UNIVERSITY OF MINNESOTA

MINNESOTA GEOLOGICAL SURVEY
D.L. Southwick, Director

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Miscellaneous Map Series
MAP M-116
Plate 2— Aggregate Endowment

AGGREGATE ENDOWMENT

by
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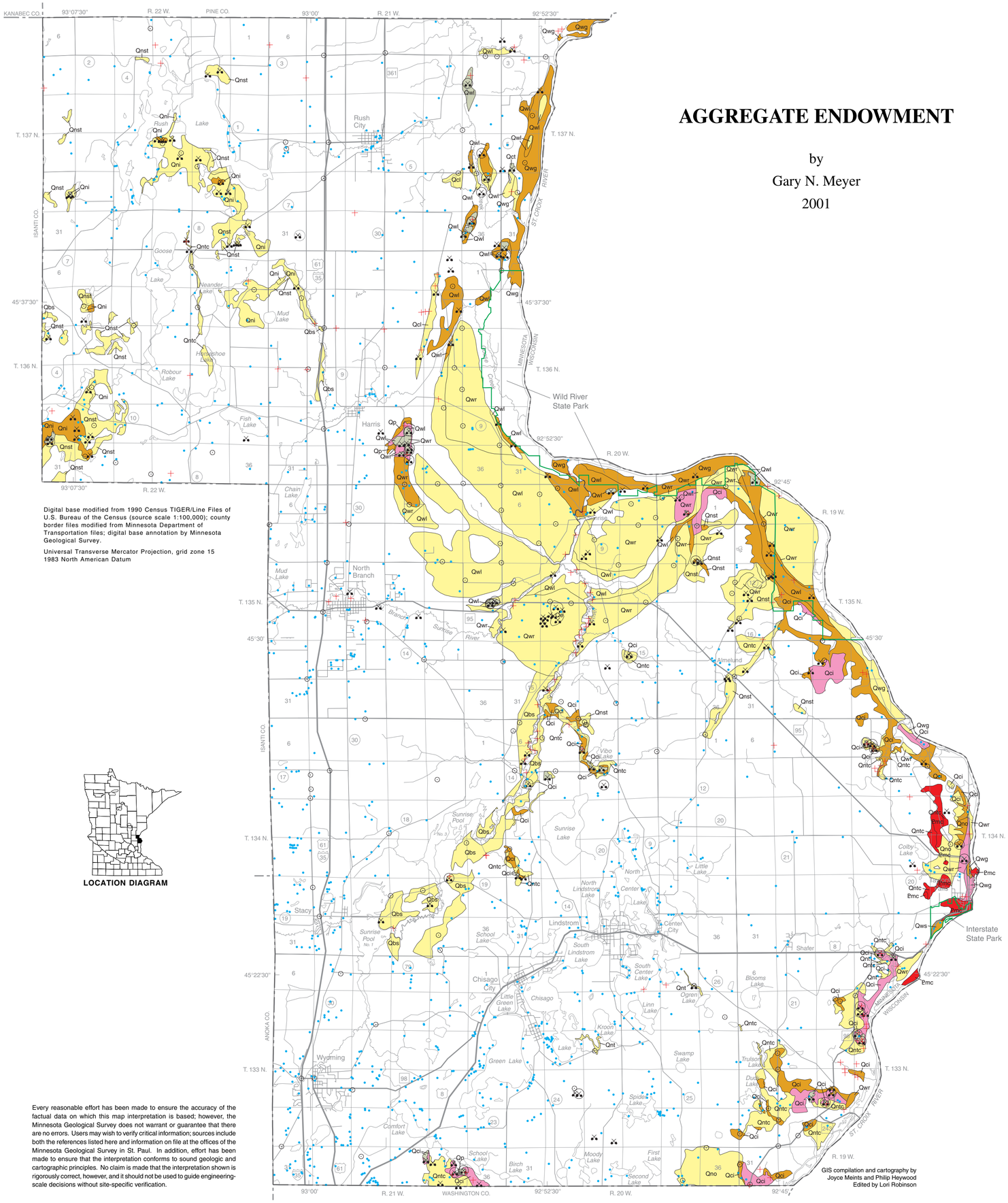
2001



Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale 1:100,000); county border files modified from Minnesota Department of Transportation files; digital base annotation by Minnesota Geological Survey.

Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

LOCATION DIAGRAM

SCALE 1:100 000

1 0 1 2 3 4 5 MILES

1 0 1 2 3 4 5 6 7 8 KILOMETERS

(Aggregate resource mapping units were delineated at 1:50,000)

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Edited by Lori Robinson

Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.

AGGREGATE ENDOWMENT—For the purpose of this study, aggregate endowment refers to geologic map units within which there is a reasonable probability of discovering and developing economically viable aggregate deposits. The endowment of sand and gravel is subdivided into three categories of relative deposit potential, based on the geological attributes and physical properties of the mapped materials. Similarly, the endowment for crushed stone is mapped on geologic criteria.

