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CRITICAL ISSUES WEBINAR

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Geologic Mapping to Empower Communities

Examples from the Great Lakes

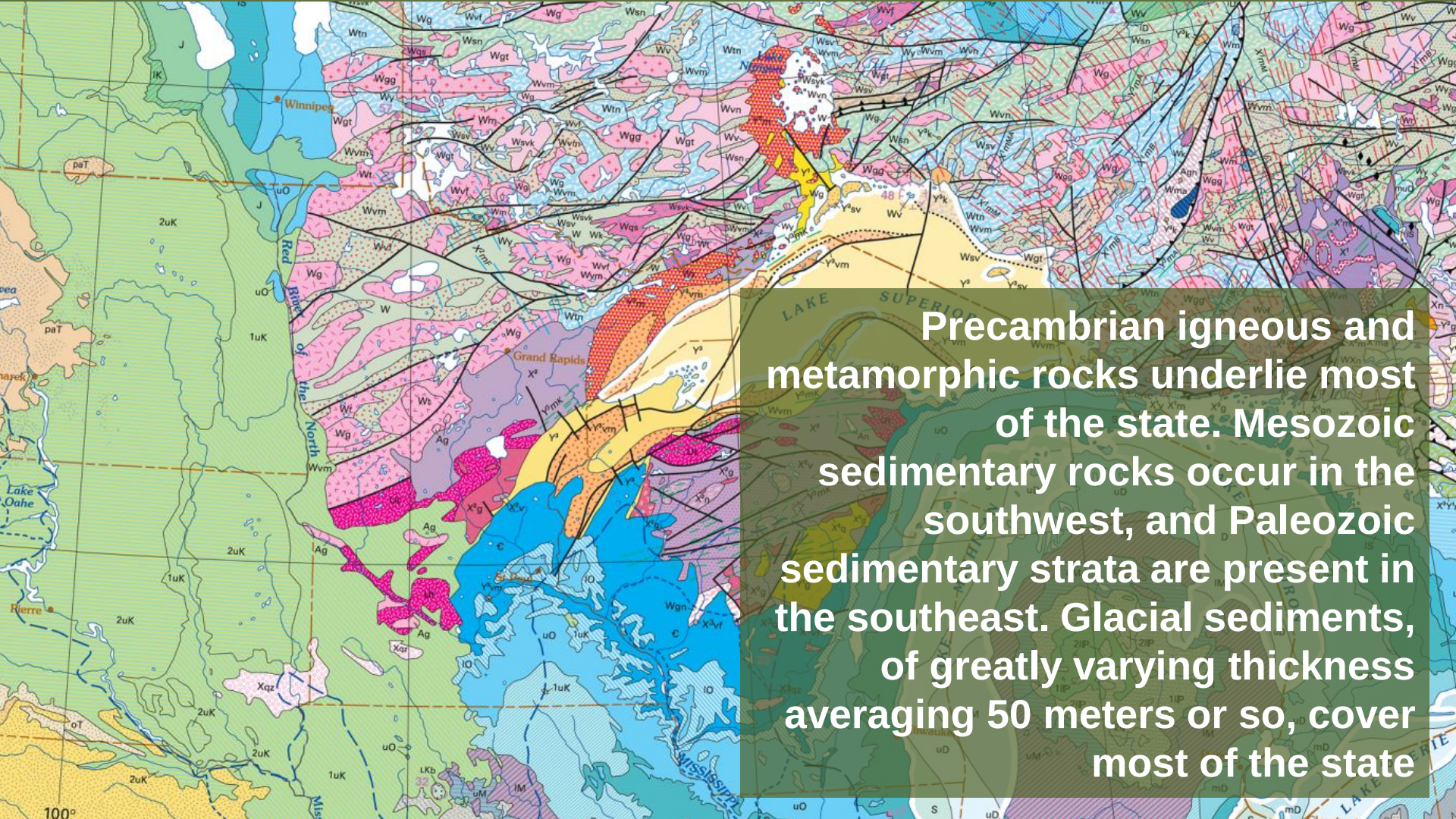
December 6th, 1:30 PM EST

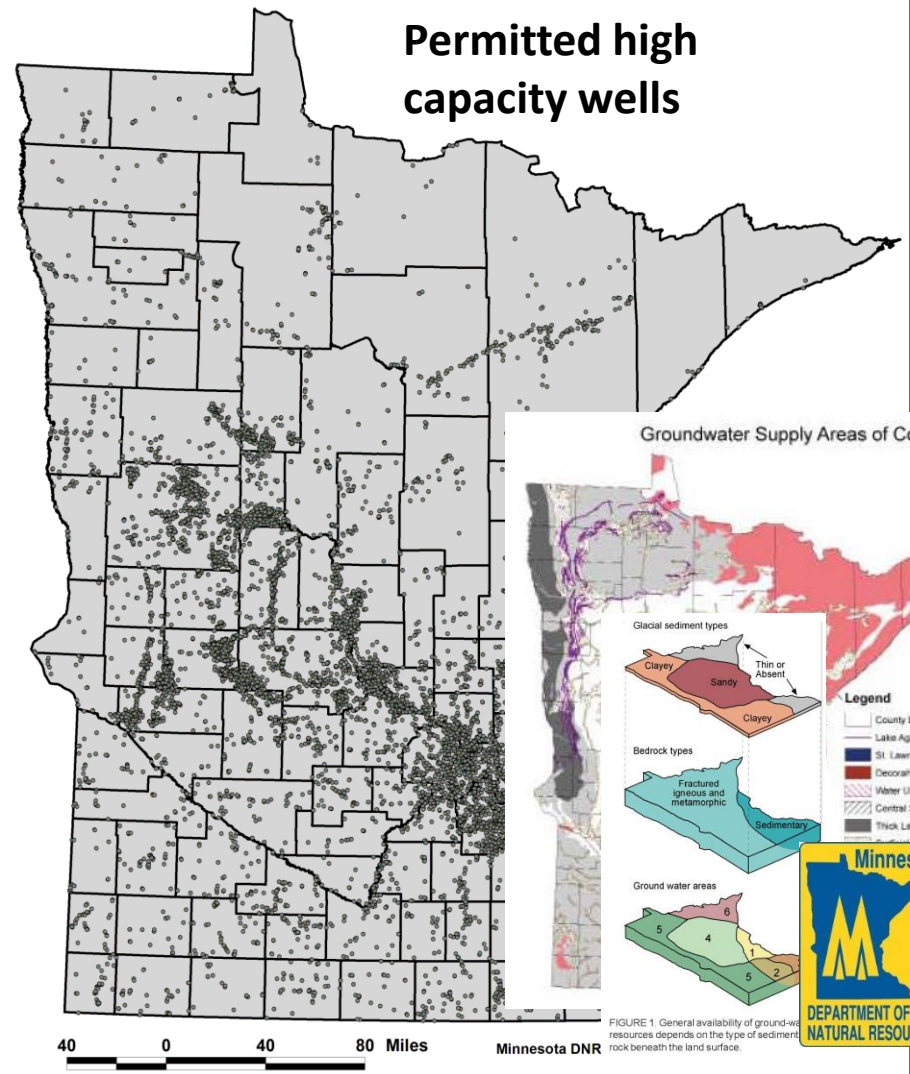
http://bit.ly/AGI-GreatLakesMapping-Webinar

Harvey Thorleifson, Director,
Minnesota Geological Survey

Status of geological mapping needed for groundwater protection in Minnesota

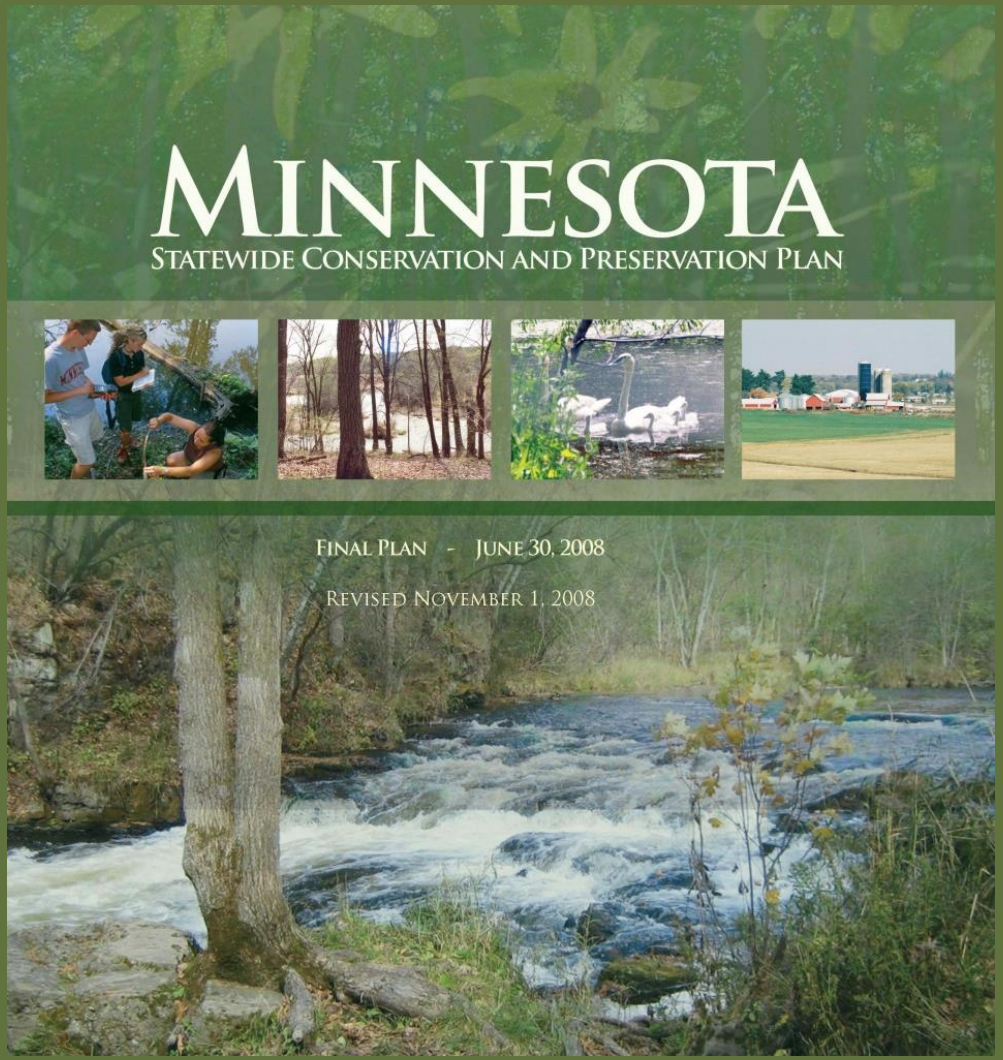
Minnesota is located between the Dakotas and Wisconsin, north of Iowa, and south of Manitoba and Ontario. Two thirds of our five million residents live in the Twin Cities. Agriculture is prevalent in the south and west, and the Iron Range in the north supplies iron ore to the US through our Great Lakes ports


