area. Electronic files of the maps in pdf and ArcView formats and an explanatory text are available at ftp://156.98.153.1/pub2/mesabi_w. The maps will also be published in the MGS Miscellaneous Map series.
The information from Result 3 will be shared with the cities of Taconite, Bovey, Coleraine, Grand Rapids, Itasca County officials and the West Range Planning Board. These individuals will be most greatly affected by the results of this pilot study. Results

will also be provided to the mining industry as a watershed reclamation model. Copies of the final report on Result 3 will also be made available to any other individuals that request it from the Department or RAMS.

Data from Result 4, in the form of a final report, map plates, and CD-ROM, were provided to local units of government proximate to Virginia and Calumet, Range Association of Municipalities and Schools (RAMS), St. Louis and Itasca counties, the mining industry, Minnesota Department of Revenue, Minnesota Department of Transportation, the Iron Range Resources and Rehabilitation Board (IRRRB), the Iron Mining Association of Minnesota (IMA), and independent sand and gravel contractors on the Mesabi Iron Range. A presentation of the project's results was given on August 21, 2001, to representatives of the mining industry, Minnesota Department of Transportation, local sand and gravel contractors, and other interested clientele. Copies of the report and associated data is available from the Minnesota Department of Natural Resources, Division of Lands and Minerals, or RAMS.

VI. CONTEXT

Over 100 years of mining on the Mesabi Iron Range has resulted in large scale land disruptions. With anticipated expansion of the taconite mines and emerging water management issues associated with past and current mining, there is a growing need for better resource data for planning on the Range. Communities, counties, and industry are in need of several basic data sets to help them in conducting their business over the next several decades. Geologic maps and databases prepared by this project will be valuable tools for government and industry in siting community and industrial expansion and facilitating watershed restoration.

A. Significance:

A growing issue on the Mesabi Iron Range is planning for and ultimately managing large pit-lakes that are being created by open-pit taconite mining.. Some existing pits exceed 5 miles long and a mile or more wide. Future pits may exceed 15 miles long and 2 miles wide. Understanding the water balance of each pit is essential to predicting future water conditions, potential outflow areas, amounts of outflow, channel design, downstream impacts, and enhancing the publics use of these areas after mining ceases. A critical water balance component is the amount of ground water outflow from each pit, which will occur primarily through the glacial drift. The depth to bedrock and the thickness of the glacial drift is the foundation information which must be known before watershed impacts can be quantified and mitigated. Part of this project is a contract with the Minnesota Geological Survey (MGS) to produce a bedrock topographic map and drift thickness map for a portion of the Mesabi Range from about Grand Rapids east to about Mountain Iron. Depending on the extent of problems with data reduction and analysis, mapping may proceed some unspecified distance east of Mountain Iron. Well log and mining company borehole data will be used to produce the maps. MGS previously mapped bedrock topography between Hibbing and Virginia under contract with the Iron Range Resources and Rehabilitation Board (IRRRB). This previous mapping will be refined and brought up to the standards used for this mapping project.

Another part of this project involves studying the hydrology of the Canisteo pit complex near Coleraine and Bovey, which was abandoned in about 1980 and has since been filling with water. Maximum water depth in the pit is about 300 feet, and if the water rises another 30 feet, surface water outflow will occur where there is presently no channel to accept the outflow without doing property damage. If a surface water outflow doesn't occur, ground water outflow would stabilize the water level, still resulting in impacts on downstream lakes. This project would allow collection of hydrogeologic data necessary to quantifying the water balance of the Canisteo pit complex and project the impacts of the outflow on downstream lakes. The results would serve as a land use model for watershed reclamation planning across the Range, helping identify what types of data and information are necessary, how the data is interpreted, and what types of mitigation are feasible. It would also assess the feasibility of stabilizing the vertical, slumping pit walls, which are presently a public safety hazard.

The large volume of stockpiled material on the Mesabi Iron Range has a great potential for recycling. Much of the material can be substituted for aggregate and some contain iron units that may be valuable with new processing techniques coming on line. Sustaining the industry and local communities by re-mining stockpiles will require the development of information on stockpile ownership and composition. Result 4 will establish a pilot area where the stockpiled materials will be analyzed to determine their suitability for construction aggregate. In addition, mineral and surface ownership of the materials will be researched. The result of such a pilot study will allow the more effective management of these stockpiled materials by their owners.

Stockpile ownership and composition data will be helpful for planning and directing the marketing and future recycling of stockpiled materials.

Since fiscal year 1984, the DNR has been conducting mineral ownership title research of lands in high mineral potential areas. In recent years, the DNR's title research has included determining surface, mineral, and stockpile ownership in areas of the Mesabi Range with potential future uses for recreation and direct reduced iron production.

B. Time:

The project as defined by this work program will be completed August 9, 2000. However, Results 1 and 2 are being completed for only the western portion of the Range and will need to be done for the remainder of the Range in the following biennium. Result 4 is for two pilot areas only and may be extended Range-wide in the future.

