Shadow Mountain Real Time Monitoring Program

Water Quality Department

This monitoring program began as two distinct programs: the Shadow Mountain Reservoir Dissolved Oxygen (DO) Monitoring Program in 2008 and the Shadow Mountain Channel Monitoring Program in 2010. These programs evolved over time and merged into the Shadow Mountain Real-Time Monitoring Program in 2023.

The program now serves many purposes: monitoring for low dissolved oxygen (DO) levels, developing a real-timedata baseline to understand water quality dynamics in the Three Lakes, and understanding flow and water quality dynamics between Grand Lake and Shadow Mountain Reservoir.

The objectives of this program are to:

1. Determine the causes, extent, and duration, of low DO events in Shadow Mountain Reservoir during the summer
2. Improve understanding of the thermal structure of Shadow Mountain Reservoir, including stratification and mixing patterns over the summer during periods of Farr pumping and no Farr pumping, and implications for nutrient release from the bottom sediments.
3. Provide a baseline of data to support the development and evaluation of potential DO mitigation strategies
4. Support Three Lakes water quality modeling efforts
5. Provide seasonal real-time data on directional flow between Grand Lake and Shadow Mountain Reservoir (Feb. 1 – Sept. 30)
6. Provide seasonal real-time water quality data in the connecting channel (Feb. 1 – Sept. 30)

MONITORING LOCATIONS

The Shadow Mountain Real Time Monitoring Program consists of five sites in Shadow Mountain Reservoir, the connecting channel, and the Granby Pump Canal. The sites in Shadow Mountain Reservoir and the Granby Pump Canal are operated by Northern Water and the sites in the connecting channel are operated by the USGS.

Table 1. Shadow Mountain Real Time Monitoring Locations

Station	Description	Latitude	Longitude	Depth	Entity
SM-DAM	Shadow Mountain Reservoir near Dam	40.2101	-105.8421	7.6 m	Northern Water
SM-MID	Shadow Mountain Reservoir Mid-Section	40.2252	-105.8378	6.7 m	Northern Water
GR-PUMP	Granby Pump Canal	40.2068	-105.8495	Surface	Northern Water
ADVM	Discharge Site in the Connecting Channel	40.246111	-105.82883	Surface	USGS
SM-CMK	Shadow Mountain Connecting Channel at Chipmunk Ln	40.246111	-105.82883	Surface	USGS

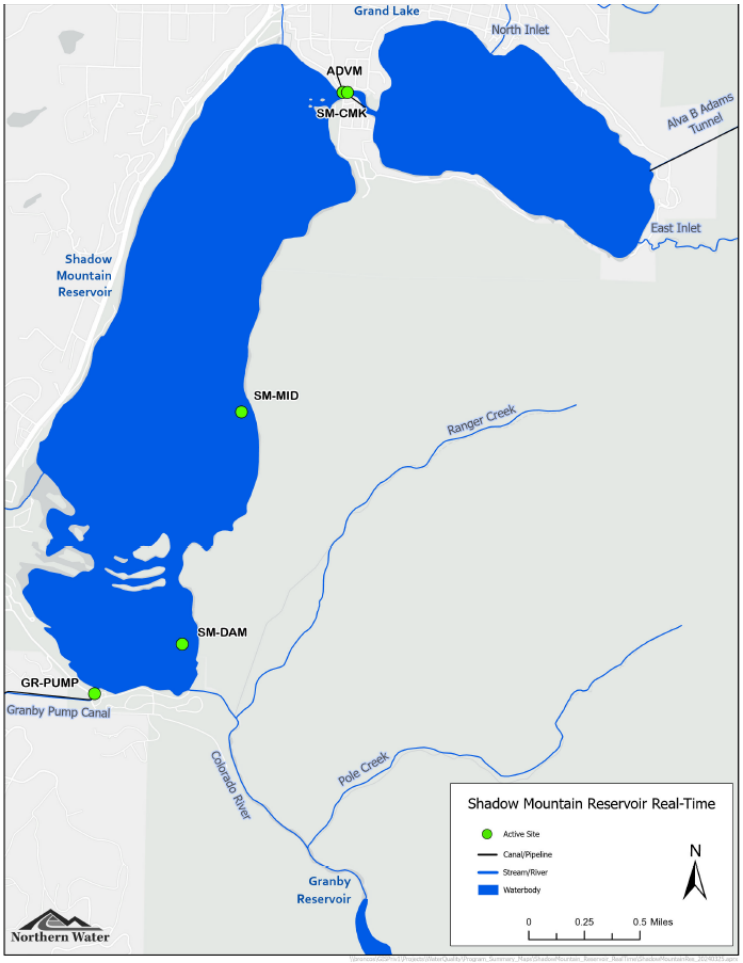

Figure 1. Map of Monitoring Locations

STATION OPERATION AND MAINTENANCE

The buoys are operational from mid-June until the end of September; the sampling period may be longer or shorter depending on ice coverage on the reservoir(s). Vertical profiles are collected every four hours at 0.5-meter increments down through the depth of the water column. Real Time data are collected at the GR-PUMP site year-round. Data at all sites are logged and transferred by telemetry on a real-time basis to Northern Water's internal database.