Precambrian igneous and metamorphic rocks underlie most of the state. Mesozoic sedimentary rocks occur in the southwest, and Paleozoic sedimentary strata are present in the southeast. Glacial sediments, of greatly varying thickness averaging 50 meters or so, cover most of the state



We are known for our lakes and rivers, and the majority of our drinking water comes from wells. Recently, Minnesotans have become concerned about groundwater contamination, and over-pumping. A 2007 Minneapolis Star Tribune editorial, for example, called for steps to restore confidence in our drinking water, including enhanced funding to the state geological survey

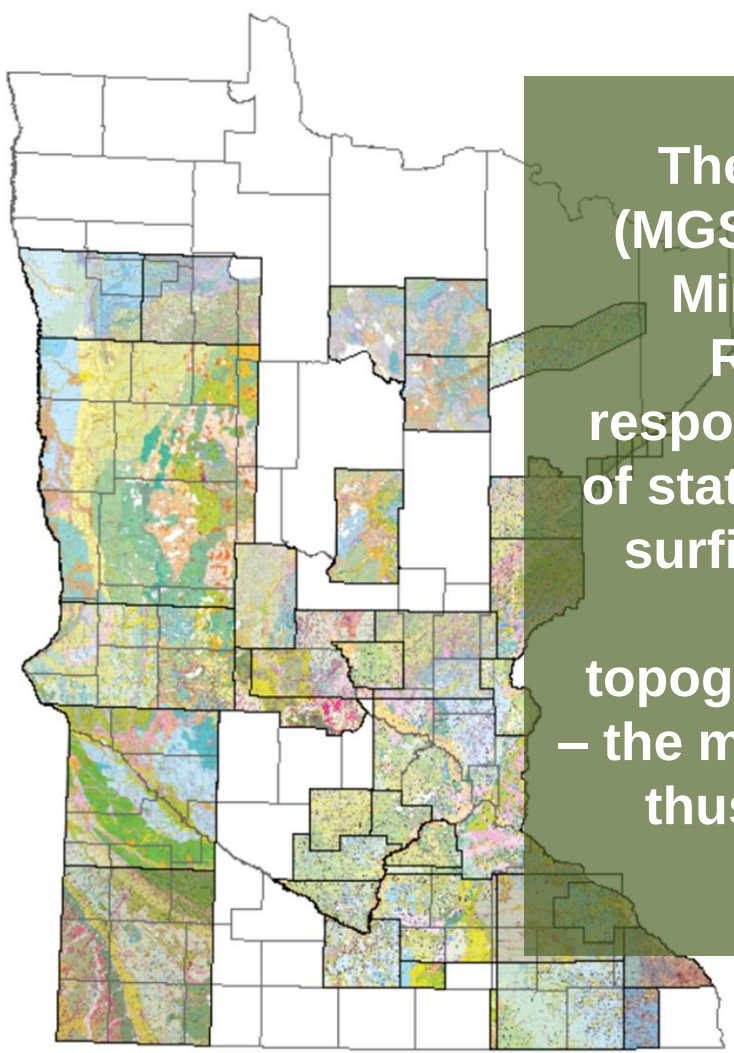
Restore confidence in local drinking water



A 2008 assessment of our environment and natural resources specified, as one of many recommendations, that statewide, consistent, multi-layered geological mapping would be required, to empower the people of the state to plan and protect their water resources

MINNESOTA WATER SUSTAINABILITY FRAMEWORK

A 2011 water sustainability framework that was commissioned by the Legislature then advocated that one of several measures of our progress in caring for our groundwater should be the rate of completion of county geologic atlases; a doubling of the pace of geological mapping was recommended



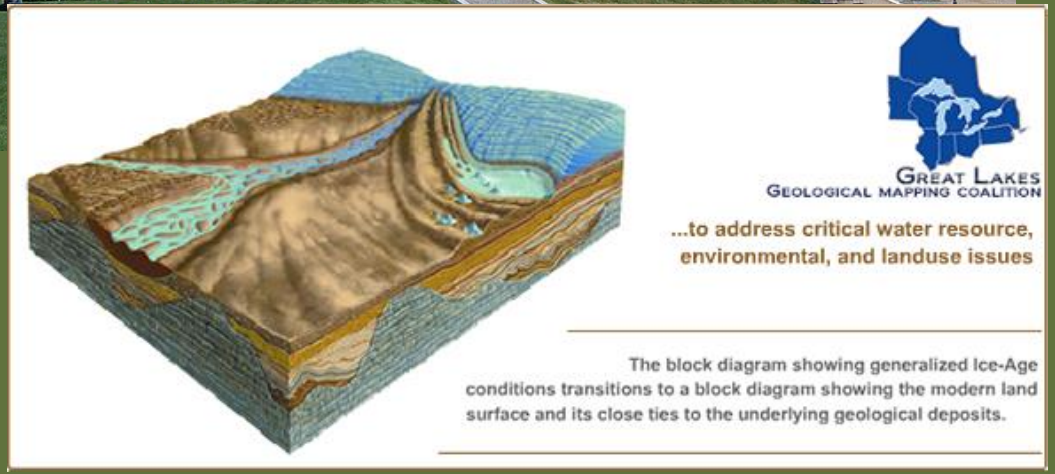
The Minnesota Geological Survey (MGS) therefore is working with the Minnesota Department of Natural Resources (DNR) to fulfill these responsibilities, through completion of statewide 1:100,000 and 1:500,000 surficial geology, bedrock geology, subsurface geology, bedrock topography, and sediment thickness – the mapping is comprehensive, and thus applicable to water and other applications

We concurrently are undertaking funded basic research that is needed to optimize our mapping, with an emphasis on enhanced hydrogeological characterization of sediment and rock strata