C. Budget Context:

Funds received for this project are not a part of the DNR base budget. The Department does have a biennial budget initiative it will be submitting to the 1999 Legislature that includes funding for long term management of watershed restoration on the Range based upon data and information developed by this project. Mineral ownership title research work is funded as part of the Minerals Division's budget from the general fund, with about $42,000 expended per year for fiscal years 1994-1998. Range hydrology work is funded as part of the Minerals Division budget from the general fund and through Cooperative Environmental Research Initiatives with approximately $60,000 general fund and $85,500 matching non-state monies for FY 1996-1998. The surface topographic map project being conducted this fiscal year and a prerequisite to completing Results 1 and 2 in this project, will be funded from approximately $170,000 general fund monies and $130,000 non-state monies. The MGS mapped bedrock topography for that portion of the Range from Hibbing to Virginia in 1987 from monies received from IRRRB, and a State Special Appropriation to the University of Minnesota. Since the initiation of this project, the Department has received $10,000 for supplemental well drilling from the Division of Waters and $5,000 for water quality sampling from the Iron Range Resources and Rehabilitation Board (IRRRB).

For 1994-1998:

1. LCMR Budget History:	$ 0
2. Non LCMR Budget History: General Fund	$440,000
3. Matching (taconite industry, USBM, IRRRB, Counties)	$235,000

Budget for Result 1, Bedrock and Drift Thickness Mapping:

Personnel Development of the bedrock topography and drift thickness maps will be labor intensive, with nearly 70% of the budget used for MGS professional salaries and student wages. Geologists and other professionals from the MGS will oversee and manage the technical aspects of this part of the project. Approximately four students will be hired to review, condense, and analyze well log records, and enter the data into a usable computer database. Estimated cost: $106,434

Equipment The primary equipment expenditure will be for computer software and maintenance. Estimated cost: $ 2,500

Other Contracts for test drilling. Estimated cost: $ 31,000

Travel expenses for MGS professionals. Estimated cost: $ 12,000

Office and other miscellaneous supplies and expenses. Estimated cost: $ 3,066

Budget for Result 2, Borehole Database:

Personnel Borehole data from mining companies, MGS archives, and the Minnesota Department of Revenue will be examined and evaluated for useful information for supporting and refining the mapping project in Result 1. Result 2 process will also be labor intensive, with about 86% of the budget used for salaries and wages. Approximately 8-10 local college students will be hired. Estimated cost: $ 82,879

Equipment The primary equipment expenditure will be for portable computers, software, and computer maintenance. Estimated cost: $ 6,000

Other Travel expenses for MGS professionals. Estimated cost: $ 4,900

Office and other miscellaneous supplies and expenses. Estimated cost: $ 1,221

Budget for Result 3, Canisteo Pilot Project:

Personnel The project will be managed by existing DNR Waters and Minerals staff, without charge to LCMR funds. Approximately 60% of the LCMR budget will be used to pay salaries for two field hydrologists. A ground water hydrologist will be responsible for quantifying and modeling the ground water components of the water balances of the Canisteo pit and the two downstream lakes, which could potentially receive outflow from the Canisteo pit. A surface water hydrologist will be responsible for quantifying and modeling the surface water components of the same water bodies. Both hydrologists will closely coordinate their efforts with technical peers from DNR Waters St. Paul office, other agencies, and interested local citizen and government groups. A technical report will be prepared at the end of the study, which will include an estimate of where the water will stabilize in the Canisteo pit, how much ground water and surface water outflow will be expected, what effect the outflow will have on downstream water resources, and what mitigation options should be considered. The study will also include an evaluation of how to stabilize the slumping, unsafe pit walls in the Canisteo.

Due to a continued delay in the completion of the ground water model by the USGS, the department will need to extend two hydrologist for three months each to complete the study findings and prepare the final report. Salary costs will be covered by salary savings generated throughout the year by cost-coding against non-LCMR projects (see amendment to program dated May 25, 2000) and from $15,000.00 withheld from the USGS contract due to their lengthy delay in product delivery.

Estimated cost: $212,500

Equipment Computer, capable of running appropriate water balance models and linking to field equipment for downloading data.

Estimated cost: $ 4,000

Field equipment, including stream gages, staff gages, precipitation gages, water level recorders, etc. Estimated cost: $ 4,500

Other Contracts for professional services, including evaluation of applicable water balance models and construction of several observation wells.

Estimated cost: $ 65,000

Supplies, including computer software, batteries, printing, and general office. Estimated cost: $ 1,500

Travel, including auto mileage. Estimated cost: $ 6,000

Other direct operating costs, including office rental, utilities, fax and copying machine, clerical support, etc. Estimated cost: $ 6,500

Budget For Result 4: Stockpile Composition, Ownership, Use

Personnel Salary/fringe for a full-time Project Analyst will be hired to conduct field sampling, coordinate materials testing, draft final report. A mining-aide will be hired to assist with field work. Estimated cost: $ 47,500

Equipment Purchase of sample bags and buckets, and auger.

