January 30, 2017


The Michigan Geological Survey is pleased to present the 2016 Annual Report summarizing the activities and achievements to the State Geologist, Harold R. Fitch, per Public Act 167 of 2011.

MISSION STATEMENT:

- The mission of the Michigan Geological Survey is to facilitate basic and applied geological research to promote the best use of Michigan's geological resources for their social and economic benefits while protecting associated resource values and the environment.
  - The safety, health, welfare, social and economic benefits of completing these functions will enhance the education and employment opportunities for Michigan residents while preserving the environment.

OVERVIEW:

The restructured Michigan Geological Survey (MGS) has been active at the Western Michigan University Geosciences Department for just over five years. The primary functions mandated for the survey by the October 11, 2011 legislation include: investigation of the state’s geological natural resources, the collection and archival of geological samples, cores, cuttings, and the preservation of geological investigations. The purpose of the Michigan Geological Survey is to serve the state’s people, industry, and governmental agencies (the clients). The MGS activities continued to operate primarily on both Western Michigan University funding and MGS grant awards received until June 30, 2016.

MGS continues to apply for and receive grants and awards for research and studies on Michigan geology, the mission of the MGS. In 2016, the MGS and our Resource Centers of WMU Geosciences staff and adjuncts (Appendix II) have been awarded approximately $887,176 ($387,176 + $500,000 Special Appropriation) in new grant funding that applies to Michigan geology, as summarized below and in Appendix III. In addition, MGS and the Resource Centers staff have continuing grant funds of approximately $524,562, that apply to Michigan Geology for a combined total of approximately $1,411,738 ($911,738 + $500,000). NOTE: There is no annual funding that applies to pay for full time MGS staff, because this incremental funding will only support those studies and some staff until these funds are expended.

The MGS wishes to acknowledge the monetary support received from the 2016 Michigan Legislature in a one-time $500,000 Special Appropriation signed by the Governor in June 2016,
effective July 1, 2016. Specifically, the efforts of Representative Brandt Iden, in association with Representatives Al Pscholka and Aric Nesbit and other local and regional State Legislators, all of whom recognized the need for a greater understanding of the natural geologic resources of our State and the support of Western Michigan University administration in also recognizing the benefits to both Michigan and the University. The goal of the MGS is to be recognized as the “Go To” resource for geologic information in the state, both for the Lower Peninsula (LP) and the Upper Peninsula (UP).

Michigan has not committed sufficient funding or expertise on a continuing basis for many decades, over 30 years, to develop programs using proven and current scientific methods and technologies to assess and manage many of the valuable natural resources of this State. The natural resources include but are not limited to subsurface water, minerals, soils, limestone and other building and construction materials, sand, salt, oil, gas, and metallic and non-metallic ores. The Office of Oil Gas and Minerals of the Department of Environmental Quality compiles segments of geologic and other data and makes them publicly available on GeoWebFace, a good data resource. However, there is not a continuing budgeted effort to properly identify, assess and present new data to sustainably manage the use of most of the natural resources. A fully functional Survey cannot occur until permanent, annually recurring appropriations and funding is provided to hire permanent professional staff that can integrate with the State departments and the Legislature to conduct needed and prioritized scientific geologic research and data collection.

The proper use, management and sustainability of these natural resources will or can provide economic and in many cases recreational benefits to Michigan, which cannot be done effectively without valid scientific data. The geological survey is the most appropriate entity to provide unbiased documentation for the assessment to support the management and the potential economic development. MGS is the “go to” source to provide validated specific scientific geologic data to support the environmental and sustainable management of these natural resources by the State Quality of Life departments of Natural Resources (DNR), Environmental Quality (DEQ), Office of Great Lakes (OGL) Agriculture and Rural Development (MDARD) and the Department of Transportation (DOT).

The Special Allocation funds provided from the 2016 budget will have the Michigan Geological Survey (MGS) develop and demonstrate a process and programs that can address an initial suite of identified data voids. MGS has the capability to use practical geological methods and incorporate the current techniques and technology that can make both the assessment and presentation of the data in format(s) useable by all the stakeholders. MGS will then present an example of the technical process or programs to justify the establishment of an annual legislative budget for the Geological Survey to manage the natural resources going forward with unbiased validated data.

Presenting the justification of a functioning survey will require the identification and selection of demonstration programs and processes which is a multi-phased approach beginning with a research survey, drafting demonstration programs of studies to compliment the research survey, stakeholder meetings to confirm or modify and prioritization of the demonstration programs. MGS
has initiated this identification process through a research survey completed in September, reaching out to all stakeholders. This included identifying their profession as business, industry, environmental professionals/consultants, citizens, State Departments, social and ancestral indigenous groups and specifying what scientific information or documentation Michigan does not have available today to identify, understand, protect and sustainably manage our resources. This survey reached out to associations, individuals and businesses that may represent over 600 contacts.

The initial phase of this process is completed and MGS has drafted an initial 10 demonstration programs to address some of these issues and MGS is now meeting with stakeholders in personal and group sessions from mid-September to late January 2017 throughout the State (UP and LP) to confirm what is important in the near and long term timeframe. This will include an outline of possible programs or processes to meet the objective, justification for annual funding for the MGS. MGS will coordinate these demonstration projects with the DEQ-Office of Oil Gas and Minerals, who is managing the budget for this demonstration program, with the initial results presented in early to mid-2017 to document the need for legislative funding and will share these results as generated with the Quality of Life Departments (DEQ, DNR, MDARD, OGL) and MDOT.