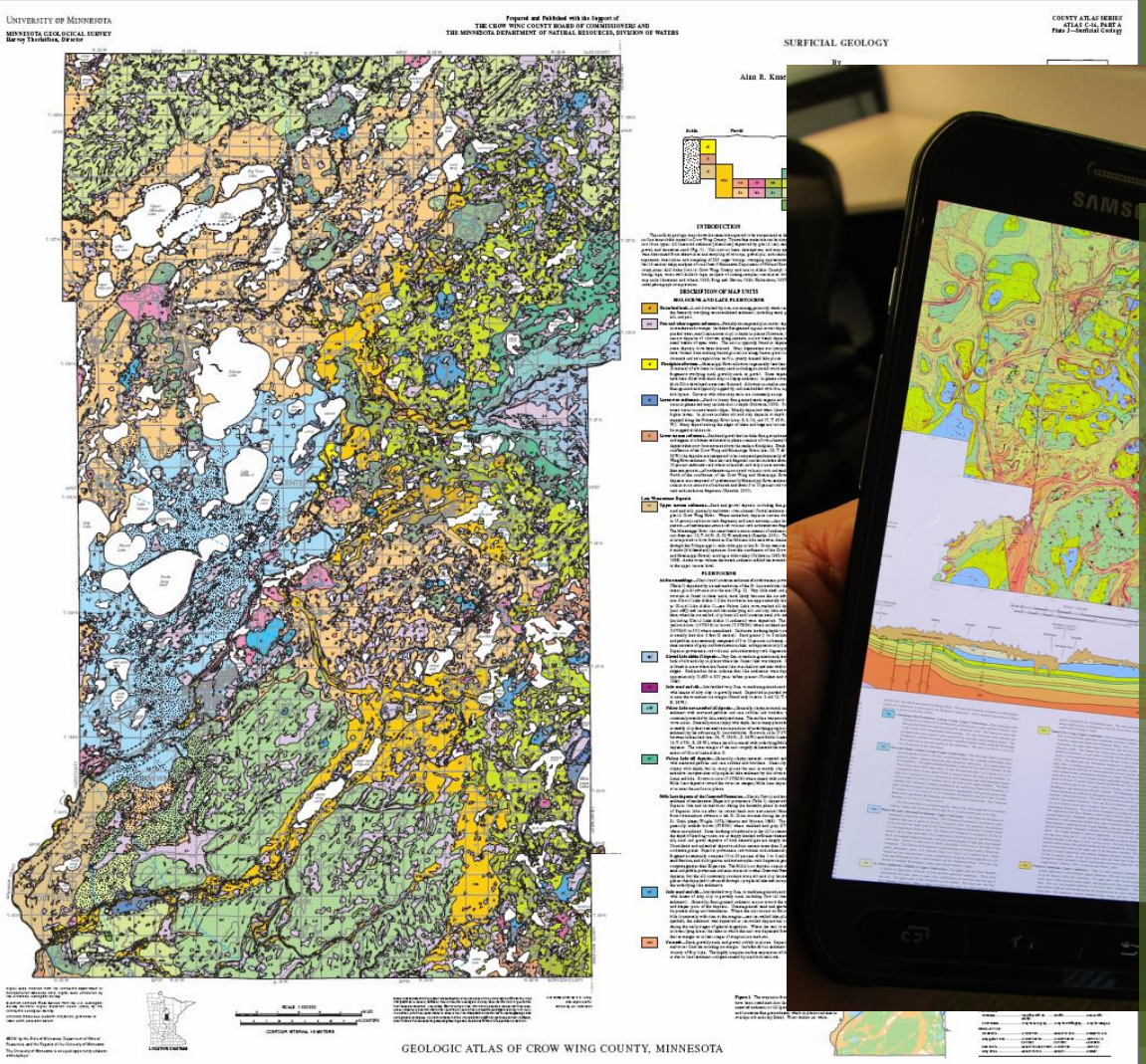
ENVIRONMENT
AND NATURAL RESOURCES
TRUST FUND

CLEAN
WATER
LAND &
LEGACY
AMENDMENT

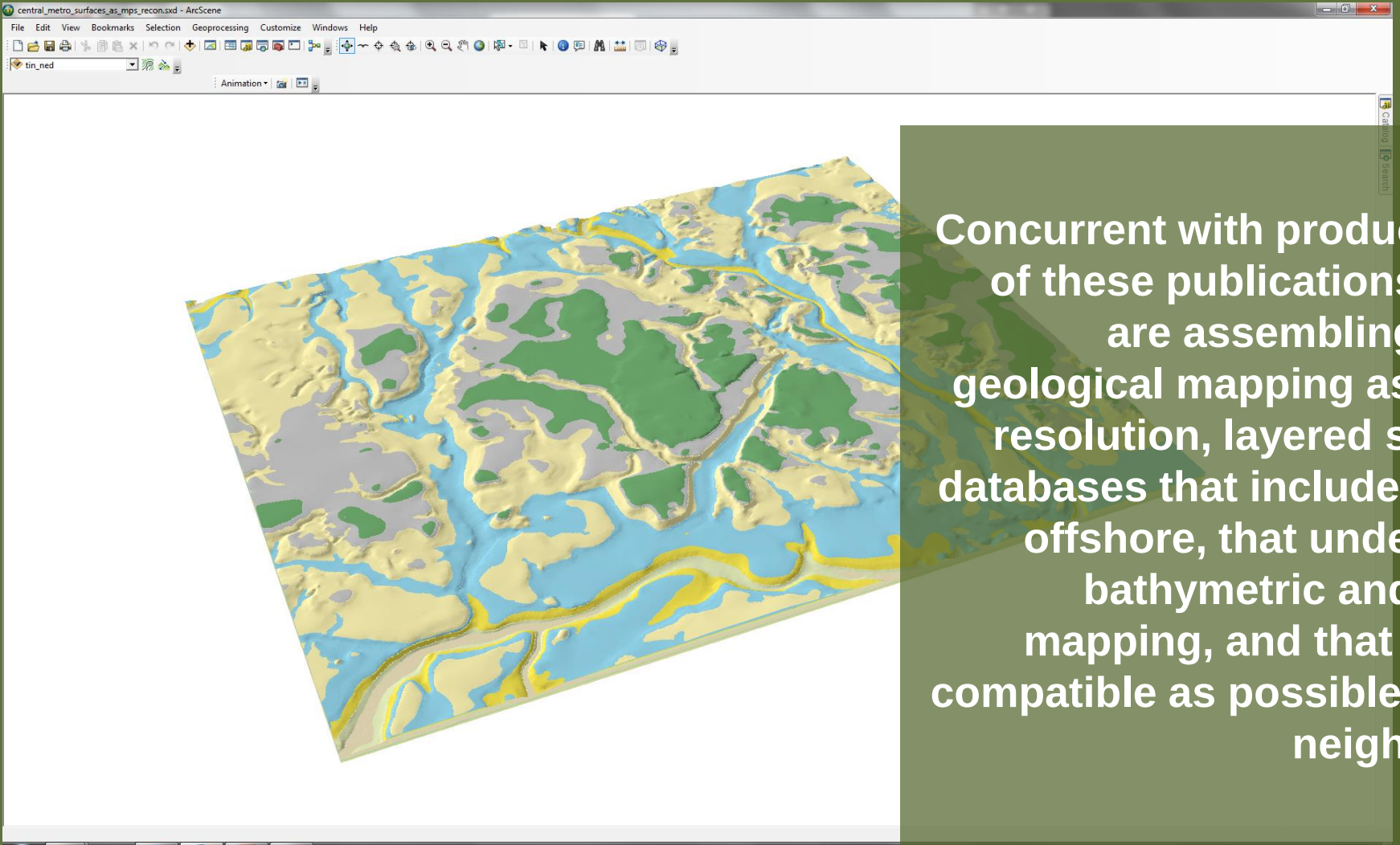
Crucial to our work is support from the Environment and Natural Resources Trust Fund, established by voter approval in 1988. In addition, in 2008, the people of Minnesota voted for a tax increase – the Clean Water, Land, and Legacy Amendment. The resulting program also supports our work



Our geological mapping thus is being very strongly supported by the Minnesota Legislature, with crucial roles also being played by programs such as the USGS Great Lakes Geological Mapping Coalition



The geological mapping is first published as authored and peer-reviewed paper maps. In addition to these born-digital publications, all of our publications back to 1872 - 50,000 pages and 700 maps - are now 100% scanned, searchable, and downloadable for free



Concurrent with production of these publications, we are assembling our geological mapping as a 2-resolution, layered set of databases that includes the offshore, that underlies bathymetric and soil mapping, and that is as compatible as possible with neighbors

MINNESOTA GEOLOGICAL SURVEY
Harvey Thorleifson, *Director*

QUATERNARY LITHOSTRATIGRAPHIC UNITS OF MINNESOTA

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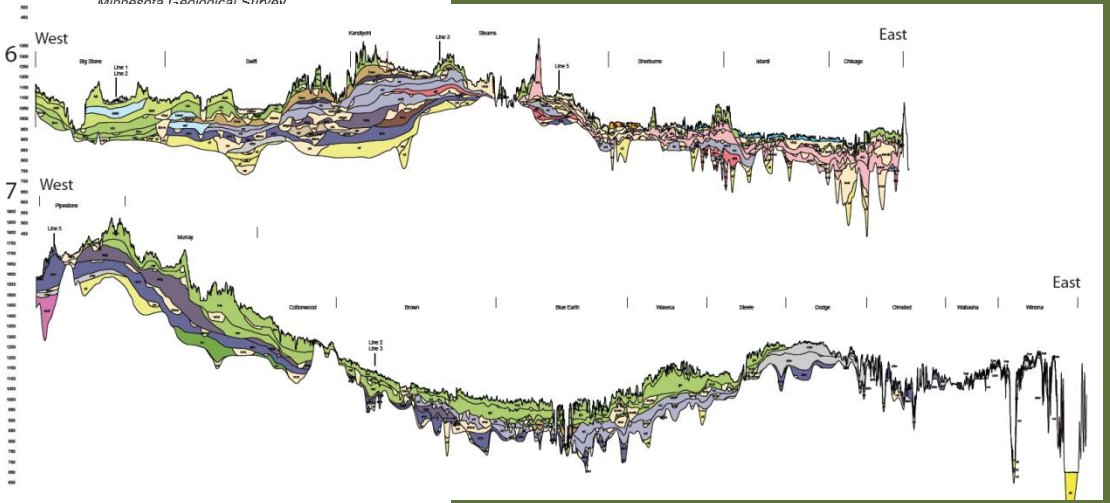
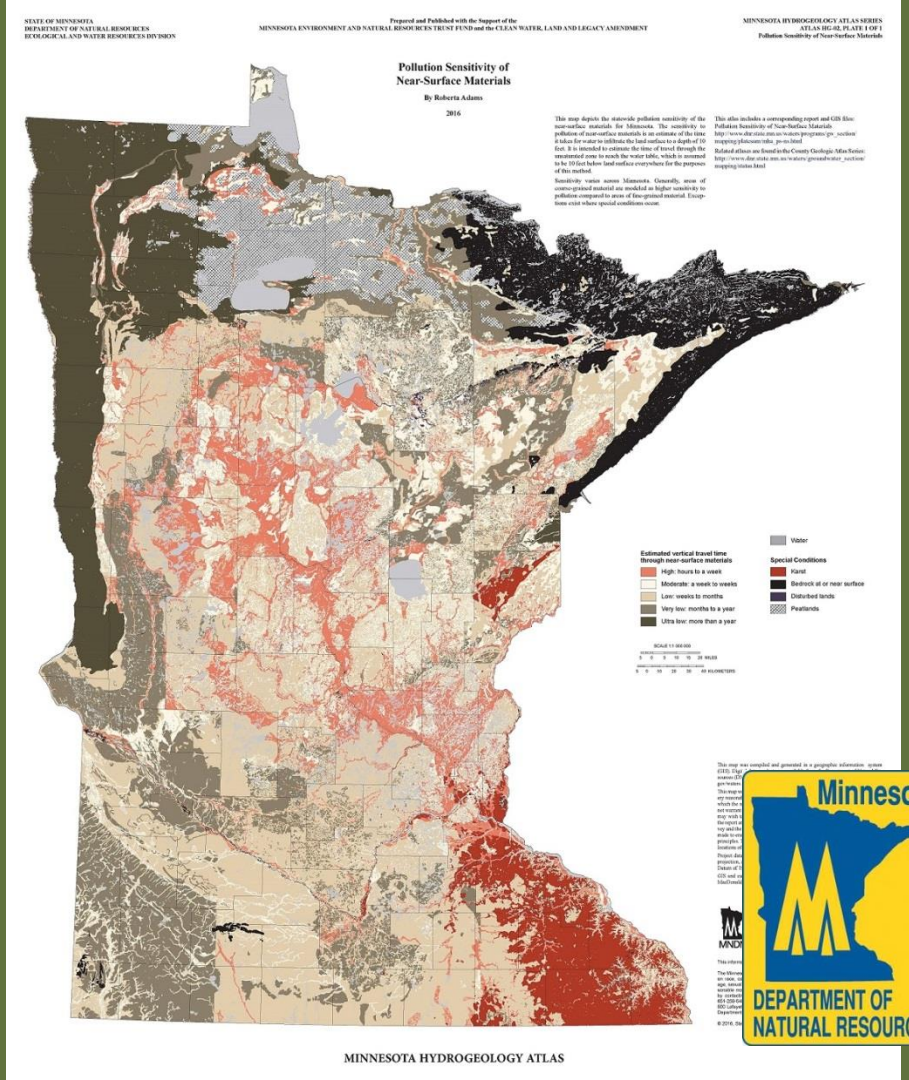
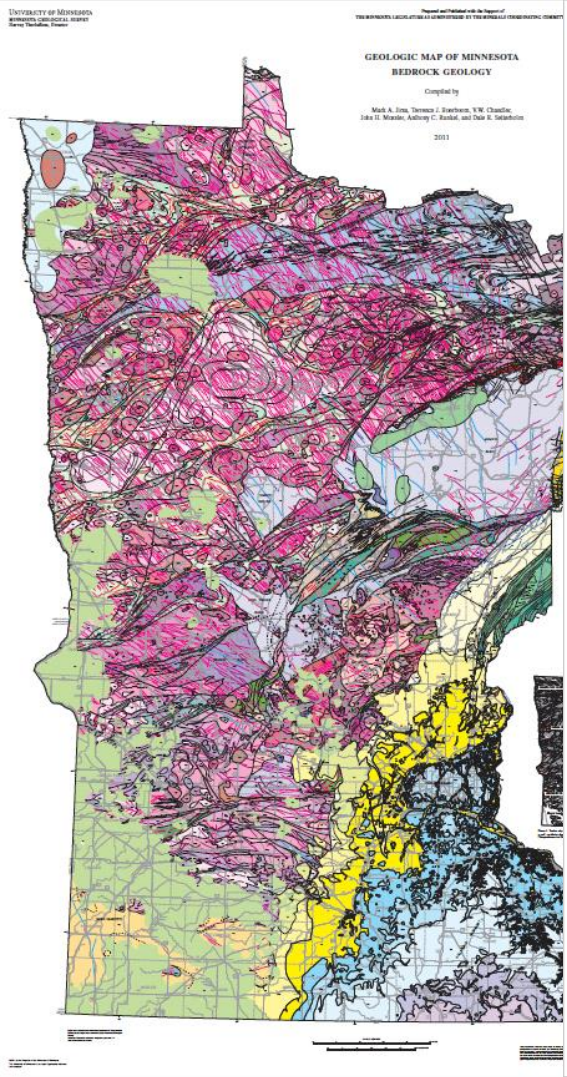
Saint Paul — 2016

