**Lake Superior NERR (LKS)** **NERR Meteorological Metadata**

**January through December, 2019**

**Latest Update: January 22, 2021**

**I. Data Set and Research Descriptors**

**1) Principal investigator(s) and contact persons –**

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**2) Entry verification –**

Data are uploaded from the CR1000 data logger to a ruggedized laptop with a Windows 7 or newer operating system. Data files are transferred to a Personal Computer via flash drive. Files are opened and exported from LoggerNet in a comma-delimited format and uploaded to the CDMO where they undergo automated primary QAQC and become part of the CDMO’s online provisional database. During primary QAQC, data are flagged if they are missing or out of sensor range. The edited file is then returned to the Reserve where it is opened in Microsoft Excel and processed using the CDMO’s NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged data and summary statistics, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, append files, and export the resulting data file to the CDMO for tertiary QAQC and assimilation into the CDMO’s authoritative online database. For more information on QAQC flags and QAQC codes, see Sections 11 and 12.

Hannah Ramage (Monitoring Coordinator) is responsible for all data management.

**3) Research objectives –**

The Lake Superior NERR is situated on the freshwater estuary at the confluence of the St. Louis River and Lake Superior, the largest and most pristine of the Great Lakes. The Reserve is a diverse, 16,697-acre complex that contains a variety of representative terrestrial and aquatic habitats allowing for extensive research and educational opportunities. The Reserve provides opportunities for research and monitoring, experiential learning, and training while continuing to contribute to the protection of the ecological health of the St. Louis River freshwater estuary and Lake Superior coastal habitats.

The Lake Superior NERR implements the NERR System-Wide Monitoring Program (SWMP). This includes four continuous water quality monitoring stations with monthly nutrient and chlorophyll sampling, a meteorological station, and monthly sampling at one site consisting of 12 nutrient and chlorophyll samples collected over a 24-hour period. Data is archived at the Centralized Data Management Office (CDMO) as per established protocols. During the 2019 open water season, four continuous water quality stations were operational. Samples were taken monthly for nutrients and chlorophyll *a*. These samples were analyzed in the Reserve Lab, according to written Standard Operating Procedures.

The SWMP weather station and data sonde site was established in Pokegama Bay (2013) and is the central location of a developing Great Lakes climate change Sentinel Site. The LSNERR climate change effects research site (Sentinel Site) is now operational with the focus of measuring the impacts of storm events on sediment delivery, basin morphology, and the consequences to aquatic plant communities, specifically wild rice.

To promote information access by the public in a timely manner, the LKS NERR provides real-time water quality and meteorological information using telemetry systems (satellite and cellular). This information will be used in the Coastal Training Program (CTP) and Education programs and is available to the public online and on an interactive display in the Lake Superior Estuarium.

**4) Research methods –**

Campbell Scientific data telemetry equipment was installed at the Pokegama Bay meteorological station (PO) in July, 2013, and transmits data to the NOAA GOES satellite, NESDIS ID #3B048454. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen-minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The “real-time” telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO’s authoritative online database. Provisional and authoritative data are available at [http://cdmo.baruch.sc.edu](http://cdmo.baruch.sc.edu/).

All data are collected in Central Standard Time (CST).

Data collection information:

The 15 minute Data are collected in the following formats for the **CR1000**:

Averages from 5-second data:

Air Temperature (°C), Relative Humidity (%), Barometric Pressure (mb), Wind Speed (m/s), Wind Direction (degrees), Battery Voltage (volts), and Total Solar Radiation (W/m2) (available from the reserve)

Maximum and Minimum Air Temperature (°C) and their times from 5-second data (these data are available from the Reserve)

Maximum Wind Speed (m/s) and time from 5-second data

Wind Direction Standard Deviation (degrees)

Totals:

Precipitation (mm), PAR (millimoles/m2), and Cumulative Precipitation (mm) (Cumulative precipitation is no longer available via export from the CDMO. Please contact the Reserve or the CDMO for more information or to obtain these data.)