MGS has met with local stakeholders subsequent to the completion of the initial research survey and the results indicated regional interest in research and studies associated with the identification of known or additional sources of groundwater for growing communities, the primary response. There are many areas of Michigan that may not have sufficient water to meet the demands of today or into the 21st Century. Initial stakeholder meetings were in the UP, at three universities, plus meeting with consultants and engineers at a conference. LP meetings included a presentation to the United Tribes conference of the twelve sovereign tribes in Manistee with the USGS Director, Dr. Suzette Kimball, plus the DEQ Outreach program in Roscommon. Other individual and meeting events are summarized in Appendix 1.

An initial demonstration project was identified and the City of Portage was approached because MGS has completed limited mapping and studies in the area and coupled with new geophysical techniques that are now available can search for buried bedrock valleys in contact with the glacial material. The presence of bedrock valleys may have the potential to document buried glacial systems that may contain unknown water resources in the glacial material, the source of Portage drinking water. This will couple the use of factual drilling data with geophysical techniques to support the identification of any bedrock valleys, a potential source of previously unknown water resources.

Also of special note, MGS submitted an unsolicited “Proof of Concept” proposal to the Groundwater Research and Education Foundation (GWREF), a foundation of the Ground Water Protection Council (GWPC) and MGS was successful. The awarded grant project will present a proof of concept in Calhoun County, using existing surficial geologic mapping data with indirect geophysical techniques to map buried bedrock valleys for potential water resources. This grant will
be one of the first MGS collaborative programs in years, where industry will provide 2D seismic data down to the estimated glacial/bedrock interface which will be integrated with MGS mapping results and the research staff will interpret the data to confirm data authenticity. In addition to the industry supplied 2D seismic data, there is funding for additional ground geophysics and confirmation drilling to support the proof of concept mapping process. Confirmation will provide a relatively low cost method of collaborative support from industry provided near surface 2D or 3D seismic to interpret the glacial thickness and the potential refined definition of the bedrock surface for the identification of bedrock valleys, sources of new water resources. This data package can then support the protection of those newly found resources from any proposed surface or subsurface activities that cannot be done in an environmentally safe manner. Success of the program can be extrapolated to many areas of Michigan and to other adjoining Great Lakes glacial sediment states and can support a more expedited assessment of those deeper bedrock associated water resources at a much lower cost.

A second demonstration example is associated with the rebuilding the Michigan infrastructure which has a major requirement for quality aggregates located in priority areas of infrastructure rebuilding and expansion. It has been postulated that known resources may not meet the quantity or quality of the projected need. This has been confirmed by MDOT, who just completed an assessment (October 2016, Michigan Aggregates, Market Study, Phase 1 Report) of current and known future aggregate resources in Michigan. There are vast areas of the State that do not have sufficient quality or quantity of aggregates with stone to meet the current needs after 10 to 15 years. More specifically, this aggregate resource will be greatly diminished when the Michigan prescribed infrastructure rebuilding program begins and then the life span of these resources will be less than 10 years. There is a current geographical high demand for aggregates supplies having sufficient stone and rock in the glacial material. MGS continues to use established surface mapping techniques in addition to sophisticated airborne tools, LiDAR (Light detection and Ranging) and GIS data output, to assist in the mapping process and allowing for identifying and presentation of the locations of favorable near surface geology that may contain aggregate resources previously not identified or extensions of the resource. Secondary geophysical tools have shown promise in some areas looking for the higher concentrations of the required stones.

Associated with this assessment of aggregate need, many Michigan residents may not be aware of what are the impacts from restricting aggregate operations in their county and then what are the future county or local tax increases and all other associated cost impacts for any construction projects they can impose on themselves for not being aware of the economic benefits of having a nearby source of aggregates. This resource can support their infrastructure installation and rebuilding required to maintain their current and future life style. Aggregates are a geological resource, located where they were deposited thousands to millions of years ago.

A third potential project will demonstrate the use of remote sensing data from the NASA Gravity Recovery and Climate Experiment (GRACE) satellites from 2002 to present collected over the last
13 years. This data has proven to address questions of long and short term impacts from water usage and storage in formations. In Michigan, this can perhaps be used to both manage and assess any possible impacts of water usage in regions of Michigan. SW Michigan is an area of possible importance to validate the data. Validated GRACE data requires surface data measurements to calibrate the imagery. MGS will be approaching the SW Michigan agricultural community to determine the availability of some of this data to confirm this remote data and compilation system can support monitoring the water resources of Michigan. Some of the surface data needed to quantify the GRACE analysis is soil moisture, stream levels and estimated water usage.

The MGS Director, John A. Yellich, has continued to both introduce and to update interested stakeholders to the progress the restructured survey has made across the state. The primary focus of many of these meetings was to present an overview of Michigan geology and the benefits that can accrue from a fully funded, functional geological survey supporting the evaluation of Michigan’s mineral, energy, and water resources. The meetings not only presented Michigan geology, natural and energy resources but highlighted the importance of the public access of the Michigan Geological Repository for Research and Education (MGRRE) core and data repository at WMU/MGS to the State. MGS has made approximately 120 presentations, meetings and discussions in the last three years to associations, committees and organizations that included: Michigan Manufacturers Association; Environmental and Mining Policy Committees; Michigan Groundwater Association; representatives of the Michigan Chamber of Commerce; Michigan Oil and Gas Association; Michigan Environmental Health Association; MI CAMP professionals; Ottawa County Planning Department; Department of Natural Resources, Environmental Quality, Agriculture and Redevelopment, Office of Great Lakes, officers, chiefs, Directors and staff; members of the Michigan sovereign tribes; and private individuals. All these contacts are associated with some aspects of agriculture, industry, municipal and rural growth, water resources, resource development, aggregate industry, and data management.