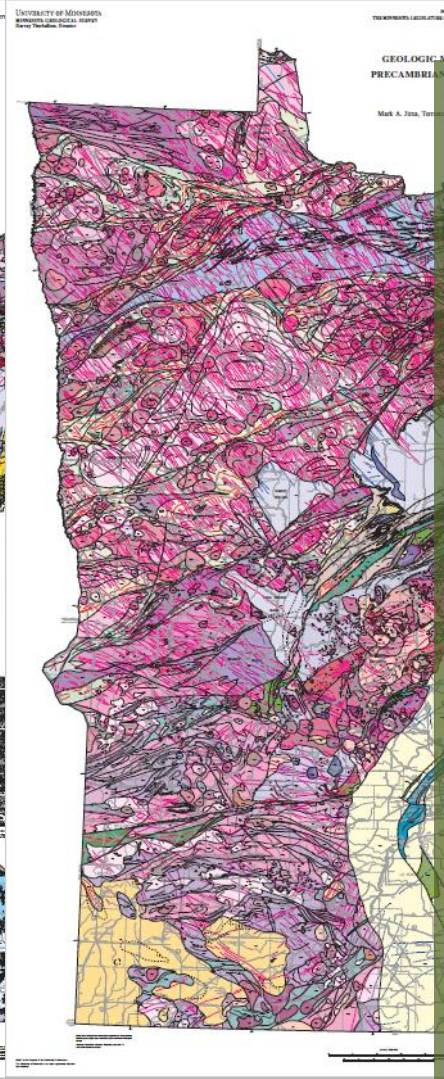


With support from the Great Lakes Coalition, we have made major strides in reconciling our Quaternary stratigraphic naming. In addition to a naming guide, it was necessary to construct several statewide cross-sections to fulfil this objective

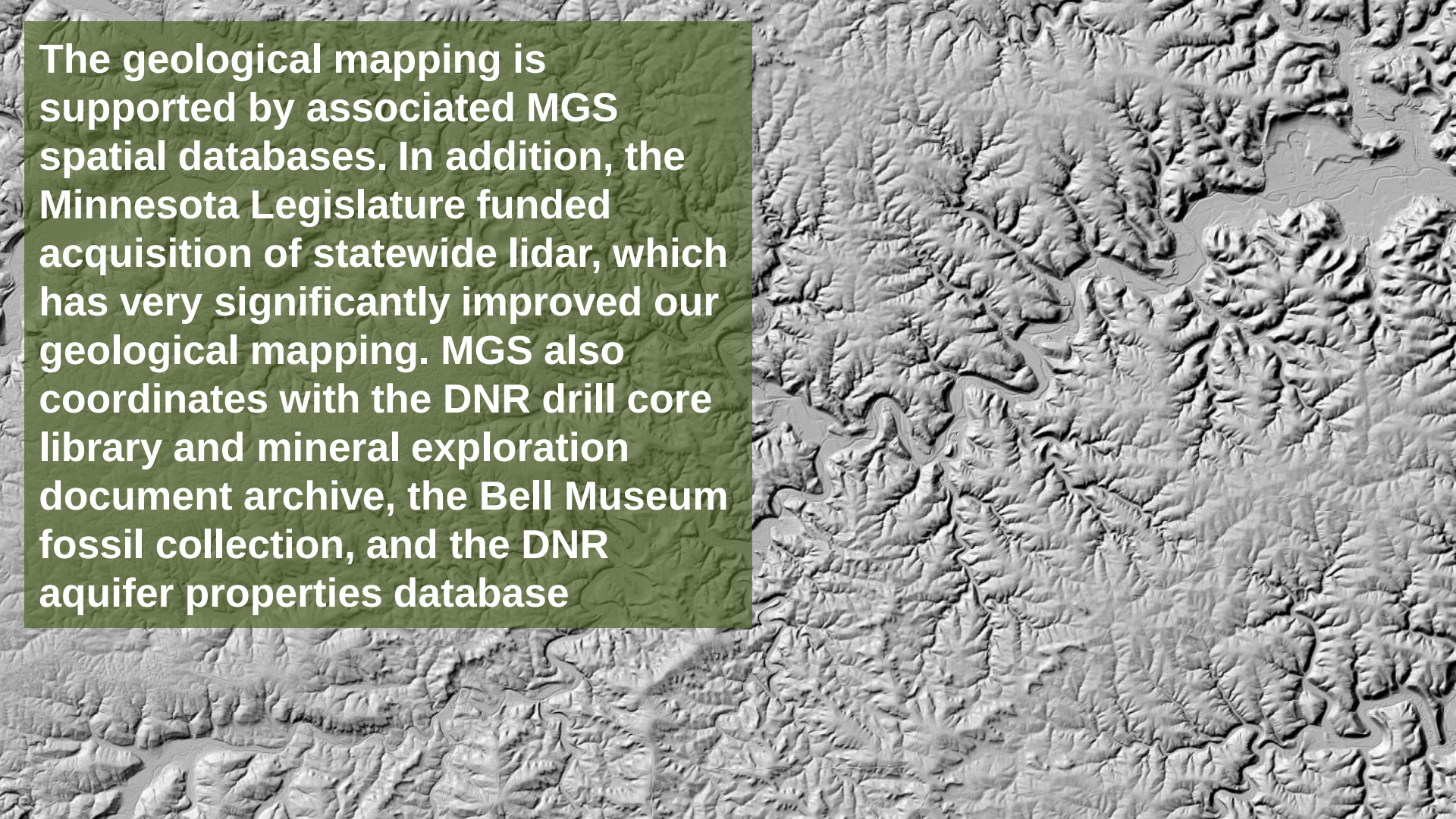


Progressively more seamless geological polygons, at 1:100,000 and 1:500,000, are tending to have thickness indicated, while properties, heterogeneity, and uncertainty will gradually be more specified. Parsing of legends, to facilitate queries, is using broadly accepted, well-defined terminology, and quantitative support, to facilitate optimal inference of properties such as hydraulic conductivity

