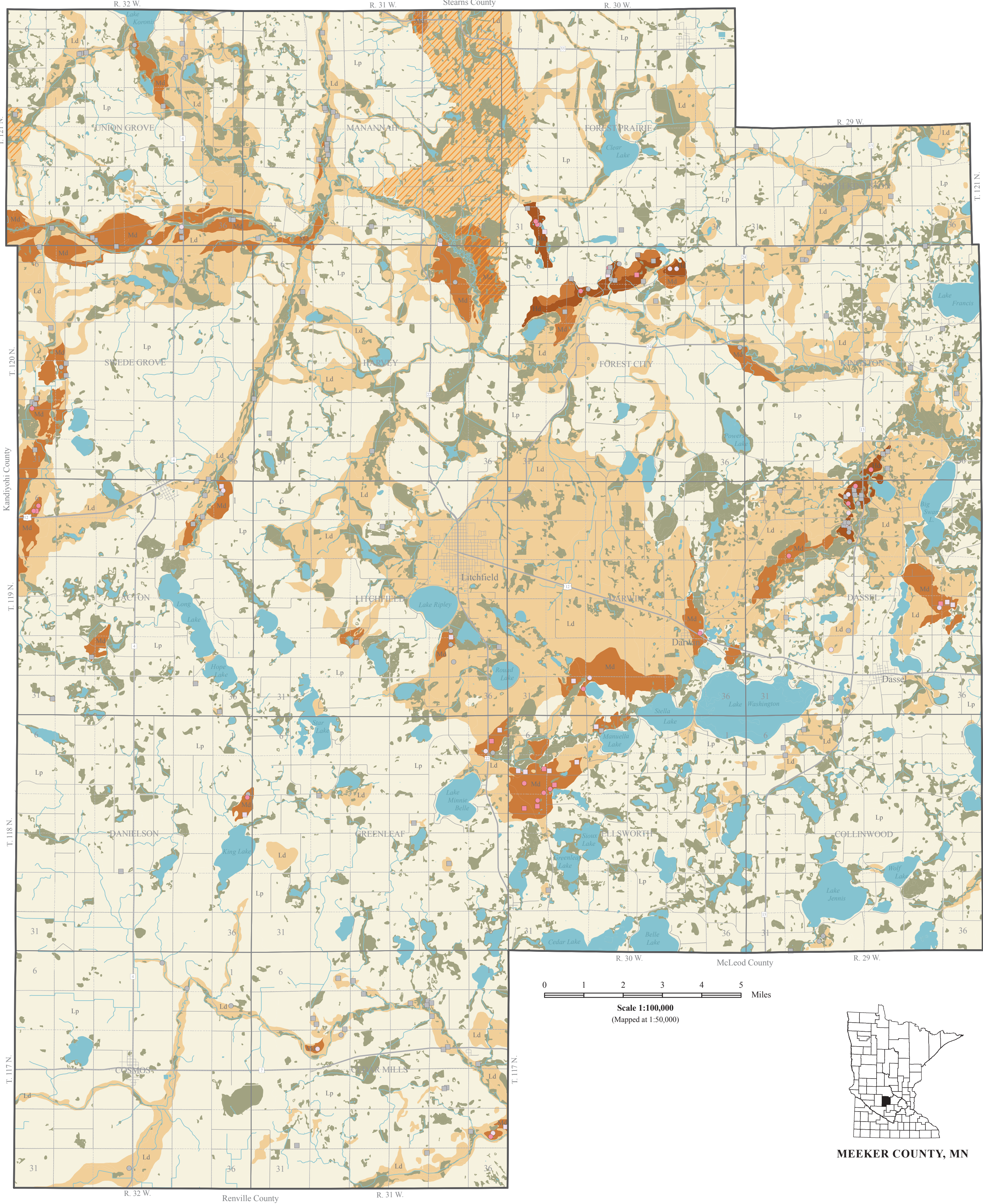


AGGREGATE RESOURCES MEEKER COUNTY, MINNESOTA

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The purpose of this project is to identify and classify potential construction aggregate resources (sand, gravel, and crushed stone) in Meeker County, Minnesota. Having locally available, low cost construction aggregates is fundamental to building and maintaining public infrastructure and private sector development. Therefore, this information is intended to assist local planners and others in making comprehensive land-use and zoning decisions regarding aggregate resources, introducing aggregate resource protection, spreading the burden of development, and promoting orderly and environmentally sound development of the resource. To accomplish these goals, two map plates and a comprehensive data set on CD-ROM were created. Plate A shows a detailed breakdown of all identified and potential aggregate resource deposits. Plate B shows geomorphology and includes a description of the methodologies used for mapping. The maps and digital data are designed to provide information to support land use decisions, such as zoning ordinances, permitting decisions, and protection of aggregate resources.