Calibration information:

The recommended calibration frequency for the MET station sensors were followed:

- Temperature/Humidity- yearly recalibration

- Rain Gauge- yearly recalibration

- Wind Speed/Direction- yearly or every 2 years (depending on the sensor)

- Barometric Pressure- every 2 years recalibration

- PAR- every 2 years recalibration

- CR1000-every 5 years (required beginning 2014, one year initial grace period)

- Total Solar Radiation – every 2 years recalibration, with recalibrations performed during the spring and summer

**5) Site location and character –**

The Lake Superior NERR is located within the estuary of the St. Louis River. The St. Louis River watershed covers approximately 3,634 square miles in northeast Minnesota and 263 square miles in northwest Wisconsin. In the upper watershed the river flows through lake clays and glacial deposits for approximately 100 miles. Near the city of Thompson the channel narrows and the river flows through a rocky rapid-filled gorge. Approximately 23 river miles upstream from Lake Superior is the Fond du Lac dam, the lowest of several dams. Below the gorge and dams the river begins to take on the characteristics of a fresh water estuary. At the mouth of the river is the largest working commercial harbor on the Great Lakes.

The MET three-meter instrument tower is mounted on a nine-foot metal platform embedded at the bank (by helical anchors in the river bed) of the Pokegama River, within the Superior Municipal Forest, such that there is no shading and minimal wind block. Sensors are placed on the tower according to the CDMO MET manual, with the exception of the rain sensor which sits at the western corner of the platform. The immediate surrounding area is riverine wetland, rising gently in elevation to forest. The Pokegama River is a tributary to the St. Louis River, entering the estuary on the Wisconsin side of Clough Island. The Pokegama River watershed measures approximately 20,144 acres, 51% of which is wetland, 37% forested, 4% developed and 6% agricultural use (the remainder is bare land or open water).

A SWMP water quality monitoring sonde was added to this station in September, 2013.

MET Geographical Location until 03/20/2018: 46.672360 -92.135614

Platform base installed at shoreline at an altitude approximately 189 meters above sea level. The 1.9 m2 metal platform sits 2.5 m above the adjacent land surface (river berm).

MET Geographical Location after 03/20/2018: 46.672307 -92.135547 (approximated)

Platform base installed on the berm/shoreline of the river out of any water flow at an altitude approximately 189 meters above sea level. When the lake level is high there is up to 0.5m standing water underneath the platform. The metal platform sits about 2.5 m above the river bottom.

The three-meter instrument tower sits on the platform such that the sensors are at the following heights;

Sensor heights in meters from platform (from river bottom)

Temperature and Humidity: 1.75 m (4.3 m)

PAR and TotSoRad: 3 m (5.5 m)

Wind: 3.5 m (6 m)

Rain: 1.1 m (3.7 m)

Distance to Oliver Bridge SWMP site: 5,350.0 meters

to Blatnik Bridge SWMP site: 8,925.7 meters

to Barkers Island SWMP site: 7,796.6 meters

SWMP Station Timeline

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Station Code | SWMP Status | Station Name | Location | Active Dates | Reason Decommissioned | Notes |
| LKSPOMET | P | Pokegama Bay | 46° 40' 20.50 N,  92° 8' 8.21 W | 08/15/2013 -03/20/2018 | move due to ice-jacking | Station moved 10m to NW |
| LKSPOMET | P | Pokegama Bay | 46°40'20.31 N, 92°08'07.97W | 03/20/2018 - | NA |  |

**6) Data collection period –**

|  |  |  |
| --- | --- | --- |
| File Start Date and Time | File end Date and Time | Notes |
| 10/02/2018 13:15 | 1/23/2019 14:00 |  |
| 1/23/2019 14:15 | 3/20/2019 13:45 |  |
| 3/20/2019 14:00 | 3/20/2019 15:45 | No data file, station powered down for sensor maintenance |
| 3/20/2019 16:00 | 5/07/2019 9:15 |  |
| 5/07/2019 9:30 | 6/14/2019 11:00 |  |
| 6/14/2019 11:15 | 7/9/2019 11:00 |  |
| 7/9/2019 11:15 | 8/20/2019 10:00 |  |
| 8/20/2019 10:15 | 10/08/2019 8:15 |  |
| 10/08/2019 8:30 | 01/24/2020 10:45 |  |

**7) Distribution –**

NOAA retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data.  The NERRS retains the right to be fully credited for having collected and process the data.  Following academic courtesy standards, the NERR site where the data were collected should be contacted and fully acknowledged in any subsequent publications in which any part of the data are used.  The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement.  The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons.  The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

Requested citation format:

NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: <http://www.nerrsdata.org/>; *accessed* 12 October 2019.

NERR meteorological data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Principal Investigators and Contact Persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page [www.nerrsdata.org](http://www.nerrsdata.org).  Data are available in comma delimited format.