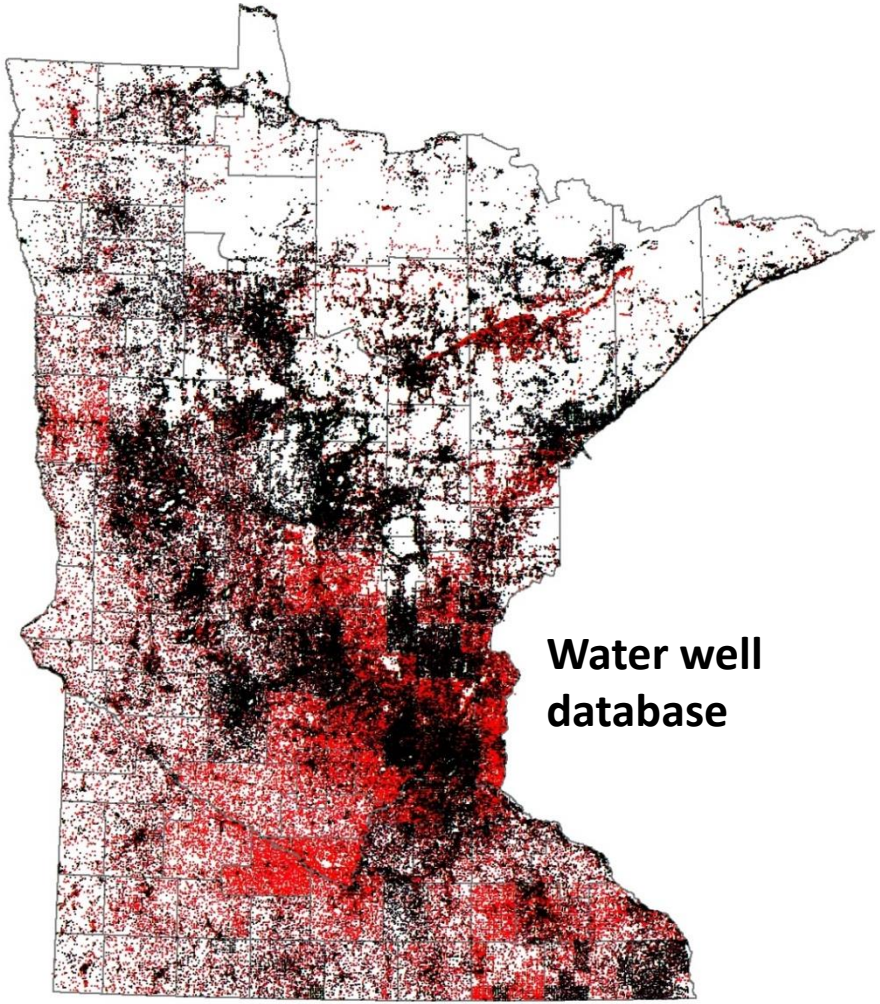




New 1:500,000 geologic mapping provides context and supports statewide analyses. The new bedrock map is layered, as Mesozoic and Paleozoic strata can be removed to reveal a Precambrian map, and we have plans to map Precambrian layers that also will be removable. A new state Quaternary map, also layered, is in development, due to much-appreciated support from the USGS Great Lakes Geologic Mapping Coalition

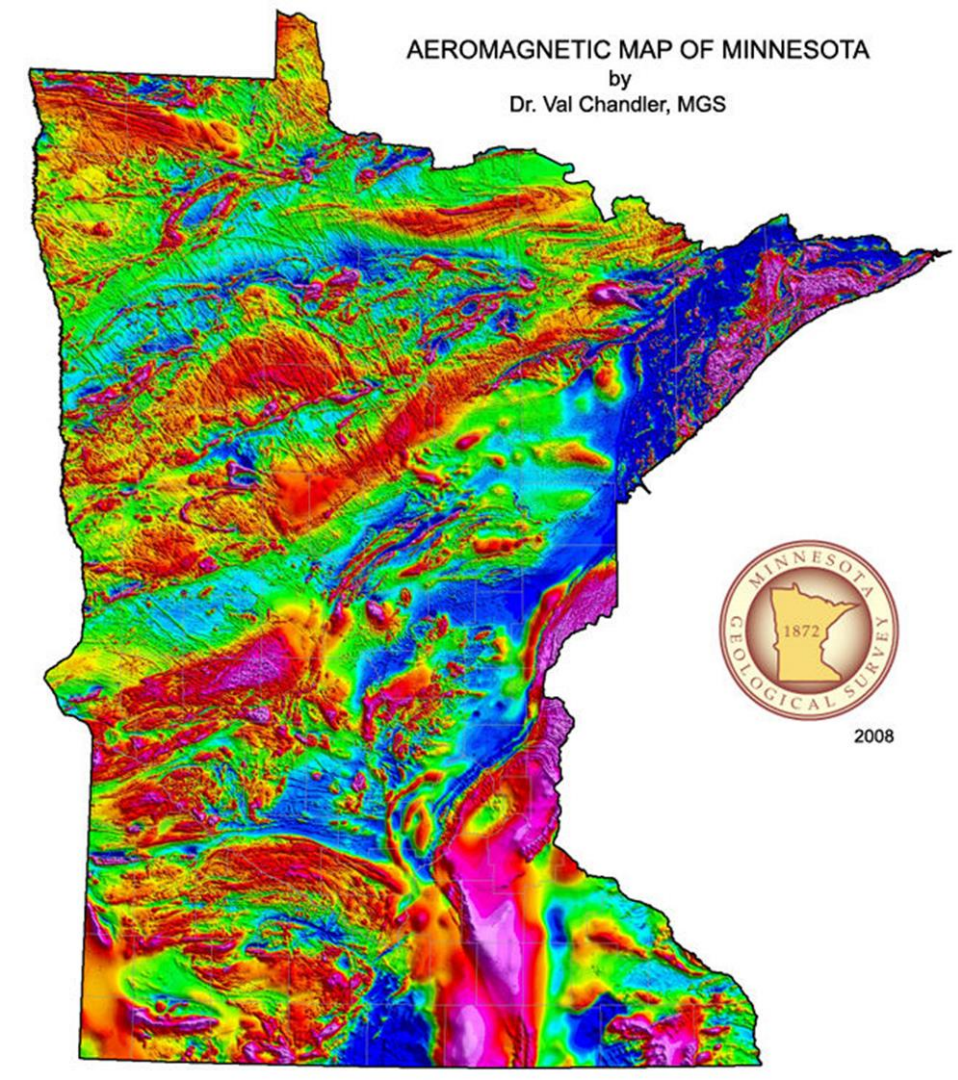


The geological mapping is supported by associated MGS spatial databases. In addition, the Minnesota Legislature funded acquisition of statewide lidar, which has very significantly improved our geological mapping. MGS also coordinates with the DNR drill core library and mineral exploration document archive, the Bell Museum fossil collection, and the DNR aquifer properties database

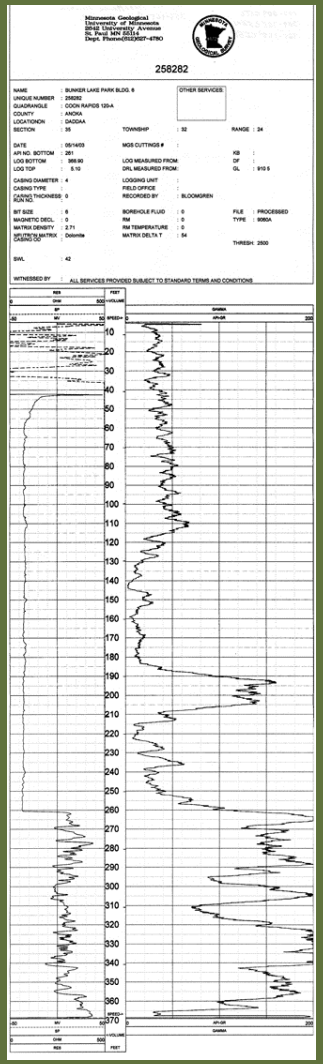


MGS geological databases include drillhole data, field observations, karst features, as well as sediment texture and lithology. The water well database is a major activity for MGS, with our partner in this role, the Minnesota Department of Health. We now have over 500,000 wells in the database

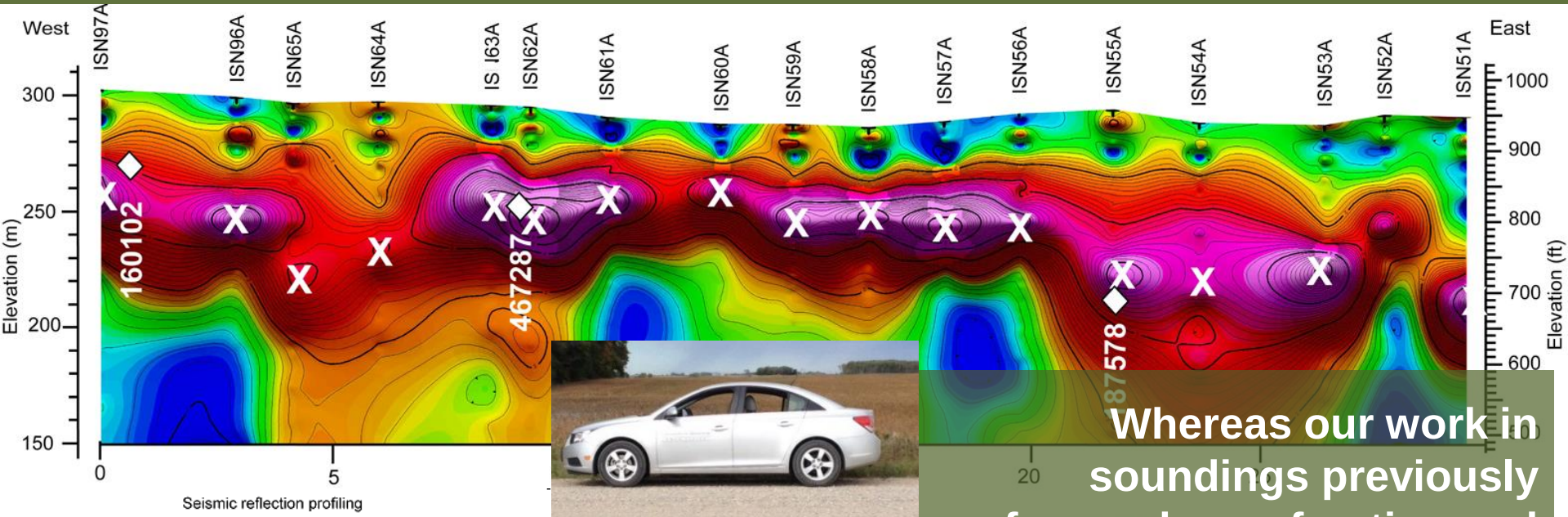
MGS geological collections include cuttings, geochemical samples, hand samples, sediment samples, and thin sections