There are several factors related to aggregate resources that affect their availability, usability, and supply. These factors include the transportation costs, the quality of the material, and land-use conflicts. Aggregate materials are high bulk, low-value commodities, which means transportation costs can account for a considerable amount of the delivered price. Having a local supply of aggregate means lower costs for public and private projects. Aggregate products, such as concrete and asphalt, have specific

quality requirements depending on the end use. Therefore aggregate deposits must be evaluated in relation to quality standards. At the same time, land-use conflicts between aggregate mining and urban developments are becoming more common. Land-use conflicts can be caused by cities expanding into adjacent rural areas, aggregate resource deposits being covered by new developments, or new development occurring adjacent to aggregate resources. As a result, the distance from the aggregate source to its consumers is increasing. Due to the increased use of aggregate material in and around urban areas, aggregate resources are being depleted rapidly.

With these and other issues in mind, the 1984 Minnesota Legislature passed a law (Minn. Stat. Sec. 84.94, Aggregate Planning and Protection) that directs the Minnesota Department of Natural Resources, in cooperation with the Minnesota Geological Survey and the Minnesota Department of Transportation, to identify and classify potential aggregate resources where urbanization or other factors are resulting, or may result in a loss of aggregate resources. When the mapping is completed, the information is provided to local governments and the public. Since this is a reconnaissance-level survey of aggregate resources, site-specific evaluations are still necessary prior to any development of the resource, especially in regards to aggregate quality or environmental review. Factors such as ownership, zoning, protected waters and wetlands, environmental permitting, and other individual site characteristics are not part of the geological resource data summarized here.

AGGREGATE POTENTIAL: For the purpose of this study, aggregate potential is defined as an assessment of the relative probability that an aggregate deposit exists within a given area, with almost all emphasis placed upon geologic evidence, parameters, and interpretation at the reconnaissance level, rather than upon economic feasibility evaluation or other related parameters. This assessment does not imply that economic aggregate deposits exist everywhere within a given map unit designated as "Potential Sand and Gravel Resources." Rather, that within such a map unit, geologic processes were active that could have created aggregate deposits at specific sites. Geologic measurements of aggregate deposits remain constant, but economic criteria and environmental permitting vary across time and place. Important site-specific factors such as ownership, zoning, protected waters and wetlands, environmental permitting, distance to markets, royalties, and individual site characteristics, such as access, all contribute to the final "potential" of a specific parcel; however, these factors were not considered in this study.

POTENTIAL SAND AND GRAVEL RESOURCES: Geologic units that are inferred to contain sand and gravel. These units exhibit the geologic characteristics that typically produce sand and gravel deposits. Existing gravel pit and MN/DOT aggregate sources lying within these units indicate identified or known resources. The geologic units having potential for sand and gravel include alluvial features (flood plains, terraces, and fans), glacial outwash features (channels and terraces), and ice-contact features (eskers and kames). These units typically contain sorted sand and gravel with little silt or clay. For a further discussion of these mapping units, refer to the Classification Methodology of Aggregate Resources section of this plate.

HIGHLY DESIRABLE SAND AND GRAVEL DEPOSITS: Glaciofluvial and ice contact features such as outwash channels and collapsed outwash ridges. These deposits are very large in areal extent. These deposits consist of sand and gravel with thicknesses typically ranging from 15 to 75+ feet with less than 15 feet of overburden. The probability that a potential sand and gravel deposit exists within this unit is high to very high. The textural characteristics of these deposits are classified as good to very good. The quality is typically moderately high to very high relative to all deposits within Meeker County.

MODERATELY DESIRABLE SAND AND GRAVEL DEPOSITS: Glaciofluvial features, such as outwash channels, terraces and plains; ice-contact features, such as eskers and kames. These deposits are moderately small to large in areal extent with sand and gravel thicknesses typically ranging from 10 to 50+ feet with less than 20 feet of overburden. The probability that a potential sand and gravel deposit exists within this unit is moderately high to very high. The textural characteristics of these deposits are moderate to very good with the quality ranging from moderate to high.

LESS DESIRABLE SAND AND GRAVEL DEPOSITS: Glaciofluvial features, such as outwash channels and terraces; ice-contact features, such as eskers and kames; deltas deposited in ponded water; and alluvial features such as flood plains and terraces. These deposits are very moderately small to very large in areal extent and consist of sand and fine gravel with thicknesses ranging from 0 to 40+ feet, with overburden thicknesses between 0 to 50+ feet. The probability that a potential sand and gravel deposit exists within this unit is moderate to very high. The textural characteristics of these deposits are moderately poor to good, with the quality ranging from moderately low to moderately high.