**8) Associated researchers and projects –**

As part of the SWMP long-term monitoring program, LKS NERR also monitors 15-minute water quality along with monthly grab samples and diel sampling for nutrient data which may be correlated with this meteorological dataset. These data are available at [www.nerrsdata.org](http://www.nerrsdata.org).

**II. Physical Structure Descriptors**

**9) Sensor specifications –**

**Parameter: Temperature**

Units: Celsius

Sensor type: Platinum resistance temperature detector (PRT)

Model #: HMP45C Temperature and Relative Humidity Probe

Operating Temperature: -40°C to +60°C

Range: -40°C to +60°C

Accuracy: ± 0.2 °C @ 20°C

Serial Number: F454006

Date of Last Calibration: 10/29/2018

Dates of Sensor Use: 03/20/2019 – current as of 05/07/2020

Serial Number: F4540095

Date of Last Calibration: 02/28/2017

Dates of Sensor Use: 04/04/2017 – 03/20/2019

**Parameter: Relative Humidity**

Units: Percent

Sensor type: Vaisala HUMICAP© 180 capacitive relative humidity sensor

Model #: HMP45C Temperature and Relative Humidity Probe

Range: 0-100% non-condensing

Accuracy at 20°C: +/- 2% RH (0-90%) and +/- 3% (90-100%)

Temperature dependence of RH measurement: +/- 0.05% RH/°C

Serial Number: F454006

Date of Last Calibration: 10/29/2018

Dates of Sensor Use: 03/20/2019 – current as of 05/07/2020

Serial Number: F4540095

Date of Last Calibration: 02/28/2017

Dates of Sensor Use: 04/04/2017 – 03/20/2019

**Parameter: Barometric Pressure**

Units: millibars (mb)

Sensor type: Vaisala Barocap © silicon capacitive pressure sensor

Model #: CS-106 (Vaisala PTB110)

Operating Range: Pressure: 600 to 1060 mb; Temperature: -40°C to +60°C;

Humidity: non-condensing

Accuracy: ± 0.5 mb @ 20°C; +/- 2 mb @ 0°C to 40°C; +/- 4 mb @ -20°C to 45°C; +/- 6 mb @ -40°C to 60°C

Stability: ± 0.1 mb per year

Serial Number: G3260090

Date of Last Calibration: 10/30/2018

Dates of Sensor Use: 03/20/2019 – current as of 05/07/2020

Serial Number: G3260032

Date of Last Calibration: 02/29/2016

Dates of Sensor Use: 06/08/2016 – 03/20/2019

**Parameter: Wind speed**

Units: meter per second (m/s)

Sensor type: 18 cm diameter 4-blade helicoids propeller molded of polypropylene

Model #: R.M. Young 05103 Wind Monitor

Range: 0-60 m/s (134 mph); gust survival 100 m/s (220 mph)

Accuracy: +/- 0.3 m/s

Serial Number WM110138

Date of Last Calibration: 10/30/2018

Dates of Sensor Use: 08/20/2019 – current as of 05/07/2020

Serial Number: WM110137

Date of last calibration: 02/05/2016

Dates of Sensor Use: 06/08/2016- 08/20/2019

**Parameter: Wind direction**

Units: degrees

Sensor type: balanced vane, 38 cm turning radius

Model #: R.M. Young 05103 Wind Monitor

Range: 0-60 m/s (134 mph); gust survival 100 m/s (220 mph)

Accuracy: +/- 0.3 m/s

Serial Number WM110138

Date of Last Calibration: 10/30/2018

Dates of Sensor Use: 08/20/2019 – current as of 05/07/2020

Serial Number: WM110137

Date of last calibration: 02/05/2016

Dates of Sensor Use: 06/08/2016- 08/20/2019

**Parameter: Photosynthetically Active Radiation (PAR)**

Units: mmoles m-2 (total flux)

Sensor type: High stability silicon photovoltaic detector (blue enhanced)

Model #: LI190SB

Light spectrum waveband: 400 to 700 nm

Temperature dependence: 0.15% per °C maximum

Stability: <±2% change over 1 yr

Operating Temperature: -40°C to 65°C; Humidity: 0 to 100%

Sensitivity: typically 5 µA per 1000 µmoles s-1 m-2

Serial Number: Q45936

Multiplier: 1.25617, 08/15/2013

Date of Last Calibration: 02/03/2016

Dates of Sensor Use: 06/08/2016 –03/20/2019

Serial Number: Q45947

Multiplier: 1.47824, 03/20/2019

Date of Last Calibration: 11/05/2018

Dates of Sensor Use: 03/20/2019 – 08/20/2019

**Parameter: Photosynthetically Active Radiation (PAR)**

Units: mmoles m-2 (total flux)