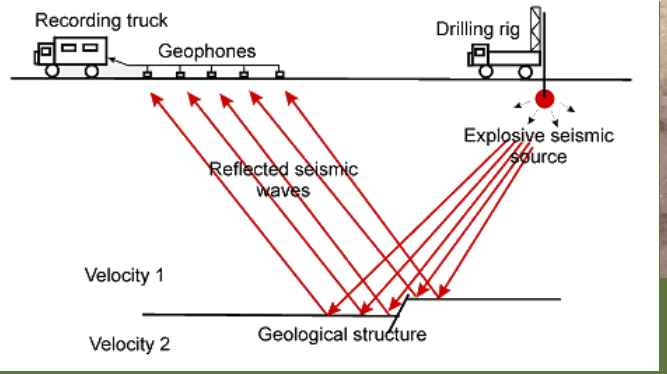


MGS geophysical databases include magnetic, gravity, rock properties, borehole geophysics, and soundings. We have completely reprocessed the state magnetic database, and the state gravity database; in both cases, feature resolution was very significantly improved

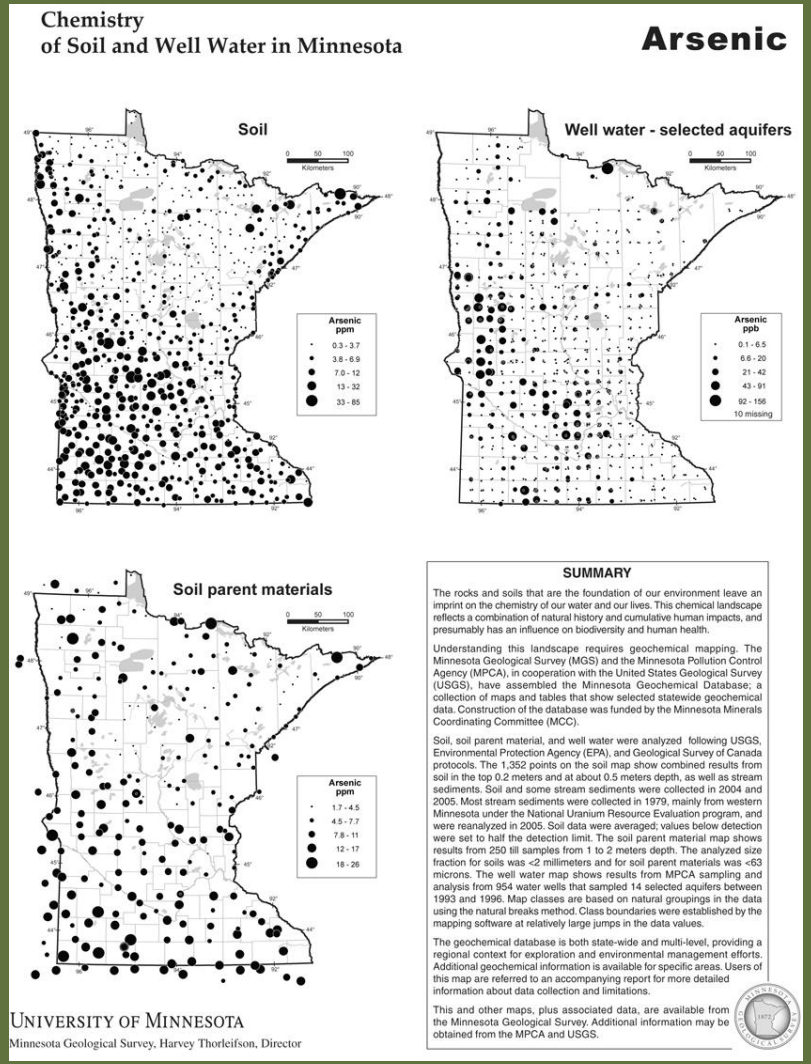


Borehole geophysical surveys are an ongoing activity for us, statewide – we have made much progress in digitizing previously-collected natural gamma logs, while our activity is broadening in multi-parameter, caliper, EM-flowmeter and borehole video logs

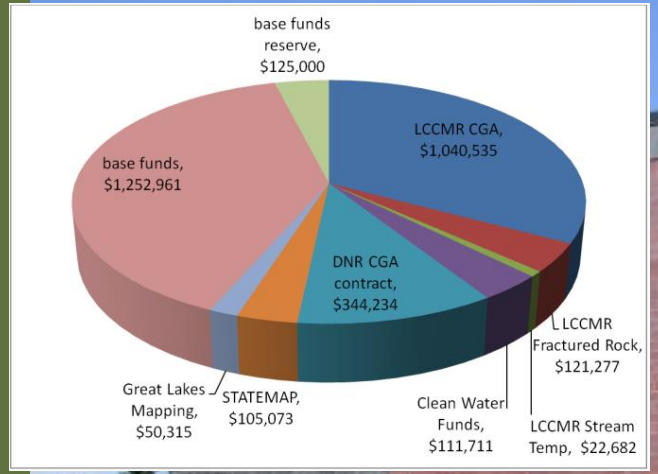




Whereas our work in soundings previously focused on refraction and reflection seismic, passive seismic is now a major emphasis for us, and a source of much helpful new data on depth to bedrock

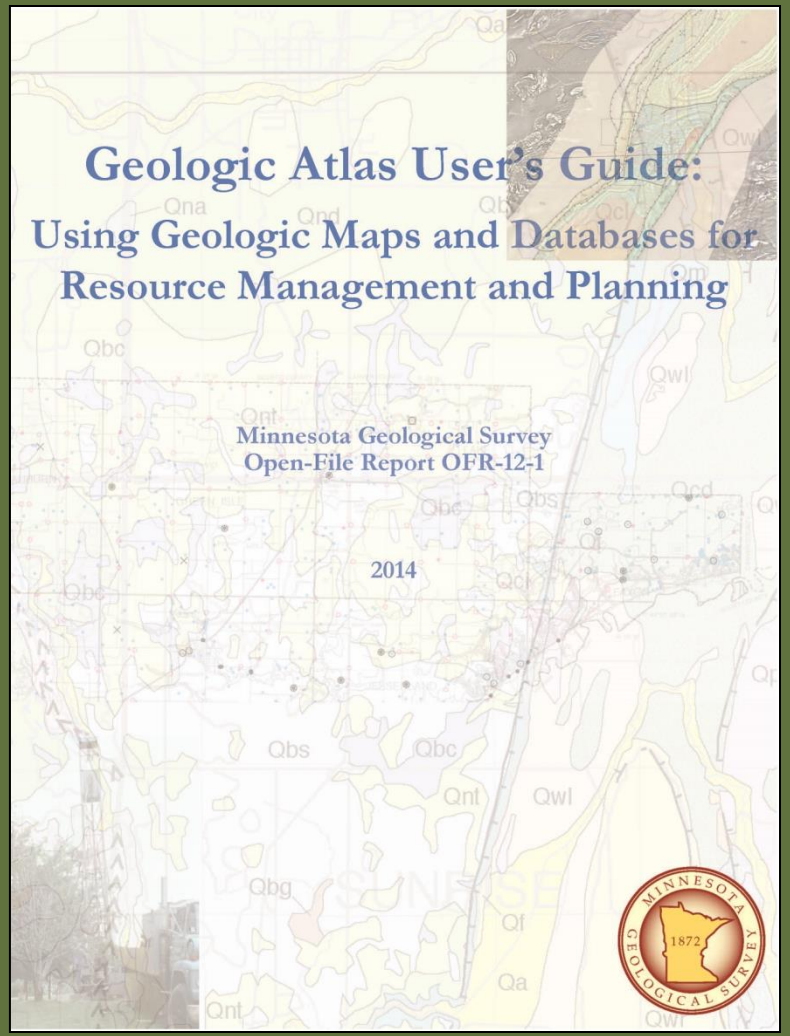


Our statewide geochemical databases, constructed with partners, include groundwater, soil, and soil parent materials, while geochronological databases are in development



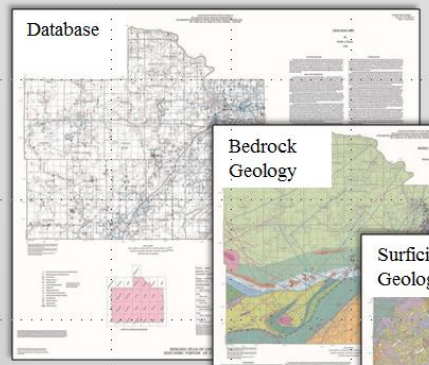
While MGS annual funding averaged $2.3M from 2003 to 2008, the average since then has been $2.9M. MGS relies on about $1.2 million in base funding, and about $1.7 million in grants and contracts each year

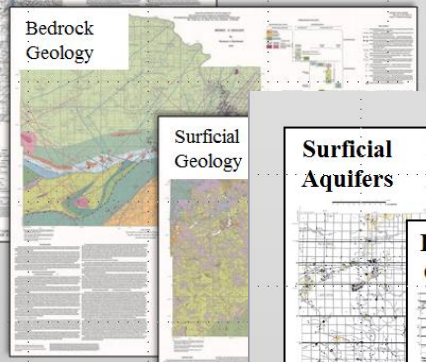
MGS staffing was stable at 28 full-time-equivalents (FTE) from 2003 to 2012; since then, staffing has averaged 36 FTE. We currently are 28 geologists, 4 information professionals, 2 administrative staff, and 6 students equivalent to ~3 FTE

