



## Lake Carmi Groundwater Study Launching in 2020

DEC, in collaboration with regional university partners, is launching a comprehensive groundwater study examining groundwater in the bedrock and surficial aquifers, including sampling near-surface groundwater in the shoreland soil, to evaluate nutrient loading via groundwater to Lake Carmi. Ground- and surface water constitute a system that needs to be studied holistically. Groundwater may enter a stream and increase its flow (gaining stream) and/or surface water may leak from a stream into an underlying aquifer(s) (losing stream). Since cyanobacteria blooms in lakes are strongly influenced by phosphorous and nitrate in the water column, it is important to know whether groundwater, surface water, or both are responsible for the transport of nutrients from their source areas.

**Research Question:** How Does Groundwater from the Fractured Bedrock and Surficial Aquifers Affect Nutrient Levels (i.e. phosphorous and nitrate) in Surface Waters from the Lake Carmi Watershed?

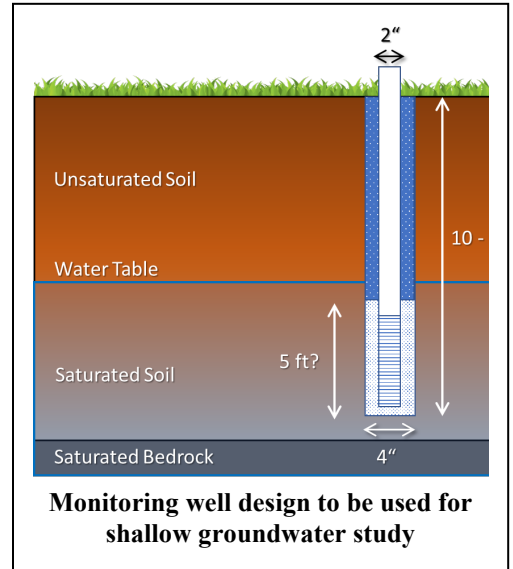
**Study Timeline:** January 1, 2020 – June 30, 2022

### Phosphorus in Shallow Groundwater

Phosphorus in ground water can be derived from several sources including: natural minerals in the soil and rock; surface water recharge to ground water; and other human-derived sources including septic systems. Calculations based on camp occupancy have estimated that between 0.13% and 3.3% of the phosphorus loading to Lake Carmi is derived from lakeshore septic systems. Based on these calculations, Total Maximum Daily Load (TMDL) report (ANR, 2009) assumed groundwater contributed 1% (15 kg/year) of the total phosphorus load to Lake Carmi.

Dissolved phosphorus interacts with other elements in groundwater and with the solid soil and rock. It can be precipitated as phosphate minerals as well as forming both weak and strong bonds with clay. While phosphorus in groundwater can quickly be immobilized, concentrations of dissolved phosphorus in groundwater are sometimes larger than in surface water, simply because groundwater is slow moving and may be in contact with natural phosphate minerals for a long time. Given that groundwater is slow moving, the total amount of phosphorus reaching our lakes and ponds in groundwater is usually small compared to surface water.

The phosphorus in shallow groundwater study is intended to compliment both studies of phosphorus in surface water streams and in the deeper bedrock groundwater.



It will provide data on the range of phosphorus concentrations (mass/volume) in soil groundwater near Lake Carmi. It will also enable a ballpark estimate of the phosphorus loading (mass/time) to Lake Carmi, which may be compared against the TMDL assumptions. It will not assess explicitly the phosphorus contribution from septic systems or provide a precise measurement of the phosphorus loading from groundwater. If necessary and practical, these goals may be addressed in a second phase of shallow groundwater investigation.

Due to practical limitations, the shallow (soil) groundwater study was delayed in 2019, but this has provided a fortuitous opportunity to coordinate with the deep (bedrock) groundwater study that has now been funded. In the spring of 2020, it is intended to install up to 14 shallow monitoring wells into saturated soil on 7 lots around the lake. Cascade Drilling, based in Montpelier, have been contracted to install the shallow monitoring wells using a small track-mounted drilling rig to facilitate access and minimize disturbance to camp residents. Groundwater will be sampled and analyzed for phosphorus each month for at least one year. The results will be reported for regions around the lakeshore and individual lots will not be identified. We are contacting previous volunteers and will be establishing access agreements with camp residents and landowners over the winter.

It is not too late to volunteer to host monitoring wells, and if you would like to be part of this important and fascinating study please contact myself, Grahame Bradley, at [grahame.bradley@vermont.gov](mailto:grahame.bradley@vermont.gov) (802-622-4129).

### **Phosphorus in Deep Groundwater**

Ground- and surface water constitute a system that needs to be studied holistically. Groundwater may enter a stream and increase its flow (gaining stream) and/or surface water may leak from a stream into an underlying aquifer(s) (losing stream). Since cyanobacteria blooms in lakes are strongly influenced by phosphorous and nitrate in the water column, it is important to know whether groundwater, surface water, or both are responsible for the transport of nutrients from their source areas.

This workplan is divided into **physical** (bedrock and surficial geologic mapping, spatial analysis of well reports/logs, construction of general hydrogeologic maps) and **chemical** (major and trace element chemistry, stable isotope, and groundwater recharge-age dating) hydrogeology parts. The physical portion results in the construction of a 3-D geologic framework and the chemical portion utilizes chemical tracers to convert the 3-D to 4-D (time). Nutrients such as phosphorous and nitrate, along with 33 other chemical parameters, will be analyzed from groundwater (bedrock and surficial wells) and surface water (streams and Lake Carmi) throughout the field area to track changes over time.

This project contributes toward Lake Champlain Basin Program's *Opportunities for Action (OFA)* and also aligns with the Lake Champlain TMDL Phase 1 Implementation Plan Chapter 4, Section H and Chapter 6, Section F, which address current and future commitments for upland lake protection and management. Also, the project supports the implementation of the 2016 Missisquoi Bay Tactical Basin Plan (see Table 16 - Summary of Implementation Actions, Lake and Shoreline: Monitor and assess surface waters to gain better understanding of condition and potential pollution sources, including internal phosphorus loading in lakes).