OTHER FEATURES:

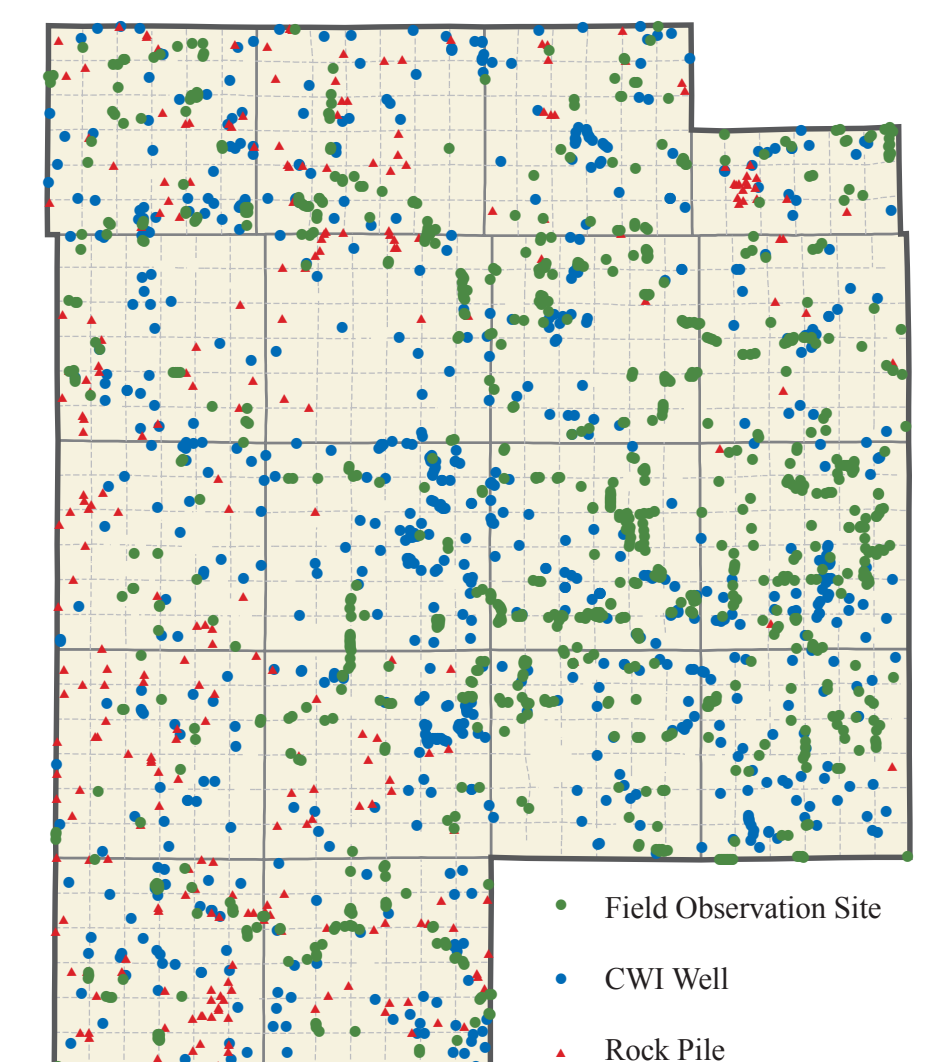
- WETLANDS:** Wetland area
- WATER:** Lakes or rivers

Significant Aggregate Resource Deposits*



*Significant Aggregate Resource Deposits are defined as those deposits most likely to be explored and evaluated for future commercial use. They include moderately and highly desirable sand and gravel.

Field Observations, County Well Index, and Rock Piles



The field observation sites were logged during the field seasons in the fall of 2003 and spring of 2004. Field work consisted of driving every accessible road in the county looking for outcrops and exposures of geological sediments, as well as drilling test holes in roadside ditches. Sediments exposed in road cuts, stream exposures, excavations such as basements, judicial ditches, construction projects, trenches (cable, pipe, tiling), and even animal holes offered several places where the surficial materials, glacial stratigraphy, and bedrock formations were observed. A total of 885 observation sites were logged in the county. The County Well Index (CWI) is an online database maintained by the Minnesota Geological Survey that contains over 300,000 wells drilled throughout Minnesota. As of 2003, when the CWI data were obtained, approximately 731 of these wells are located in Meeker County. Most of the wells (695) contained geological descriptions that were found to be useful for this study. The rock pile sites were observed and recorded during field work. The sites consist of rocks that were placed into significant piles and could be considered a resource, such as for rip-rap or to be crushed for a class 5 product.