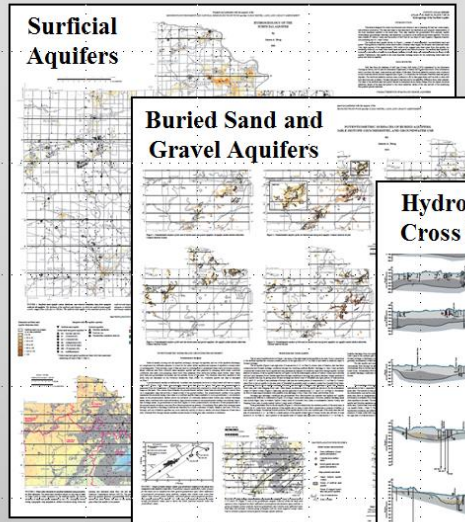


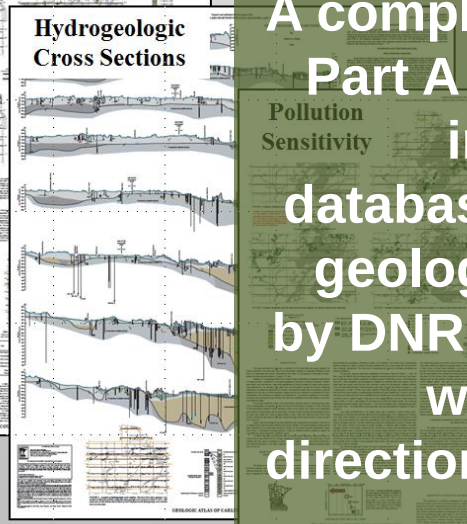
Our focus is on County Geologic Atlases. A User's Guide to Geologic Atlases helps non-geologists, especially decision-makers, understand the information products and their uses. Atlases are available in print, or in digital formats, including pdfs and GIS files

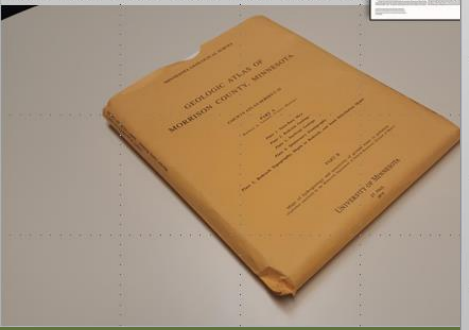
COUNTY GEOLOGIC ATLAS
Part A



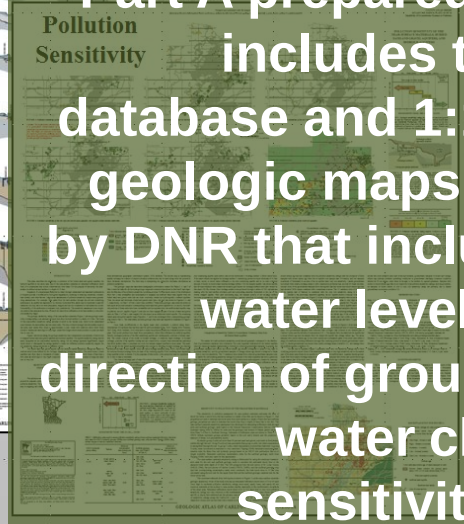








COUNTY GEOLOGIC ATLAS Part B

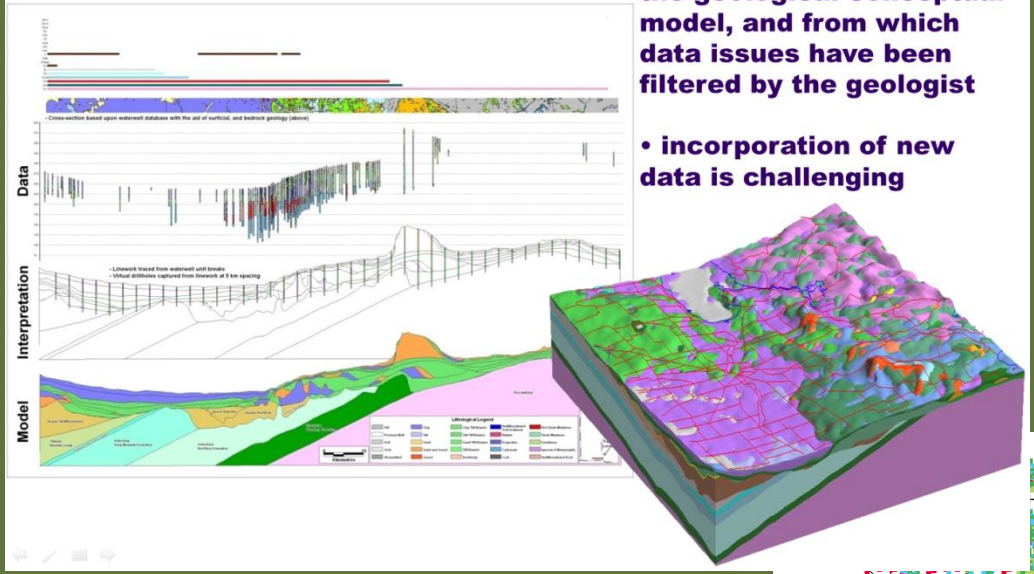


MNDNR

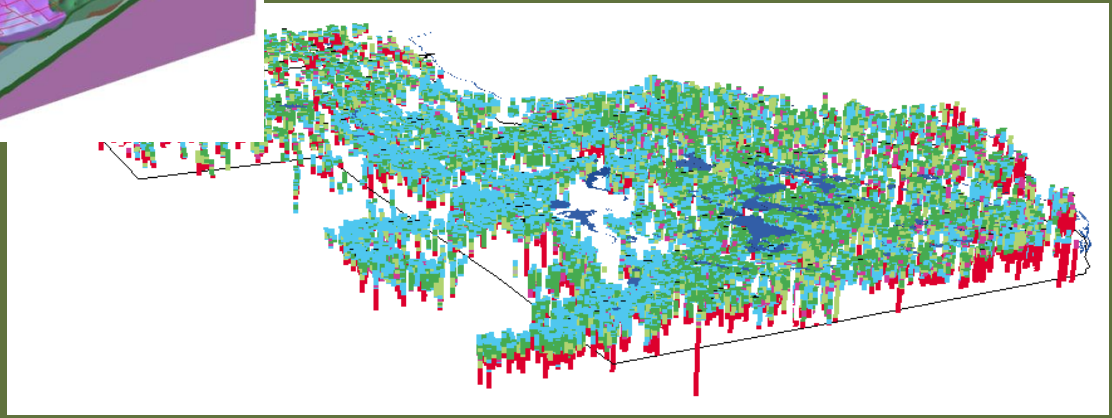
A complete atlas consists of a Part A prepared by MGS that includes the water well database and 1:100,000 scale geologic maps, and a Part B by DNR that includes maps of water levels in aquifers, direction of groundwater flow, water chemistry, and sensitivity to pollution

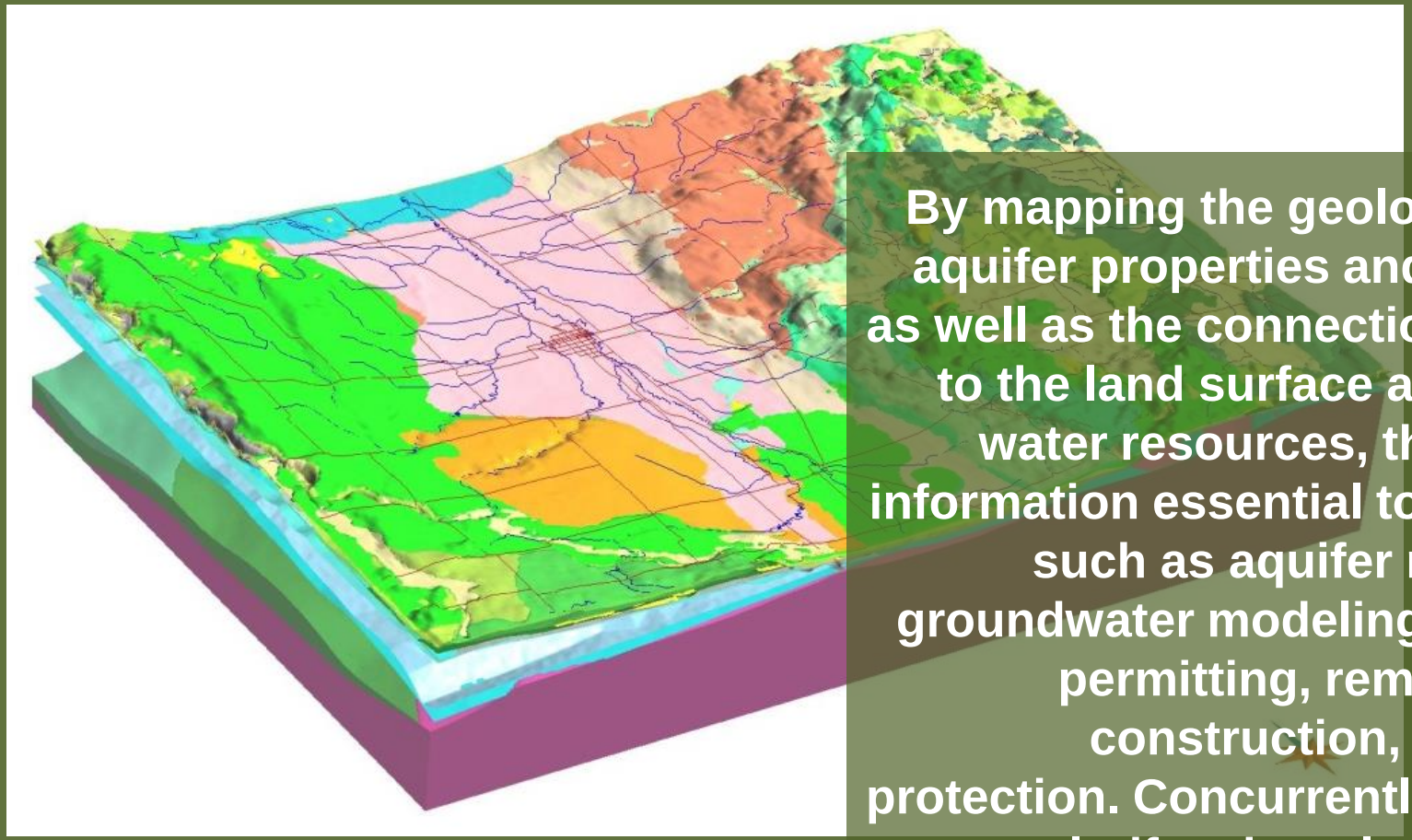
Cross-sections drawn through lithologic data

