**PROJECT TITLE: Mapping Lake Superior’s Changing Biogeochemistry**

1. **PROJECT STATEMENT:**

**Using new high-resolution remote-sensing imagery, we will map the impact of storm events on water quality across western Lake Superior to help optimize soil and water conservation efforts.**

As climate changes, more frequent intense rain events (z.umn.edu/48fi) and land use changes threaten the quality of the clear waters of Lake Superior. Both increase the amounts of nutrients and sediments reaching the lake, which impacts water quality and may compromise ecosystem services such as drinking water or recreation.

Water quality varies across the lake and over time. Tracking and mapping these variations is crucial to understanding how land and lake interact and how the lake system sustains and recovers from events such as snowmelt or major storms. Water quality is currently monitored along the coastal zone but not across the off-shore zone (90% of the surface of the lake in MN), due to the high cost of direct off-shore sampling and sensing from ships. Our project will try to establish off-shore monitoring by taking advantage of newly available high-resolution and high-frequency satellite imagery to drastically reduce the need for direct in-lake sampling/sensing.

The main hypothesis is that the high-resolution (small pixels) should make it easier to correlate the satellite imagery to important water quality parameters such as temperature, sediments, nutrients, organic matter, and chlorophyll. If such correlations between imagery and water samples can be well established, it will be possible to cheaply derive **high-resolution maps of water quality estimates in near real-time from new satellite images**, as well as to reconstitute maps for past events, provided images are available (**goal 1**).

Those maps will help **to understand where, when and how “hot-spots” of poor water quality form, and to link them back to contributions from specific watersheds or portions of shore** (**goal 2**). Based on this information, and building on existing work on erosion risk, we will be able **to identify critical land areas that need to be prioritized for soil & water conservation efforts (goal 3**), which might include protection from certain land uses. Deliverables will include publicly available online maps of lake and land for use by scientists, managers, as well as for the education of the general public.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1 Title: Mapping of water quality and problematic “hot-spots” in Lake Superior**

We will address Goals 1 and 2 by collecting surface water-quality samples and sending in-water sensors to investigate light and temperature regimes throughout the water column in western Lake Superior in July/August 2020 (when the lake is subject to nearshore algae blooms), May 2021 (when the lake is impacted by snowmelt), and June/July 2021 (season of recent large storms in the watershed). We will sample regions visibly impacted by events (“plumes” or algae blooms) as well as clear-water portions of the lake. These field data will be matched with satellite data for the same dates, to establish correlations between remote imagery and water quality measured in the lake. These correlations will be used to create maps of water quality parameters across the lake, which can be updated based on new satellite data. These maps will highlight “hot spots” of temperature, total suspended solids (TSS), nutrients, and chlorophyll. This is a cost-effective way to get key information to managers about the current and future locations of waters impacted by TSS, high nutrient loads or algae blooms.

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| **Outcome** | **Completion date** |
| Measurement of in-lake water quality data (3 campaigns, about 820 samples)  | October 2021 |
| Development of predictive satellite/in-lake data correlations | January 2022 |
| Mapping of lake “hot spots” using satellite data and in-lake to satellite data correlations | June 2022 |
| ENRTF budget: $235,514 (82% of total budget) |  |

**Activity 2: Linking problematic “hot-spots” to contributing or at-risk land areas to promote and prioritize conservation efforts**

Activity 2 will bridge the common gap between science and policy. We will work with partners, starting with local Soil & Water Conservation Districts, to develop a web site presenting the results from activity 1 through online maps and spatial analysis tools that they will use to prioritize conservation actions with the greatest impact on the lake and to educate the public. A Sea Grant outreach specialist will work on further dissemination and help to adapt the final product to varied audiences.

We will address goals 2 and 3 with two main priorities. First, we will determine with our partners which types of visualizations best identify where the materials that will form “hot-spots” of degraded water quality enter the lake after weather events (specific streams, specific portions of shore). Since in-lake water circulation is complex, larger inputs from land will not necessarily generate larger “hot-spots”. Managers need efficient visualizations to identify which inputs are most harmful. Once these have been identified, the second priority will be to determine, within those specific watersheds or along those specific portions of shore, the land areas that likely contribute the most materials, as well as land areas whose contribution would greatly increase in case of unfavorable land cover changes. We will build on existing soil erosion and water quality risk datasets from the MN Board of Water and Soil Resources. Once again, we will work with our partners to create visualizations/simulations that best link what happens on land to what ends up happening in the lake.

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| **Outcome** | **Completion date** |
| Recruitment of partners/prospective users for co-development and testing of visualizations and tools  | May 2021 |
| Development of cartographic visualizations to link “hot-spots” to contributions from land | October 2022 |
| Development of spatial analysis tools and/or cartographic visualizations to identify principal land areas contributing or at-risk to contribute to lake “hot-spots”  | June 2022 |

ENRTF budget: $50,678 (18% of total budget)

**III. PROJECT PARTNERS AND COLLABORATORS**

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| ***Partners receiving ENRTF funding:*** | ***Partners not receiving ENRTF funding:*** |
| - GAC - Geospatial Analysis Center (director: Stacey Stark)- SeaGrant (Environmental literacy educator: Marte Kitson) | - GLOS- Great Lake Observing System (via Jay Austin from the Large Lakes Observatory)- South Saint-Louis County Soil & Water Conservation District (Manager: R.C. Boheim)- Lake County Soil & Water Conservation District (Acting Manager: Karen Tucker) |

**IV. LONG TERM IMPLEMENTATION AND FUNDING**

The final deliverable will be a web atlas somewhat similar to what has been created for the MN atlas of natural resources ([z.umn.edu/48fg](https://z.umn.edu/48fg)), focused on the Lake Superior region and offering more advanced visualizations and tools. It will feature maps of the lake water quality that are currently lacking and visualizations that highlight land/lake interactions. The site will be hosted by UMD’s Geospatial Analysis Center for several years after the end of the project. This project is a proof of concept for a methodology that creates and disseminates actionable knowledge to a variety of constituencies interested in protecting the waters of Lake Superior, at a time where more frequent major storm events bring novel and dramatic consequences such as algae blooms. We anticipate that upon successful completion, federal agencies could be interested in prolonging and expanding this monitoring effort to the entire Great Lakes basin.

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:** Budget Spreadsheet, Map/ Visual component, Project Manager Qualifications and Organization Description