The judgment of potential deposit quality is based predominantly on reconnaissance-level geologic evidence and interpretations. This study does not identify specific aggregate resources, which are defined in part on economic and social criteria. Furthermore, this assessment does not imply that economic aggregate deposits exist everywhere within a given map unit; rather, within each map unit geologic processes were active that could have created aggregate deposits at specific sites. Geologic endowment, though imprecisely measured, is fixed, whereas economic criteria and environmental regulations vary across time and place. Important site-specific factors such as ownership, zoning, protected waters and wetlands designations, environmental impact, required permits, distance to markets, royalties, and site access, all contribute to the final "potential" of a specific parcel; however, these factors were outside the scope of this study.

POTENTIAL SAND AND GRAVEL SOURCES—These units exhibit the geologic characteristics that typically produce sand and gravel deposits. Existing gravel pits and Minnesota Department of Transportation (MN/DOT) aggregate sources lying within these units indicate identified or known resources. The geologic units having the best potential for sand and gravel include terrace, outwash, and ice contact (eskers, kames, and fans) features; these units typically contain sorted sand and gravel with little silt and clay. The units are classified by sand and gravel thickness, thickness of overlying deposits, percentage of material retained on the number 4 sieve (4.76 millimeter pore space), and percentage of spall materials[1] (Table 1). Excellent to good quality deposits generally contain less than 1.5 percent total spall materials. Good to moderate quality deposits generally contain less than 5 percent total spall materials. Gravel in moderate to poor quality deposits generally includes more than 5 percent total spall materials.

Unit boundaries and labels from the Chisago County surficial geology map (Plate 1) are shown within the aggregate map units to further aid in differentiating the deposits, as described below.

Highly desirable sand and gravel deposits—Highly desirable deposits are defined as those having a sand and gravel thickness of 20 to greater than 50 feet (6 to >15 m), generally less than 5 feet (1.5 m) of overburden, on average greater than 20 percent of material retained on the number 4 sieve, and are of excellent to moderate quality. The probability that a sand and gravel deposit exists within this unit is very high to moderately high. This unit includes portions of ice-contact deposits of the Cromwell Formation (Qci), and West Campus formation deposits found below terraces of the St. Croix valley (Qwr, Qwl, and Qwg). Sand and gravel deposits of the West Campus formation generally are thinner and have somewhat higher spall and LAR values[2] than the deposits of the Cromwell Formation. Ice-contact deposits of the Cromwell Formation are more likely to have large lenses of fine-grained sediment. The only deposit in this unit likely to contain significant spall material is mapped east of the town of Sunrise within the Richfield terrace of the West Campus formation (Qwr). It consists of about 15 feet (5 m) of coarse, shale-bearing sand and gravel overlying more than 10 feet (3 m) of non-shale-bearing sand and gravel.

Moderately desirable sand and gravel deposits—Moderately desirable deposits have a sand and gravel thickness ranging from near zero to greater than 40 feet (12 m), less than 10 feet (3 m) of overburden, generally more than 15 percent material retained on the number 4 sieve, and are of excellent to poor quality. The probability that a sand and gravel deposit exists within this unit is high to moderate. This unit includes portions of the Cromwell and New Ulm Formations (Qci, Qni, and Qno) and the West Campus formation (Qwr, Qwl, Qwg, and Qws). Sand and gravel deposits of the West Campus formation in the northern part of the county are gravel-rich, but commonly are less than 20 feet thick (6 m), and the water table is generally less than 20 feet (6 m) below the surface. Most other deposits in this unit have a relatively low percentage of gravel, but some were thus classified because of a lack of data. The small area of New Ulm till (Qnst), mapped east of Sunrise, is interpreted to be relatively thin over Cromwell Formation gravel. Deposits of the New Ulm Formation contain gravel of mixed Superior and Riding Mountain provenance (see Table 1 on Plate 1—Surficial Geology), with generally less than 5 percent spall materials. However, the large ice-contact deposit of the New Ulm Formation (Qni) mapped in the Rush Lake area is shale-rich.

Less desirable sand and gravel deposits—Less desirable deposits consist primarily of sand and gravelly sand (less than 15 percent retained on the number 4 sieve) ranging from near zero to greater than 20 feet thick (6 m), with overburden no more than 20 feet thick (6 m), and are of excellent to poor quality. The probability that a sand and gravel deposit exists within this unit is high to moderately low. This unit includes deposits of the West Campus formation that are inferred to contain small amounts of gravel, and ice-contact deposits of the Cromwell Formation buried by more than 10 feet (3 m) of clayey overburden, which may also contain only small amounts of gravel. Gravel zones within the New Ulm Formation deposits (Qni, Qno, and Qnst) are generally thin or of small extent. Better quality deposits may be within 20 feet (6 m) of the surface in a few areas of New Ulm Formation in the eastern portion of the county. This unit also includes New Ulm outwash that contains coarse gravel beds in places, buried by generally less than 15 feet (5 m) of fine lacustrine sand of the New Brighton formation (patterned Qbs).