At all meetings and presentations, the MGS underscored the benefit and the need for state funding if the MGS is to provide the science needed to address critical geological issues. MGS and Michigan Technological University (MTU) have a formal Memorandum of Understanding (MoU) and MGS and a second MoU with Wayne State is in place and MGS is discussing a similar type of MoU agreement with Central Michigan University. The MGS Director met with the MTU Dean of the College of Geological and Mining Engineering and Science and Department of Geology Chair to review special projects and issues. Also discussions and meetings were held with Northern Michigan geosciences faculty and Lake Superior State University (LSSU) Department of Geology and Physics faculty to discuss UP interests and partnerships. Issues discussed were geologic mapping, airborne geophysical surveys, core repositories, and economic development in the UP supported by scientific research through the MGS, MTU and the MGRRE core repository data base at this time. The priorities recommended were state funding for core storage and coordinated data management to support economic development in the UP utilizing the scientists of MTU, LSSU and MGS and the MGRRE facility data systems.

Michigan is the only Great Lakes state that has not committed to any annual funding for either statewide or specific, local geologic mapping. For example, there are two mapping methods that can be independent, or are more efficient if they are integrated. Direct field mapping coupled with confirmation sampling or drill holes and the second, indirect airborne geophysics can provide an
expedited approach to a geologic and resource mapping program resulting in near term useable scientific data, but it must be ground proven or validated. This information would support future continued geologic and natural resource management and potential economic development in the state. Michigan funding to support the MGS mapping in Michigan was endorsed by Senator Tom Casperson to the House Legislative Budget Committee last April 2016. **NOTE: MGS cannot maximize the application for Federal USGS National Cooperative Geologic Mapping Program (NCGMP) matching funds, until there are direct monies or full time staff to use for the matching dollars.**

MGS has presented significant documentation in support of completing high quality LiDAR (Light Detection and Ranging) mapping programs in most areas of the State. Such a program could expedite geologic mapping in many areas of the Lower Peninsula. LiDAR also supports all facets of Michigan’s economic and business entities including agriculture, municipal development, drain commissioners, forestry, flood issues, aggregates and water resources. The LiDAR program, has finally garnered additional interest by many parties for implementation and completion using federal, state and local funding.

Quality airborne data collection associated with natural resources using airborne geophysics, the indirect measuring of earth’s physical properties, has not been done in Michigan. A USGS demonstration program was morally supported by MGS and many Michigan geoscientists and it was initiated in late spring, 2016. This was located in areas of the Upper Peninsula that have complex Precambrian geologic terranes buried under Paleozoic and glacial rock cover and the area is from Menominee to Gwinn and Iron Mountain to Escanaba. Such a study, when completed can potentially lead to the mapping and definition of geologic units and structure that is conducive to water, minerals or other buried resources.

The MGRRE core and data repository is the cornerstone of available Michigan Basin scientific geologic data and it represents an estimated $20 billion in savings to replace this data or the samples in over 560,000' of core, 20,000 well cuttings, >2,000 water well cuttings and electronic versions of all the logs and analytical data compiled on the MGRRE computers. MGS is seeking annual state legislative funding for survey staffing, and for core and data repositories that will combine the geologic data resources of MGRRE and would support data compilation programs that can be used at a repository in the UP as a collaborative data facility.

The MGS has an Advisory Council (Appendix IV) established at the time of the transfer of MGS to WMU in 2011. The members of the Council represent a cross section of interests for Michigan and they have been kept apprised of the initiatives and programs during this period. The members have provided guidance and input to these programs to garner State annual funding for MGS, MGRRE and our overall collaborative programs and MGS appreciates their volunteer efforts to support these initiatives and programs.

Attached, Appendix V, to this annual report is a summary of all 2016 Michigan geologic research, for all submitted proposals and awards, publications, map products, presentation abstracts, and reports completed by MGS, WMU, and known student researchers, an incremental testament of having ongoing research and the economic benefits of a functional geological survey, a Return on Investment (ROI).

**GENERAL - MICHIGAN GEOLOGICAL SURVEY ACTIVITIES AND ACHIEVEMENTS:**
RESOURCE CENTERS – Appendix II

MGRRE:

The Michigan Geological Repository for Research and Education (MGRRE) has served Michigan for over 30 years under the direction of Dr. William Harrison III. It continues to be the primary asset of the MGS. MGRRE conducted Petroleum Technology Transfer Council (PTTC) workshops in March and November of last year, with a combined attendance of over 180 industry professionals/consultants/regulators and companies a continuing the energy industry collaborative program for over 20 years. Samples and data were received and industry visits and meetings were conducted to present reports and review the data and samples.

Oil and Gas: The March PTTC conference in Mount Pleasant was the presentation of the multi-year research project by Dr. Chris Swezey of the USGS supported by MGRRE core, samples and data on the Michigan Basin. The project, “Geologic Assessment of Underground Oil and Gas Resources of the US portion of the Michigan Basin” was the result. This interpretive information was shared with industry, consultants and agency professionals. WMU geoscience students also presented many of their research projects to the industry representatives.