TABLE 1: CLASSIFICATION OF SAND AND GRAVEL POTENTIAL

Characteristics	Desirability Rating			
	Highly	Moderately	Less	Limited
Surficial Geology Features	Glaciofluvial outwash channels and terraces	Outwash channels and terraces; eskers and fans; alluvial terraces, fans, bars, floodplains	Outwash channels and terraces; eskers and fans; alluvial terraces, fans, bars, floodplains	Moraines, collapsed channels; glacial lake beds; colluvial slopes; small alluvial features
Sediment Description	Sand and gravel	Sand and gravel	Sand with occasional sand and gravel	Clay/silt/sand with occasional sand and gravel
Probability	High to very high	Moderately high to very high	Moderate to very high	Very low to moderate
Sand and Gravel Thickness (in feet)	15-75+	10-50+	0-40+	0-20+
Overburden Thickness (in feet)	0-5	0-10	0-50+	0-100+
Sand and Gravel Deposit Size (areal extent)	Large to very large (40-50+ acres)	Moderately small to large (10-50+ acres)	Moderately small to very large (10-50+ acres)	Very small to moderately small (0-10 acres)
Sand and Gravel Textural Characteristics	Good to very good	Moderate to very good	Moderately poor to good	Poor to moderately poor
Sand and Gravel Quality	Moderately high to very high	Moderately high	Moderately low to high	Low to moderate

CLASSIFICATION METHODOLOGY FOR AGGREGATE RESOURCES

The aggregate resources of Meeker County were divided into four categories: 1) highly desirable sand and gravel deposits, 2) moderately desirable sand and gravel deposits, 3) less desirable sand and gravel deposits, and 4) limited potential for aggregate deposits.

The sand and gravel resources were divided into these categories based on the host geological feature, probability (certainty) that sand and gravel exists within a unit, sand and gravel thickness, overburden thickness, deposit size (areal extent), textural characteristics (sieve analysis), quality (soundness and durability) of the material, and the sediment description as observed in the field (Table 1). For example, a flood plain deposit typically hosts sand and gravel, thus the feature may have potential. If the deposit has a very high probability. If that deposit is 30 feet thick with 2 feet of overburden and covers 40 acres in areal extent, the aggregate thickness, overburden thickness, and deposit size are all in the high to very high category. If the texture indicates a high percentage of gravel and the quality meets MN/DOT specifications, then this flood plain deposit is categorized as a highly desirable sand and gravel deposit. Even if a deposit has good geological characteristics for sand and gravel, one economic factor, such as haul distance costs, could make a deposit less economically desirable, but economic factors were not considered in this study. Bedrock resources were not evaluated in this inventory because the overburden thickness is greater than 80 feet.

The areas identified as limited aggregate potential did not meet the above-mentioned criteria for either sand and gravel or crushed stone. The deposits may have been too small in areal extent, not thick enough, have too much overburden, may not have met the quality specifications, or contained material too fine in size.

Along with aggregate potential, all known identified sources of aggregate were mapped. This includes gravel pits ranging in size from less than an acre to more than 50 acres. These gravel pits may be active, inactive, depleted, or reclaimed, but represent an area where aggregate is or has been mined.

AGGREGATE RESOURCES:
 Aerial photograph interpretation, field work, and delineation of mapping units by Heather Anderson, 2003-2005. County Aggregate Mapping Program, Division of Lands and Minerals, Minnesota Department of Natural Resources. Source information included aerial photographs from NAPP (National Aerial Photograph Program), 1991-1992, 9" x 9" color infrared photos at 1:40,000, DQOs (Digital Orthophoto Quadrangles) at 1:12,000 from USGS (United States Geological Survey), DRGs (Digital Raster Graphics) at 1:24,000 from USGS, 7.5-minute USGS topographic quadrangles at 1:24,000 (dating from 1963-1993), the Soil Survey of Meeker County, 1989 (ground conditions from 1983), from the USDA-NRCS (United States Department of Agriculture - Natural Resources Conservation Service) and CWI (County Well Index) database from the Minnesota Geological Survey, downloaded in 2001.

BASE MAP DATA SOURCES:
 Lakes, wetlands and rivers from National Wetland Inventory, U.S. Fish and Wildlife Service, compiled at 1:24,000 from aerial photography (1979-1988) and spot field checked. Public Land Survey - PLS Project, 2001. Minnesota Department of Natural Resources, Division of Lands and Minerals. Roads from MN/DOT Basemap 2001 - Roads, Minnesota Department of Transportation, BaseMap Development Group, Surveying and Mapping Section. Civil Townships and Municipal Boundaries from MN/DOT Basemap 2001 - Civiltwp and Mun, Minnesota Department of Transportation, BaseMap Development Group, Surveying and Mapping Section.

MAPPING ASSISTANCE SOURCES:
 Cartography by Kevin Hanson, Renee Johnson, and Heather Arends. GIS database design and data processing by Renee Johnson. Database assistance by Kristen Lee. Field and drilling assistance by Rocco Kihlstrom, Doug Kosman and Pat Genselman.