While deployed, the sondes are calibrated on a bi-weekly schedule. During calibration, grab samples are collected at the same depth as the calibration measurements. The samples are sent to Northern Water for chlorophyll analysis and BSA Environmental Services, Inc. for phytoplankton analysis. These data are used to calibrate the chlorophyll and blue green algae sensors.

The connecting channel ADVM and SONDE sites are maintained by the U.S. Geological Survey (USGS) Lakewood Field Office in cooperation with the Colorado River Water Conservation District and Grand County. The USGS site ID is 09014050.

Real-time discharge and water quality data are available online at USGS Site 09014050.

A summary of program changes are listed in Appendix 1 – Changes to Monitoring Program, Schedule, or Locations.

SAMPLING EQUIPMENT

A buoy monitoring system is located at the Shadow Mountain dam and middle sites (SM-DAM and SM-MID). The SM-DAM site is equipped with YSI EXO2 Sonde, the SM-MID site is equipped with a YSI EXO2 Sonde. Both sondes collect chlorophyll a, blue green algae, temperature, D.O., specific conductance, pH and turbidity data.

A YSI EXO2 Sonde is installed in the Granby Pump Canal (GR-PUMP) which collects temperature, DO, specific conductance and pH data. Data are collected at one-minute intervals and averaged every 15 minutes.

Figure 2. Real-time water quality monitoring buoy in Shadow Mountain Reservoir.

There are also two sites located within proximity in the connecting channel. One site is for the Acoustic Doppler Velocity Meter (ADVM) which measures bi-directional flow. The flow data indicate the direction of flow through the channel. Flow from Shadow Mountain Reservoir to Grand Lake is shown as positive flow on the daily discharge table and hydrograph. Flow from Grand Lake to Shadow Mountain Reservoir is shown as negative flow. Water stage and water velocity are measured with an ADVM and transmitted with satellite telemetry. The other site (SM-CMK) is a water quality sonde that measures chlorophyll fluorescence, phycocyanin fluorescence, pH, specific conductance, temperature, and turbidity.

APPENDIX 1 – HISTORY OF PROGRAM CHANGES

Changes to Sampling Schedule, Monitoring Frequency and Sample Collection

Year	Description of Change
2008	Program begins, collecting weekly temperature, dissolved oxygen, specific conductance, and pH profiles throughout the summer at several sites in Shadow Mountain Reservoir, Grand Lake and Lake Granby. In Shadow Mountain: DO profiles taken in increments of 0.5 m from the top to bottom using a DO probe. In Grand Lake DO: profiles taken in increments of one meter in the top 30 meters then every 5 meters to the bottom. Samples taken weekly from July 1 to Sep 30 and increased in Shadow Mountain to daily during turn over.
2009	Sampling is discontinued after being sampled for the last time in 2008 at: SM-NE2, SM-NOR, SM-PIN due to redundancy with other sites. GR-FAR is added as a monitoring site when DO levels at GR-PUMP are less than 6mg/L requiring a DO profile performed at 1m increments. The site is approximately 0.2 miles from the banks and 15m deep.
2010	Sampling is discontinued after being sampled for the last time in 2009 at: SM-CEN, SM-TRM, SM-PIC, SM-NE1 Sampling in Shadow Mountain Channel begins.
2011	Sampling is discontinued after being sampled for the last time in 2010 at: SM-SOU, SM-ISL, and SM-CHL No sampling takes place at SM-MID from 2011 to 2014 when a buoy is installed. A buoy system is installed at SM-DAM to continuously monitor DO levels in SMR. Profiles taken twice per day, at noon and midnight.
2012	GR-FAR – Lake Granby near Farr Pump Plant is discontinued after being sampled for the last time in 2011.
2012	The field measurements are automated with a buoy system installed at SM-DAM to collect DO profiles at a depth increment of 0.1 meter from 1 meter or 7 meters every four hours. This data is logged and transferred with telemetry on a real-time basis. The buoy will be installed in mid-July until the end of September or when the buoy can be deployed and removed for the season (note – buoy not functional until Aug 21, 2012) A YSI probe is also installed in the Granby Pump Canal (GR-PUMP) to concurrently monitor dissolved oxygen levels in the canal. This data is collected at a 15 min interval and will also be logged and transferred by telemetry on a real time basis. These data will be collected year-round.
2014	A second real time monitoring site was added in Shadow Mountain Reservoir at SM-MID.
2019-2020	Paired grab samples for chlorophyll a were taken in 2019 and 2020 to compare against the buoy's automatic profiles.
2023	The Shadow Mountain Dissolved Oxygen Monitoring Program and the Shadow Mountain Channel Monitoring Program are combined to form the Shadow Mountain Real Time Monitoring Program to eliminate redundancy and better reflect the program's evolution and objectives.
2025	The USGS decided to move the location of the multiparameter sonde within the connecting channel due to reduce fouling and required maintenance. The location of the sonde is moving towards Shadow Mountain about 200 ft. Comparison analyzes were done between these two locations with acceptable agreement between measured results. The historic location of this sonde was at: 40.2462, -105.8277and the new site will be co-located with the ADVM.


Northern Water