A follow-up PTTC program was held at MGRRE in November and continued to focus on the Dr. Chris Swezey report, “Geologic Assessment of Underground Oil and Gas Resources of the US portion of the Michigan Basin”. Industry professionals, students, consultants were invited to see, touch and look at more of the specific formation cores and data discussed in the Report.

This program is similar to those earlier PTTC workshops that resulted in the Collingwood, Antrim and Trenton Black River resurgences in oil and gas exploration and future discoveries in 2005, 2006, 2009, 2010 and 2013 where core samples from many of the formations were presented to the attendees to allow for hands on review and discussions. This is additional specific documentation that the MGRRE data resource has provided Michigan with new economic benefits.

Samples and core: MGRRE has been in receipt of many mineral samples throughout the years and this year the entire mineral collection of the Steve Wilson family, father and siblings was donated to WMU/MGS/MGRRE. We are pleased to receive this wonderful collection having many unique museum quality samples that are now on display. There were many duplicate mineral specimens and they were presented to the Geosciences department student Geology Club, who will sell them to support and defer field trip travel costs. A special thank you is extended to the Steve Wilson family for their generosity.

MGRRE was offered a number of unique sets of samples, cores and data this past year, which were previously under the control of two other Michigan universities, a Detroit area engineering firm and a private individual who no longer had a need for this data set. Three examples of data offered to MGRRE. The first, were university samples that totaled more than 150 pallets of core and cuttings samples from the earliest drilling in the Michigan and this was delivered in six semi-trailer truck loads. WMU/MGS has now formalized an MoU with Wayne State for continuing access to the core for their students, an ongoing benefit to Wayne State students. The Detroit engineering firm donated 17,000 feet of core, in 821 boxes from 230 shallow bedrock holes for an engineering project that did not receive funding. The core samples represent Antrim, Dundee and Traverse formations from SE Michigan, where there has been a minimum of drilling, testing and core
recovery for resources. Monetary donations were solicited from the past MGRRE supporters and they covered the incremental costs of the shelving for this unique set of Michigan core samples.

The next set were boxes of drill samples from some of the deepest wells drilled in Michigan, samples this person borrowed from another university that had donated all of their cuttings collection to MGRRE years ago. These samples are now combined with the existing set of cuttings. The last set of university samples were over 400 boxes of core from a bedrock groundwater study from at least two areas of the State, Saginaw and Battle Creek. They will be combined with the thin sections and data summaries currently at MGRRE.

The MGS and MGRRE has annually requested and received incremental funding for core, data storage, and other services through generous donations from industry sources.

Ongoing Studies and Grants: Listed below are some of the ongoing and most recent achievements that have emerged from the numerous requests and onsite researcher visits for data review at MGRRE. A summary of the value of the new 2016 grants, ongoing grants and submittals can be found in Appendix III.

The collaborative scientific program for carbon sequestration research in oil and gas reservoirs continues with funding by the Department of Energy (DOE). The program includes MGRRE/WMU, MGS, Midwest Regional Carbon Sequestration Partnership (MRCSP), Battelle National Laboratories, Memorial Institute, Core Energy, and the DOE. Requests for and review of geologic core, thin sections and wire line logs and other data are incorporated into this program. As a result of this program, Dr. William Harrison, Dr. David Barnes, Dr. Stephen Kaczmarek are conducting research with a number of students on the development of new Niagaran reef reservoir models. Additional benefits are a greater understanding of formations and areas and those formations having potential for gas storage, continuing to make Michigan the number one in the US for gas storage operations at more than a billion cubic feet.

MGRRE applied for and received a grant from the USGS-National Geological and Geophysical Data Preservation Program (NGGDPP) in support of their data capture and preservation functions. During 2016, 1500 well records were scanned and over 9,000 feet of core was reboxed and some of the well record data can be used to identify prospective wells and zones for secondary recovery, as well as for safe underground natural gas and CO2 storage. MGRRE researcher Lolita Krievs categorized, and confirmed well identities and uploaded the data to the National Catalog (http://ndc.sciencebase.gov) at the NGGDPP.

MGS continues to emphasize the importance of geologic data and the Return on Investment (ROI) from the systematic retention of core, drill samples, and geologic data in paper format, and its enhanced importance when converted to electronic formats.

As MGS has noted in previous presentations and annual reports, as both an indirect and direct result of MGRRE, a functioning core repository and data source, Michigan has been provided with major economic benefits in the last 12-15 years to include: State tax revenue, huge contributions to the Natural Resources Trust Fund and State royalties and major research efforts associated with Department of Energy and USGS grants for National programs associated with CO2 Sequestration and data management, respectively. Specifically, there has been no State funding provided to MGRRE and MGS to cover the costs or annual funding to maintain these services at a nationally
recognized research facility which has resulted in hundreds of millions of dollars to Michigan through these documented natural resource recovery benefits and the collaborative scientific work conducted by industry and other researchers at the MGRRE facility with the staff and students.

In addition, tens of successful collaborative student theses, industry and Federal agency research studies, and other geological programs conducted over the last 30 years are also documented and industry has graciously donated to show their appreciation. Yet as of this date, there has been no direct annual funding for MGRRE or MGS by the State of Michigan to support this ongoing data resource, which has shown tremendous scientific research and economic benefits.