Estimated cost: $ 2,000

Office Supplies/Printer Supplies/Photocopies: (pens, paper, printer cartridges, printer paper, diskettes, photocopies).
Estimated cost: $ 1,500

Other Materials testing, which may include screen classification, gradation, strength, and freeze/thaw. Estimated cost: $ 18,000

Contract for Test Drilling Estimated cost: $ 21,000

In-State Travel Expenses related to project activities.
Estimated cost: $ 7,000

Printing the final report on stockpile ownership, composition and use.
Estimated cost: $ 2,000

Distribution of final report on stockpile ownership, composition and use to interested parties. Estimated cost: $ 1,000

VII. COOPERATION

In addition to the individuals listed above, this project involves the cooperation of the following, who will provide assistance in the form of staff time, or other in-kind participation:

Minnesota Department of Natural Resources
Division of Minerals - Bill Brice, Director
Division of Waters - Kent Lokkesmoe, Director

Iron Mining Association of Minnesota
Ann Glumac, Executive Director

Iron Range Resources and Rehabilitation Board
Brian Hiti, Administrative Manager

National Steel Pellet Company
Jerry Drong

Minnesota Department of Revenue
Tom Schmucker, Administrative Engineer

United States Steel, Minntac
James Swearingen, General Manager

Itasca County
Leo Trunt, Commissioner

St. Louis County
Elizabeth Prebich, Commissioner

The Minnesota Department of Natural Resources, Division Minerals staff will be carrying out the activities associated with stockpile ownership, composition and use.

VIII. LOCATION

Result 1 & 2	Grand Rapids to Mountain Iron along the Mesabi Iron Range in Itasca and St. Louis counties
Result 3	Itasca County near Coleraine, Bovey and Taconite
Result 4	Itasca County near Calumet and Marble St. Louis County near Virginia

IX. PERIODIC WORK PROGRAM PROGRESS REPORTS WILL BE SUBMITTED NOT LATER THAN: March 2000, and December 2000.

A FINAL WORK PROGRAM REPORT AND ASSOCIATED PRODUCTS WILL BE SUBMITTED September 30, 2001.

Attachment A: Deliverable Products and Related Budget					
LCMR Project Biennial Budget	Objective/Result				
	Result 1	Result 2	Result 3	Result 4	Row Total
Budget Item	Maps, GIS layers of bedrock topog and drift thickness	Compilation of mine borehole database	Canisteo Pilot Project	Stockpile Pilot Project	
Project analyst	-	-	-	47,500	47,500
Ground Water Hydrologist	-	-	91,000	-	91,000
Surface Water Hydrologist	-	-	121,500	-	121,500
Dale Setterholm, geologist*	7,454	-	-	-	7,454
Bruce Bloomgren, geologist*	31,128	-	-	-	31,128
Val Chandler, geophysicist*	18,693	-	-	-	18,693
Emily Bauer, geologist*	3,344	-	-	-	3,344
G. B. Morey, geologist*	-	6,408	-	-	6,408
Mark Jirsa, geologist*	5,018	25,090	-	-	30,108
Robert Tipping, hydrogeologist*	6,000	6,000	-	-	12,000
Joyce Meints, GIS specialist*	10,330	5,165	-	-	15,495
Lynn Swanson, map editor*	3,090	1,030	-	-	4,120
Phillip Heywood, cartographer*	2,674	1,783	-	-	4,457
Undergraduate student (new hires)	18,703	37,403	-	-	56,106
Space rental, maintenance, utilities	-	-	6,500	-	6,500
Printing and advertising	-	-	500	2,000	2,500
Communications, telephone, mail	200	100		1,000	1,300
Contracts, professional/technical	-	-	45,000	21,000	66,000
Test drilling	31,000	-	-	-	31,000
Other (observation wells, piezometers)	-	-	20,000	-	20,000

* Minnesota Geological Survey Employee/University of Minnesota

Materials testing	-	-	-	18,000	18,000
Local automobile mileage paid	3,000	2,000	3,000	-	8,000
Other travel expenses in MN			3,000	7,000	10,000
Vehicle rental, U of M motor pool	4,000	-	-	-	4,000
Lodging, meals on Iron Range	5,000	2,900	-	-	7,900
Travel outside Minnesota	-	-	-	-	-
Office supplies	316	121	500	1,500	2,437
Other supplies	-	-	500	-	500
Base maps	1,000	500	-	-	1,500
Ink cartridges, paper for plotter	800	500	-	-	1,300
Scanning services	750	-	-	-	750
Tools and equipment	-	-	4,500	2,000	6,500
Office equipment and computers	-	-	4,000	-	4,000
Portable computers, scanners	-	5,000	-	-	5,000
Computer maintenance	1,000	500	-	-	1,500
Software	1,500	500	-	-	2,000
Other capital equipment	-	-	-	-	-
Other direct operating costs	-	-	-	-	-
Land acquisition	-	-	-	-	-
Lands rights acquisition	-	-	-	-	-
Buildings and other land improvement	-	-	-	-	-
Legal fees	-	-	-	-	-
COLUMN TOTAL	$155,000	$95,000	$300,000	$100,000	$650,000