POTENTIAL CRUSHED STONE SOURCES—Bedrock formations that are suitable for crushing for aggregate. These units, found only in the Taylors Falls area, consist of basalt (traprock) of the Clam Falls volcanics (Emc), which forms high-quality aggregate when crushed. The mapped areas are greater than 100 feet thick (30 m), with generally less than 20 feet (6 m) of overburden. Other bedrock formations (Cu) near the surface in Chisago County are not suitable for crushed aggregate.

Highly to moderately desirable bedrock deposits—Available data indicate thick basalt is within 20 feet (6 m) of the surface. These units have a very high to moderate probability of containing bedrock suitable for crushed aggregate.

LIMITED POTENTIAL FOR AGGREGATE SOURCES—The map shows that the remainder of Chisago County is underlain by geologic units that have little or no potential for significant aggregate resources. Most eolian sand (Qe) and lacustrine sand of the New Brighton formation (Qbs) and New Ulm Formation (Qnls) contain little or no gravel, at least within 20 feet (6 m) of the surface. Significant aggregate resources are not thought to be present below the peat (Qp) in the county, other than possibly in a portion of the St. Croix valley within and east of Harris. Floodplain alluvium (Qa) likely contains gravel in places, particularly adjacent to the St. Croix River, but insufficient data were available to differentiate gravelly areas, and none of those deposits are likely to be accessible to mining. The loamy till member of the New Ulm Formation (Qnt) contains few gravel lenses near the surface. Additional, unmapped deposits of Cromwell sand and gravel are likely present beneath the Twin Cities member (Qntc), particularly in the southeast third of Chisago County. Patches of gravelly sand overlying water-washed areas of both till members are too small and thin to be significant. The mapped areas of lake clay and silt of the Cromwell Formation (Qclc) likely are overlain by only thin patches of gravelly sand, whereas bodies of sand and gravel overlying or interbedded with till of the formation (Qct) may be substantial in places.

IDENTIFIED AGGREGATE RESOURCES—Those areas where aggregate resources have been or are currently being mined. Pit locations have been gathered from aerial photographs, topographic maps, the county soil survey (Anderson, 1995), MN/DOT files, and fieldwork for this study. The pits may be active, inactive, depleted, or reclaimed.

Large gravel pit, or an area of more than one gravel pit or gravel-pit operation—The larger pits are outlined based primarily on ten-year-old air photos, so at least some are likely more extensive than portrayed. Aggregate resources may remain within some pits. Smaller pits are shown only by symbol.

Gravel pits–MN/DOT files—Minnesota Department of Transportation's Aggregate Source Information System listing of aggregate sources. Test hole logs, sieve, and quality test data are available.

MAP SYMBOLS

Field observation—Location for which data are available. Includes outcrops, roadcuts, and construction sites.

Soil boring—Includes Minnesota Geological Survey giddings holes and Minnesota Department of Transportation bridge borings.

Country Well Index (CWI)—Record of water-well construction (well driller's log).

Qws— **Unit label**—Indicates surficial geology unit from Plate 1. An aggregate unit on this map may include several surficial units, and/or a single surficial unit may be subdivided into multiple aggregate units. See Plate 1 for details of the surficial geology units.

State Park Boundary

Table 1. Sand and gravel potential.

desirability	High		Moderate			Less		
sand and gravel thickness (feet)	20–50+		0–40+			0–20+		
overburden thickness (feet)	<5		<10			<20		
retained on #4 sieve probability	>20% very high to moderately high		>15% high to moderate			<15% high to moderately low		
total spall quality	<1.5% excellent to good	<5% good to moderate	<1.5% excellent to good	<5% good to moderate	>5% moderate to poor	<1.5% excellent to good	<5% good to moderate	>5% moderate to poor

[1]Spall materials are rock particles that will cause a pop-out in hardened concrete or bituminous pavement. Maximum permissible spall materials allowed by the MN/DOT in coarse aggregate for concrete used in highway construction, by weight percent of total sample, are: shale, 0.7 percent; soft iron oxide particles, 0.3 percent; total spall materials (shale and iron oxide, plus unsound chert, coal, and clayey limestone), no more than 1.5 percent. Maximum permissible total spall materials in bituminous pavement is 5.0 percent.

[2]LAR (Los Angeles Rattler) is a standard method for testing resistance of aggregate to abrasion. Coarse aggregate is rotated in a steel cylinder with steel balls for a specified time. The percentage of fine material abraded from the coarse aggregate originally put in the cylinder, expressed as percentage of loss, is the LAR value. The more resistant the aggregate, the lower the value. Maximum permissible loss for aggregate used in highway pavement construction (total sample) is 40 percent. All deposits in Chisago County which had test records available had LAR values much lower than 40 percent; however, some deposits classified as having moderate to poor quality potentially could exceed the 40 percent limit.

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AGGREGATE RESOURCE POTENTIAL OF CHISAGO COUNTY, MINNESOTA