**Surficial mapping cores and data:** The MGRRE repository is also the location for all of the drilling and coring samples from the surficial geologic mapping programs done in Michigan. These samples and the supporting data are cataloged and available for research on glacial and shallow bedrock geology, critical to understanding the water resources of Michigan.

**MGS and MGRRE Websites:** The number of contacts (hits) on a website is a measure of the importance of that information resource. The MGRRE and MGS website contacts indicate greater visibility with an increased public exposure and an increased number of data sets. Between 2012 and 2014, the number of unique requests at the MGRRE website (different ID for each request) increased from 17,838 to 27,425. However, during 2016, MGRRE changed to a new server and documentation was limited to a very limited number of days and the numbers do not accurately reflect the contacts, but are estimated at 1,008 unique IP addresses and more than 1,776 hits for this period, a very low estimate. The MGS website has been fully functional for the last three years and the number of unique IP requests for 2016 was at 2,616, approximately 220 per month.

**Geologic Mapping:** Dr. Alan Kehew and John Yellich, direct the MGS submittals to participate in, and submit projects in both of the USGS Federal National Cooperative Geologic Mapping Programs (NCGMP), STATEMAP, and Great Lakes Geologic Mapping Coalition programs, which provide matching Federal dollars for geologic mapping. This past year, the USGS mapping program awarded funding to map areas in both the Lower Peninsula, (Cass County – Vandalia, Jones, Mottville, Decatur and Marcellus Quadrangles) under the direction of Dr. Alan Kehew and John Yellich, and in the Upper Peninsula (Gogebic County – Bessemer; Dickinson County – Norway Quadrangles), under the direction of Dr. Joyashish Thakurta.

The emphasis in the two USGS mapping programs is concentrated in the areas of favorable geology for water and mineral resources for the Upper Peninsula, and for state-wide (UP and LP) aggregate and water resources. The need for accurate geologic data and aquifer characterization in the LP cannot be overestimated. The LP studies are being conducted with an introduction to a refined 3-D approach that includes a combination of surface geologic mapping with hand augering, trenching and confirmation of lithologies combined within a limited rotosonic, wireline or geoprobe drill coring program. The refined subsurface geologic mapping approach includes core samples and sieve analyses, down-hole geophysical logs, hand auger testing, and validated geologic logs from water well drillers. The combination of these components with available LiDAR imagery results in a more accurate geologic depiction of an area’s surface topography and its stratigraphic section. This increases the quality of the data used in assessing the potential areas for aggregate resources, the underlying water-bearing strata, and the potential availability of water for high production users.
such as the agricultural community. Quality LiDAR, if available, also allows for a more rapid assessment of the geology of areas where physical access maybe limited, and where field validation can be focused on mapping the continuity of the geology.

Groundwater, Data Bases, Resource Assessments: For review, the governor’s Water Use Advisory Council (WUAC), under the direction of the director of the DEQ, completed a two-year review of the water resource issues in the state in 2015. The WUAC supports the adoption of the Great Lakes Compact that requires permitting of large capacity water wells, and quantifies their impact on local stream flows. Local requests have been made to the MGS for information on the quality and quantity of the groundwater in certain areas of the state, but many of the requests cannot be supported by MGS, because the local or personal request does not have funding associated with any proposed study at this time.

One of the issues revealed by the WUAC was that available geologic data is not being used. The MGS recognizes that there is an abundance of geologic data that is not available for use in assessing our resources, which also includes aggregates as well as groundwater. This situation was presented and is described below.

The State of Michigan has numerous data sets and documents that are either in paper or microfiche format, along with various electronic databases. None of these data sets communicate with each other, nor are they retrievable in a uniform electronic format. There could be up to a million data sets that represent geologic information having an estimated minimum value of over $10 million ($10.00/) up to 1.0 billion.

Michigan risks the loss of a substantial portion of these data resources due to physical deterioration and lack of resources to cover the expense of proper management and physical storage. This is called “orphan data”. The inefficiency that is inherent in the use of outdated databases is substantial. The result is that state employees, and the public, spend unproductive time in both retrieving and sorting data before it can be effectively used.

It is obvious that there is a demand for a set of central electronic databases that could be used to archive standard geologic information into formats that are easily searchable and appropriate for the type of information requested. A centralized set of databases would make Michigan’s agencies more functional and time responsive. Properly prepared electronically formatted files would also provide the public with an expedited mechanism to fill FOIA requests, or to allow inquiry rather than personally handling paper files. The files would be made available through three electronic steps: request, receive, and review. A searchable electronically formatted document program would encourage greater use of available data, and would save manpower and time for both state employees and public users. For example, many of the databases could be supported by a multi-tiered fee structure, and users would have existing documents almost instantly available. Fees would cover the cost of continuing input and maintenance of electronic data.

Drillers Workshop and a DEQ Geologists Outreach Roscommon Stakeholder review: In 2015 and 2016, the MGS proposed a format for drill hole data entry by water well drillers to support more consistent, verifiable data for water resource studies. MGS conducted a training session for the drillers training workshop in February. A collaborative effort is being proposed by MGS to have the professional geologic community and the drillers input “standard” formatted data to the same data
base. Per discussions and feedback, MGS has confirmed that drillers and users of water well data would appreciate a standardized approach to data notation and entry of drill cuttings information to a standard format.