- this results in depiction of a fully plausible geology that conforms to the geological conceptual model, and from which data issues have been filtered by the geologist
- incorporation of new data is challenging

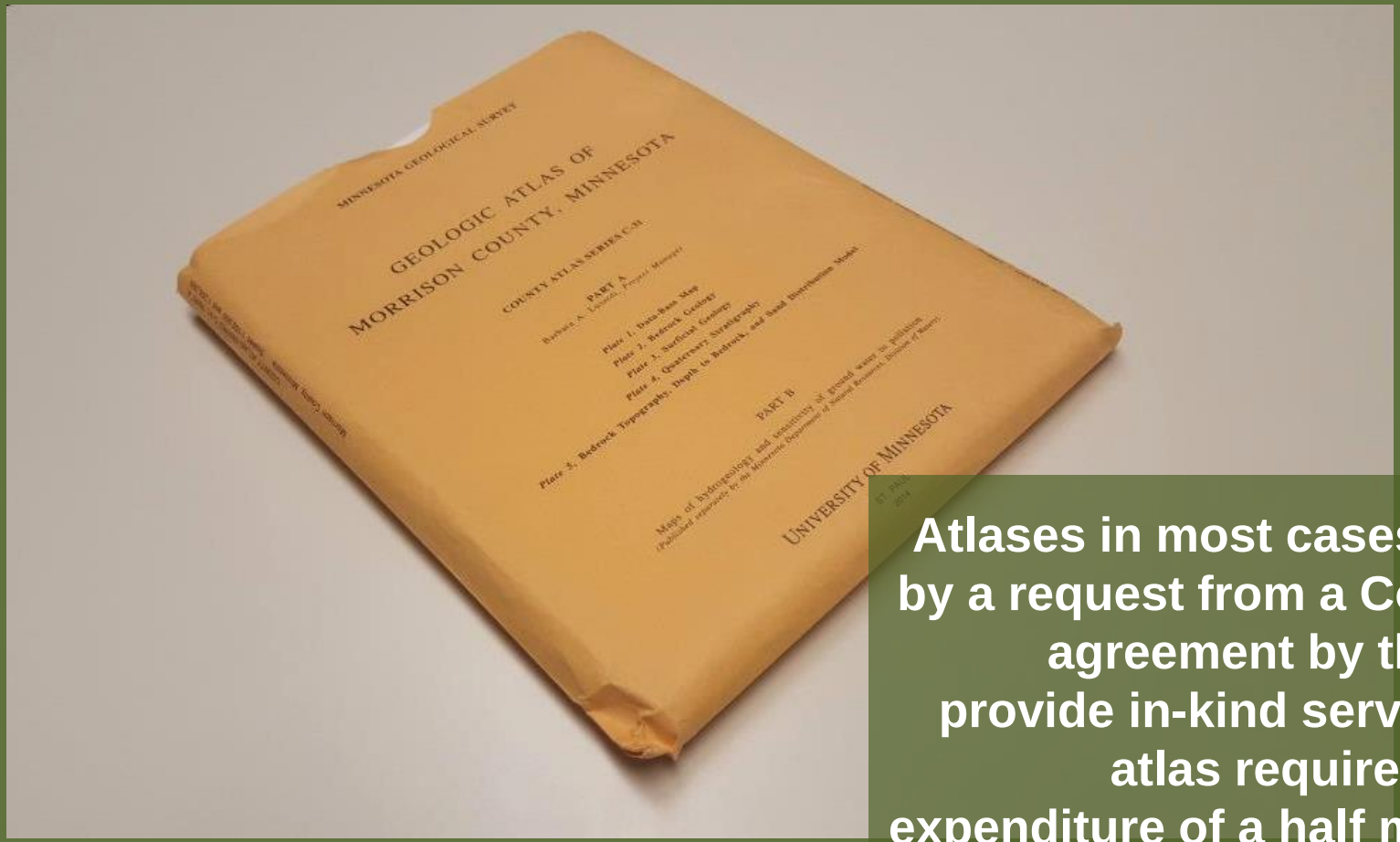


Our subsurface mapping utilizes a cross-section method that brings together new drilling and geophysical data, water well data, geostatistical analysis, and geologists' judgement

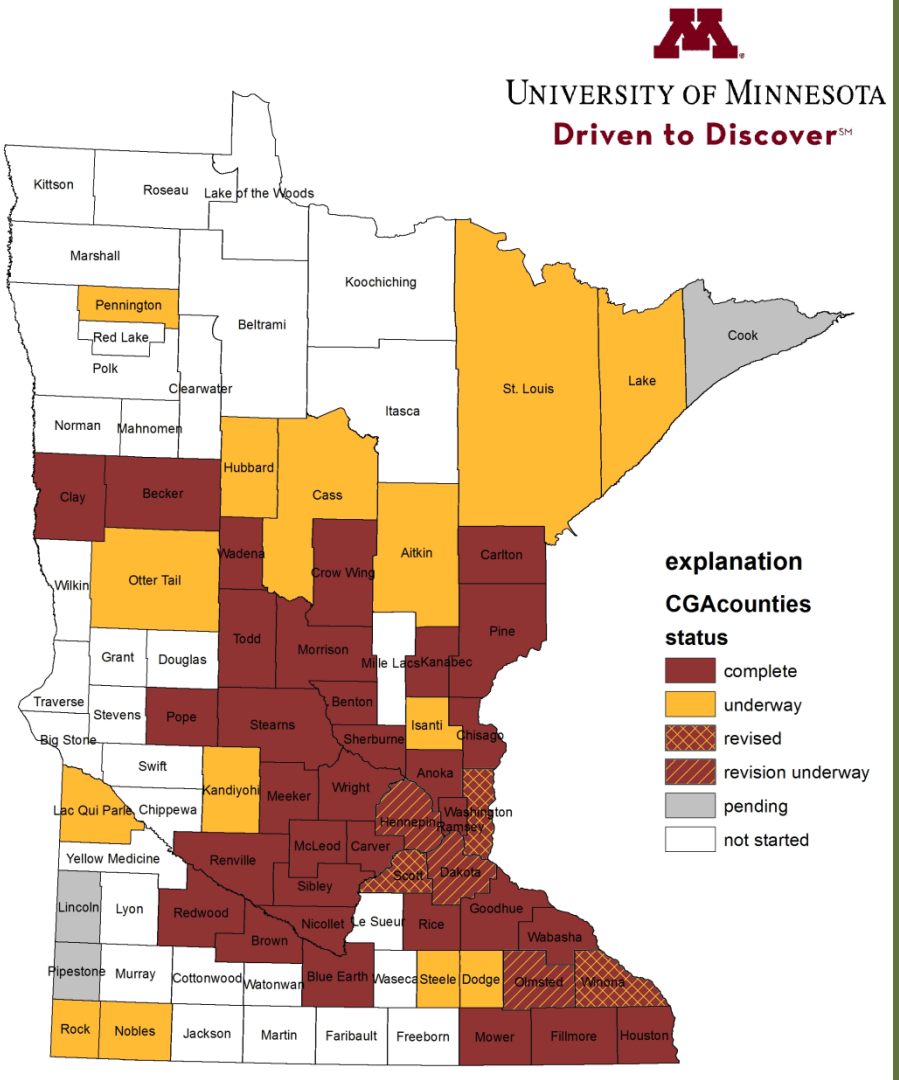




By mapping the geology, we define aquifer properties and boundaries, as well as the connection of aquifers to the land surface and to surface water resources, thus providing information essential to applications such as aquifer management, groundwater modeling, monitoring, permitting, remediation, well construction, and wellhead protection. Concurrently, the Atlases clarify mineral resources and engineering conditions



Atlases in most cases are initiated by a request from a County, and an agreement by that County to provide in-kind service. A typical atlas requires a total MGS expenditure of a half million dollars over about four years



38 counties are complete, 32 are not started, 3 are pending, 3 are revised, 3 revisions are underway, and 14 new Atlases are in progress. Atlases are being completed at a rate of ~5 per year, so with ~50 completions remaining, statewide atlas coverage will be achieved in a decade, depending on the pace of revisions and accompanying research – we foresee that we will then focus on Atlas revisions and associated activity

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Geologic Mapping to Empower Communities

Examples from the Great Lakes

In summary, strong support from the Minnesota Legislature has allowed the Minnesota Geological Survey to grow, and to focus on the actual needs of the people statewide. Concurrently, very helpful roles are being played by programs such as the USGS Great Lakes Geologic Mapping Coalition, and the National Cooperative Geologic Mapping Program. We welcome discussion and advice

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