Sensor type: cast acrylic diffuser (filter) and photodiode

Model #: SQ110

Light spectrum waveband: 410 to 655 nm

Temperature response: 0.06 +/- 0.06% per °C

Stability: <±2% change over 1 yr

Operating Temperature: -40°C to 70°C; Humidity: 0 to 100%

Sensitivity: typically 0.2 µmoles s-1 m-2

Serial Number: SQ-1100SS\_28857

Multiplier: 0.025, 08/20/2019

Date of Last Calibration: 05/10/2019

Dates of Sensor Use: 8/20/2019 – current as of 05/07/2020

**Parameter: Total Solar Radiation**

Units: W m-2

Sensor Type: high stability silicon photovoltaic detector

Model #: LI200S

Light Spectrum Waveband: 400 to 1100 nm

Temperature dependence: 0.15% per oC maximum

Stability: <+/- 2% change over 1 year

Operating Temperature: -40oC to 65oC; Humidity: 0 to 100%

Sensitivity: typically 90 uA per 100 W m-2

Serial Number: PY74852

Multiplier: 112.233, 03/20/2019

Date of Last Calibration: 11/05/2019

Dates of Sensor Use: 03/20/2019 – current as of 05/07/2020

Serial Number: PY74880

Multiplier: 108.2368, 08/15/2013

Date of Last Calibration: 02/03/2016

Dates of Sensor Use: 06/08/2016– 03/20/2019

**Parameter: Precipitation (unheated rain gauge)**

Units: millimeters (mm)

Sensor type: Tipping Bucket Rain Gauge (Texas Instruments)

Model #: TR-525I

Rainfall per tip: 0.01 inch

Operating range: Temperature: 0° to 50°C; Humidity: 0 to 100%

Accuracy: +/- 1.0% up to 1 in./hr; +0, -3% from 1 to 2 in./hr; +0, -5% from 2 to 3 in./hr

Serial Number: 48686-711

Date of Last Calibration: 06/08/2016

Dates of Sensor Use: 02/20/2017 – 03/26/2019

Serial Number: 48685-711

Date of Last Calibration: 12/04/2018

Dates of Sensor Use: 03/26/2019 – current as of 05/07/2020

The CR1000 has 2 MB of Flash EEPROM that is used to store the Operating System. Another 128 K Flash is used to store configuration settings. A minimum of 2 MB SRAM is (4 MB optional upgrade) available for program storage (16K), operating system use, and data storage. Additional storage is available by using a compact flash card in the optional CFM100 Compact Flash Module.

**Date CR1000 Installed:** 06/08/2016

**Date CR1000 Calibrated:** 09/15/2015

**CR1000 Firmware Version (s):** *LoggerNet Version 4.1(update date unknown)*

**CR1000 Program Version(s):**  *lkspomet\_VER5.5\_06072016.cri; lkspomet\_CR1000\_5.5\_032019.cri; lkspomet\_CR1000\_5.5\_082019.cri*

**10) Coded variable definitions -**

Sampling station: Sampling site code: Station code:

Pokegama Bay PO lkspomet

**11) QAQC flag definitions –**

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter’s associated flag column (header preceded by an F\_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is above or below sensor range, or missing. All remaining data are then flagged 0, as passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

-5 Outside High Sensor Range

-4 Outside Low Sensor Range

-3 Data Rejected due to QAQC

-2 Missing Data

-1 Optional SWMP supported Parameter

0 Passed Initial QAQC Checks

1 Suspect Data

2 *Open - reserved for later flag*

3 *Open - reserved for later flag*

4 Historical Data: Pre-Auto QAQC

5 Corrected Data

**12) QAQC code definitions** –

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories, general, sensor, and comment. General errors document general problems with the CR1000, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an \* below) can be applied to the entire record in the F\_Record column.