A standard approach to the logging of drill cuttings is a way for MGWA members to add real value to the non-standard datasets that exists today. This is ongoing discussion.

**Economic Geology:** Dr. Joyashish Thakurta, the Geosciences Department economic geologist / petrologist, has focused his research on the igneous and metamorphic rock suites of the Upper Peninsula of Michigan. His current UP research efforts are integrated into an overall program of mapping, sample collection, and geochemical analysis of little known geologic environments. He has written proposals to conduct research with mining companies that will allow students to sample and analyze data for their respective theses. As previously noted, MGS has been spearheading the endorsement of a USGS funded aeromagnetic demonstration project to be located in an area of buried Precambrian rock types that may contain favorable geology of social and economic importance. Dr. Thakurta has been surface mapping in parts of this proposed demonstration area. These programs offer the potential to stimulate assessment of the geology that would benefit the leasing of state and private land containing a potential for buried geologic targets.

**MGS GIS Data Management and MGS Store:** MGS continues to format new and historic maps and other documents to comply with ArcGIS standards. Dr. Peter Voice compiled this year, “Michigan Geology: a Bibliography” a summary of all the bibliographic documentation of over 7,000 references on Michigan geology from all sources including all research theses and dissertations that have not been published. Dr. Voice contacted each University library and was able to get the accurate references on documents that were little known to the public for tens of years. These references provide the path to acquire the papers or documents. Many of these documents and reports will be archived into the MGS Data Management system and others will have references of where they may be accessed, because of copyright issues, or no known copy was located. The MGS believes that there are many older Michigan publications and paper resources that need to be acquired and archived, in order that they can be made available to the scientific community and to the general public.

The State of Michigan did not have an accurate compilation of natural resource production using all available data sources. Dr. Peter Voice initiated and completed this compilation through assembling all the available natural resource production statistics from Michigan, USGS and other data sources compiled since the 1840’s until 2013, the last validated information, over 170 years. The efforts of Dr. Voice are commended for searching all these sources, in addition to the conversion of some of the production statistics to common values to assist in the interpretation of the data sets throughout the production period. This summary of the compilation and data can be found on the MGS website as a PDF-PPT of his research compilation effort [http://wmich.edu/sites/default/files/attachments/u584/2016/MI%20Resource%20Production%20P\_lots.pdf](http://wmich.edu/sites/default/files/attachments/u584/2016/MI%20Resource%20Production%20P\_lots.pdf).

**Outreach and CoreKids K-12 program:** Dr. Peter Voice has coordinated and directed the CoreKids K-12 program at MGS-MGRRE for over four years which has had increasing interest by the Michigan
education community. The program emphasizes the importance of earth science education of middle and high school students, and has evolved to include informing the adult community. Many teachers are now turning to the educational resources at the MGS-MGRRE facility and CoreKids. The number of contacts being made with students or with the general public at informal presentations, special events, or school sessions, has continued to be a success during the past year. With the help of many student colleagues they present interactive classroom modules explaining Michigan’s geologic history, natural resources, and hydrogeology. The program visited a number of schools over the last four years. Coupled with specific allied partners, the earth science related events such as the Michigan Department of Environmental Quality and the Kalamazoo Geological and Mineral Society Annual Show, the CoreKids program had 30 events this past 18 months. The program has also expanded to the eastern part of the state. Teachers are realizing the benefits of this program, and the MGS hopes to incorporate it into the State K-12 program going forward. Over the past 48 months, the program has interacted with 55,077 people including K-12 students, college students, teachers, professional geologists, and the general public.

CoreKids has cultivated allied partnerships over this four year period. As a result, there is now a total of seven partners, which include the University of Michigan, the Detroit Museum of Natural History, the Michigan State University Museum, the Michigan Mineralogical Society, and the Central Michigan Lapidary and Mineral Society. The program continued its association with the Cranbrook Institute of Science, the Kalamazoo Air Zoo, and the Kalamazoo Geological and Mineral Society. In addition, the CoreKids program strengthened its ties with the state teachers associations (Michigan Earth Science Teachers Association [MESTA] and Michigan Science Teachers Association [MSTA]).

Dr. Voice co-chaired the GO-MPS session at the Northcentral GSA meeting in 2016 in Urbana-Champaign, Illinois with Lisa Anderson (a WMU Geosciences Alumni).

The CoreKids program received a generous gift of $5,000 from the American Institute of Professional Geologists (AIPG). The CoreKids program (Dr. Peter Voice with Dr. Heather Petcovic) also submitted a National Science Foundation (NSF) proposal to support an online education portal focused on the resources of the MGRRE facility in the amount of $450,000, but was not awarded any funding for this excellent submittal.

**Geohazards:** MGS has initiated discussions with the USGS through the National Cooperative Geologic Mapping Program Director, John Brock; the Illinois State Geological Survey; and the Indiana Geological Survey to present a collaborative program for assessing the shoreline systems of Lake Michigan. The area of interest is the dune sands and their associated impacts on housing and the developing beach features and structures. These discussions have evolved to have a joint Great Lakes states, Federal and Canadian geological surveys meeting scheduled in April 4-6, 2017. The USGS, NOAA and other Federal agencies will join the state and Canadian geological surveys, with representatives of State Departments and university professional having an interest, to discuss how to establish research programs on active shorelines of the Great Lakes States. In addition, MGS will support emphasis on baseline data on the active shorelines of Michigan, Indiana and Illinois, particularly along Lake Michigan.

Particular interest is being discussed to map these areas with airborne surveys, perhaps using current or research technology in radar, LiDAR or other remote sensing methods in aircraft or
drones and using existing data, i.e. Interferometry to assess and track movements in centimeters per year of slope stability.

**Remote Sensing:** The MGS and the Remote Sensing Laboratory under the direction of Dr. Mohamed Sultan is preparing proposals to support satellite imaging and airborne geophysical surveys for mapping faults, karst features, water resources, and other geological features. The capabilities of the lab will be used to assess the history of water resources in SW Michigan, using the NASA Gravity Recovery and Climate Experiment (GRACE) satellites to demonstrate the ability to manage water resources with existing data. The primary emphasis has been in areas outside of the U.S., however, recent studies are being initiated for validation in the U.S. using tested, and proven, remote sensing techniques.

Attachments:
Appendix I- List of Natural Resource meetings
Appendix II – Resource Centers
Appendix III –MGS/WMU/MGRRE Grants and Contracts
Appendix IV – MGS Advisory Council members
Appendix V - MGS/WMU 2016 Publications and presentations
Appendix I

Natural Resource meetings

Post July 1, 2016
Summary of Stakeholder meetings, presentations and resource data collection sessions

1. September 8, 2016; Michigan Tech, Houghton; Dean- Wayne Pennington College of Engineering and Geology, Chair John Gierke, Geology-Hydrogeology.


3. October 7, 2016; WMU – Geosciences Department Advisory Council meeting, MGRRE

4. October 12, 2016, Roscommon, MI; DEQ Outreach program for all geologists in DEQ DNR, etc.

5. October 20, 2016, Marquette, MI. Society of Exploration Mineralogists and Engineers fall meeting presentation.

6. October 21, 2016, Lake Superior State University, Geology Dept, faculty and students presentation and discussions.

7. October 26, 2016, Little River Casino, Manistee, MI, Twelve Sovereign Tribe (United Tribes of Michigan Meeting) presentation and discussions with USGS Director Suzette Kimball.

8. December 1, 2016; AIPG meeting Ann Arbor, professional geologists, open discussion.

9. December 8, 2016; MOGA Board of Directors meeting presentation, Mount Pleasant.

Appendix III
Michigan Geological Survey, MGRRE, WMU Geosciences
Professional Activities Report for 2016

Michigan Related Research Grants and Contracts
MGS generated ~ $887,176 in NEW research grant funding in 2016

New Grants and Awards:

Michigan Geological Survey, a 2016 Michigan Legislative Special Appropriation funding: “Identifying the programs to assess the Natural Resources of Michigan” managed through the MDEQ-Office of Oil Gas and Minerals for the period 2016 to 2018 in the amount of $500,000.

Harrison, William B., III, 2016, National Geological and Geophysical Data Preservation Program
Funded by United States Geological Survey, $38,673

National Science Foundation: EAR-Instrumentation & Facilities, PI: S. Kaczmarek & A. Caruthers
“Acquisition of a handheld XRF spectrometer to enhance sedimentary and paleoenvironmental research, Award #1636441 ($76,771) 2016-2018

Yellich, J. A., Kelew, A.K and Thakurta, J.; USGS STATEMAP National Cooperative Geologic Mapping program (NCGMP) awarded 2016-2017 funding to Surface Map: Mottville 7.5 Minute Quadrangle, Cass County and the Iron Mountain 7.5 Minute Quadrangle in Dickinson and part of Wisconsin in the amount of $124,687 for both projects.

Yellich, J. A. and Kelew, A. K.; USGS Great Lakes Geologic Mapping Coalition a part of the NCGMP was awarded 2016-2017 funding for Surface Mapping the south ½ of the Decatur and Marcellus Quadrangles in Cass County in the amount of $72,524 for both quadrangles.

Yellich, J. A.; Sauck, W.; and Kelew, A. K.; Ground Water Research and Education Foundation of the Ground Water Protection Council of the National Ground Water Association awarded an unsolicited grant for a “Proof of concept/demonstration using geophysical methods to map water resources” 2016-2017 in the amount of $74,521.

Existing or continuing Grants and Awards: (~$524,562)
Barnes, David A. and William B. Harrison, III, 2014 to 2017, Reservoir Characterization and Petrophysical Studies in Niagaran-Silurian Northern Lower Michigan, Midwest Regional Carbon Sequestration Partnership, Phase III, Budget Period 4, Funded by Battelle Memorial Corp. (approximately) $150,000 per year

Kelew, A. E. and Yellich, J.A.; USGS Great Lakes Geologic Mapping Coalition, Surficial Geologic Mapping Cass County, Michigan; two mapping projects; 1. Jones 7 1/2 Minute Quadrangle, and continue Barry and Calhoun County composite maps; and 2. Vandalia 7 ½ Minute Quad to initiate a county composite map,. 2016-17; $72,500 USGS award for the two projects
Yellich, J.A.; MDEQ, MDNR, Office of Great Lakes will support the Vandalia mapping project in the amount of $44,000, the first State funds since the USGS program began, to match Federal funds.