General Errors

GIM Instrument malfunction

GIT Instrument recording error, recovered telemetry data

GMC No instrument deployed due to maintenance/calibration

GMT Instrument maintenance

GPD Power down

GPF Power failure / low battery

GPR Program reload

GQR Data rejected due to QA/QC checks

GSM See metadata

Sensor Errors

SDG Suspect due to sensor diagnostics

SIC Incorrect calibration constant, multiplier or offset

SIW Incorrect wiring

SMT Sensor maintenance

SNV Negative value

SOC Out of calibration

SQR Data rejected due to QAQC checks

SSD Sensor drift

SSN Not a number / unknown value

SSM Sensor malfunction

SSR Sensor removed

Comments

CAF Acceptable calibration/accuracy error of sensor

CCU Cause unknown

CDF Data appear to fit conditions

CML Snow melt from previous snowfall event

CRE\* Significant rain event

CSM\* See metadata

CVT\* Possible vandalism/tampering

CWE\* Significant weather event

**13) Other remarks/notes** –

Data are missing due to equipment or associated specific sensors not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for “not a number” and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Small negative PAR values are within range of the LI-COR sensor and are due to normal errors in the sensor and the CR1000 Datalogger. The Maximum signal noise error for the LI-COR sensor is +/- 2.214 mmoles/m2 over a 15-minute interval. These values are automatically flagged and coded as <1> (CAF).

Relative Humidity data greater than 100 are within range of the sensor accuracy of +/-3% and are flagged and coded as suspect, <1> (CAF). Values greater than 103 are rejected <-3>.

Data recorded for all parameters (with the exception of cumulative precipitation) at the midnight timestamp (00:00) are the 15-minute averages and totals for the 23:45-23:59 time period of the previous day. Cumulative precipitation data at the midnight timestamp (00:00) are the sum of raw (unrounded) precipitation data from 00:00 to 23:59 of the previous day. Summing each individual 15-minute total precipitation value from the same period will result in small differences from cumulative precipitation due to rounding. It is especially important to note how data at the midnight timestamp are recorded when using January 1st and December 31st data. **Note: Cumulative precipitation is no longer available via export from the CDMO. Please contact the Reserve or the CDMO for more information or to obtain these data.**

From 01/01/2019 00:00 through 04/29/2019 00:00 and again from 10/21/2019 00:15 through 12/31/2019 11:45 the unheated precipitation gauge was left uncovered due to the need to capture occasional heavy winter rain events, however, these data are not considered accurate due to the effects of freezing, melting, and sublimation. All values for total precipitation and cumulative precipitation are therefore flagged as rejected, <-3> (CSM). From 03/20/2019 16:00 to 03/26/2019 10:30 the precipitation gauge was removed for maintenance; therefore, Total and Cumulative Precipitation values are flagged <-3> [SSR] (CSM).

03/20/2019 14:00 – 16:00 Barometric Pressure, PAR, and TSR sensors were swapped during the power down, <-2>[GPD](CSM). An updated programed was uploaded following the maintenance, <-3> [GPR] (CSM).

There were noticeable changes in PAR values following the swap to a freshly calibrated sensor (SQ-1100SS\_28857) (assumed to be accurate) on 08/20/2019. The PAR sensor (Q45947) has not been calibrated since it was removed. Acceptable drift is +/- 2% for this sensor. Since drift numbers are not known all PAR data prior the sensor swap, from 03/20/2019 16:15 to 08/20/2019 09:45 are flagged and coded as <1> [SSD] (CSM). If users are comfortable assuming that drift was linear (in a real world environment it is unlikely to be entirely linear), these data may be ‘corrected’ for assumed linear drift at the user’s discretion using manufacturer’s. **Note**: Elevated and slightly negative PAR values are included in the sensor drift flagging and coding.

08/20/2019 10:00 All parameters rejected due to maintenance to swap the PAR sensor. A new Apogee PAR sensor was installed to replace the LI-COR PAR sensor that had been installed since 03/20/2019. A program was uploaded following the sensor swap. Although the program upload did not reset the record number to 0 it is believed to have uploaded correctly. All data at 10:00 are rejected and coded with [GPR](CSM) to reflect this upload. PAR data 10:15 – 10:30 are rejected due to the sensor swap.

Slightly elevated nighttime PAR values were observed throughout the year and were flagged as suspect. Reasons for the elevated values are unknown. PAR values >0 that occurred between sunset + 60 minutes and sunrise – 60 minutes were flagged <1> (CSM). https://sunrise-sunset.org/calendar was used to determine sunrise and sunset times for determining timestamps to flag and code.

Small negative PAR values collected with the Apogee sensor are flagged and coded as suspect, <1>(CSM). See notes above for information about negative PAR values collected with the LI-COR sensor.