2015-17 “The influence of road salt deicers on the chemistry of Michigan lakes”, Michigan Department of Environmental Quality (co-PI’s: Dr. Carla M. Koretsky & Dr. Kathryn Docherty), $32,262

Kehew, A.E. and Thakurta, J.; USGS STATEMAP National Cooperative Geologic Mapping program awarded 2016-2017 funding to Surface Geologic Map: Duck Lake and Springport 7.5 Minute Quadrangles, Calhoun and Eaton Counties; and Surficial Geologic Map: Norway and Bessemer 7.5 Minute Quadrangles, Dickinson and Gogebic Counties, Michigan, in the amount of $104,000 for both projects.


**USGS Quadrangle Maps produced and published in 2016:**

Thakurta, J., 2016, Bedrock Geology of the Norway 7.5 Minute Quadrangle, Dickinson County, Michigan, Bedrock Geologic Map Series BGM-16-01, scale 1:24000.

Thakurta, J., 2016, Surficial Geology of the Bessemer 7.5 Minute Quadrangle, Gogebic County, Michigan, Surficial Geologic Map Series SGM-16-02, scale 1:24000.


**Proposals submitted in 2016 and still pending, funding would be in 2017 and beyond**

## Michigan Geological Survey, Advisory Council

<table>
<thead>
<tr>
<th>NAME</th>
<th>AFFILIATION, PROFESSIONAL INTEREST AND (OTHER)</th>
<th>PRIMARY PHONE CONTACT</th>
<th>EMAIL</th>
<th>ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>John A. Yellich</td>
<td>Director Michigan Geological Survey, Western Michigan University, Dept. of Geosciences</td>
<td>303-901-2886(M)</td>
<td><a href="mailto:john.a.yellich@wmich.edu">john.a.yellich@wmich.edu</a></td>
<td>517-341-5458 (W) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>Ali Kehew</td>
<td>Departmental Chair, Geosciences Department, Western Michigan University, Dept. of Geosciences</td>
<td>269-387-5495</td>
<td><a href="mailto:akehew@wmich.edu">akehew@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>Mohamed Sultan</td>
<td>Director of the MGS - MGIRIE and MGRRE core repository at WMU, WMU Geosciences Department</td>
<td>269-387-5451</td>
<td><a href="mailto:mohamed.sultan@wmich.edu">mohamed.sultan@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>William Harrison</td>
<td>Director of the MGS - MGIRIE and MGRRE core repository at WMU, WMU Geosciences Department</td>
<td>269-387-6001</td>
<td><a href="mailto:wharrisonII@wmich.edu">wharrisonII@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>Ali Kehew</td>
<td>Consultant, Geosciences Department, Western Michigan University, Dept. of Geosciences</td>
<td>269-387-5495</td>
<td><a href="mailto:akehew@wmich.edu">akehew@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>John A. Yellich</td>
<td>Director Michigan Geological Survey, Western Michigan University, Dept. of Geosciences</td>
<td>303-901-2886(M)</td>
<td><a href="mailto:john.a.yellich@wmich.edu">john.a.yellich@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
</tbody>
</table>

### Ex-Officio Members

<table>
<thead>
<tr>
<th>NAME</th>
<th>AFFILIATION, PROFESSIONAL INTEREST AND (OTHER)</th>
<th>PRIMARY PHONE CONTACT</th>
<th>EMAIL</th>
<th>ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greg Skopec</td>
<td>WMU/VP Government Affairs (State and Federal)</td>
<td>269-387-2072(W)</td>
<td><a href="mailto:gskopec@wmich.edu">gskopec@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
<tr>
<td>Katie M. John</td>
<td>WMU/Director of Government Affairs (State and Federal)</td>
<td>269-387-3006</td>
<td><a href="mailto:kmjohn@wmich.edu">kmjohn@wmich.edu</a></td>
<td>303-901-2886 (M) 1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241</td>
</tr>
</tbody>
</table>
Appendix V

Publications and Published Abstracts of Professional Presentations - 2016
(Student Authors are Highlighted in Bold)


Kehew, Alan E., Esch, John M., and Karki, Sita, 2016, Post LGM dynamics and basal drainage regime of the Saginaw Lobe, south-central Michigan:

Voice, Peter J., and Harrison III, William B., Clinton-type deposits in the Michigan basin: a preliminary discussion of the significance of Lower Silurian hematitic, phosphatic grainstones in Western Michigan, Geological Society of America Abstracts with Programs, v. 48, no. 5,

Harrison, III, William, Voice, Peter J. and Caruthers, Andrew, Salina Group Lithofacies in the Michigan Basin: A Review from A to G, Geological Society of America Abstracts with Programs, v. 48, no. 5,

Harrison, III, William B., Antrim Shale Natural Gas Play in Michigan: 30 years later, A Retrospective; Ontario Petroleum Institute Annual Meeting, May 4-6, 2016

Rine, M., C02 Sequestration in the Michigan Subsurface (oral), Kalamazoo Geological and Mineral Society, Portage, MI, September 2016


Rine, M., Caruthers, A., Kaczmarek, S., Barnes, D., and Harrison III, W., 2016, Using a combination of chemo-, bio-, and sequence stratigraphy to resolve the chronostratigraphic relationships of Niagara-Lower Salina Reef Complexes throughout the Michigan Basin (poster), Michigan Petroleum Technology Transfer Council Conference, March, Mt. Pleasant, MI

Rine, M., Kaczmarek, S., Barnes, D., and Harrison III, W., The importance of geologic study for the application of carbon capture and storage (CCS) in Otsego County, Michigan (poster), WMU Graduate College Creative Poster Competition, April, 2016, Kalamazoo, MI, Best Student Poster Award.