New Hampshire Geological Survey
National Ground-Water Monitoring Network Project
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Final Report

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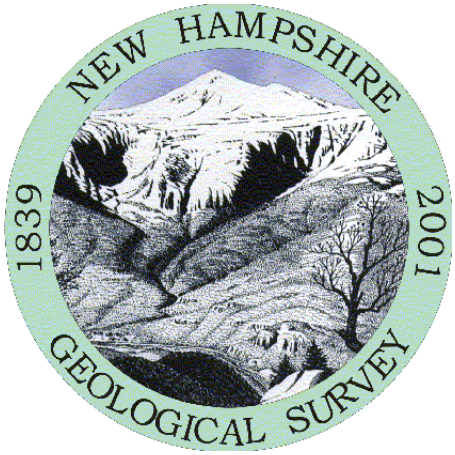

Introduction

The New Hampshire Geological Survey (NHGS) began participation in the National Groundwater Monitoring Network (NGWMN) in June of 2016. This document is meant to fulfill our obligation of a final progress report under this grant.

In our proposal, NHGS outlined year 1 steps to join the NGWMN which included reviewing data collection procedures, organizing our data into a database, evaluating wells to determine consistency with current NGWMN network classification matrices, and providing web services that can be used by the NGWMN portal. In year2, we proposed to maintain our data system that provides data to the NGWMN portal. NHGS has completed all of these tasks.

Procedures Review

NHGS reviewed data collection methods and any Standard Operating Procedures currently and historically employed. We determined that the method we employ for using an electronic tape to measure groundwater levels is consistent with section GWPD 4 of USGS Techniques and Methods 1-A1 (Cunningham 2011). One item this comparison did elicit is the need for NHGS to calibrate and periodically (annually) compare our electronic tape devices.

We also determined that pressure transducer data logger data is also being collected consistent with section GWPD 16 of the USGS technical procedure (Cunningham 2011). This review did, however, highlight the need to document the logger condition during each monthly measurement and perform a field calibration, as necessary. Our current practice does not provide for immediate field calibration which is typically delayed until appropriately trained personnel can perform this operation. We are reconsidering this approach.

Data Organization and Quality Control/Quality Assurance

NHGS proposed to use the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) HydroServer data system to store and disseminate data (Maidment 2008). This system consists of several standardized pieces of software. The data store is a SQL Server instance with a schema specifically designed to store time series environmental data. The data store also provides for metadata and controlled vocabulary organization and is integrated with desktop software to load, analyze and qualify data. And lastly, the system provides web services that allow access to time series data formatted in WaterML 1.1. Time series data will be provided to the NGWMN Portal using this web service. As of March 2017, all data systems are in place on production servers.

Most of NHGS wells have previously been part of the USGS Ground Water Site Inventory (GWSI) database. Therefore, NHGS obtained from GWSI monthly hand-measured data across the

period of record for each well. During that process, NHGS did not heavily scrutinize the data as the data had already undergone USGS review.

An evaluation of hourly data from pressure transducer loggers from 18 wells (see Figure1) was initiated. Data from these wells range back to 2011/2012 and had not been qualified in any meaningful way. Python scripts were created to review these data and eliminate obvious bad data, overlaps in record, confirm measurement time intervals (ensuring consistency of logger recording) and perform a comparison to corresponding monthly hand measurement values. Copies of anomalous values from these analyses were dumped out into external error files. The error files were reviewed and if errors were found they were investigated for the specific issue identified and either retained in the record or excised. Records with significant departures from the monthly comparison hand level measurements were inspected individually, largely by plotting hydrographs. In a few cases, the hydrographs indicated a consistent but clear departure from the monthly measurements. In these instances a mathematical transformation was calculated for the hydrograph and if a 95% or greater r^2 was achieved, the transformation was applied to the data. Generally, we determined the transformations were acceptable because some of the initial logger installations were erroneously carried out based on the manufacturer's instructions. In each instance, record-level metadata document that a transformation was applied and reference the equation used with the resulting r^2 value.

Following qualification, data were loaded into SQL Server with all associated record and station level metadata. This effort highlighted the need to develop a written QA/QC standard operating procedure for handling data from the loggers and hand level measurements. These procedures will be used for qualifying and handling data going forward.

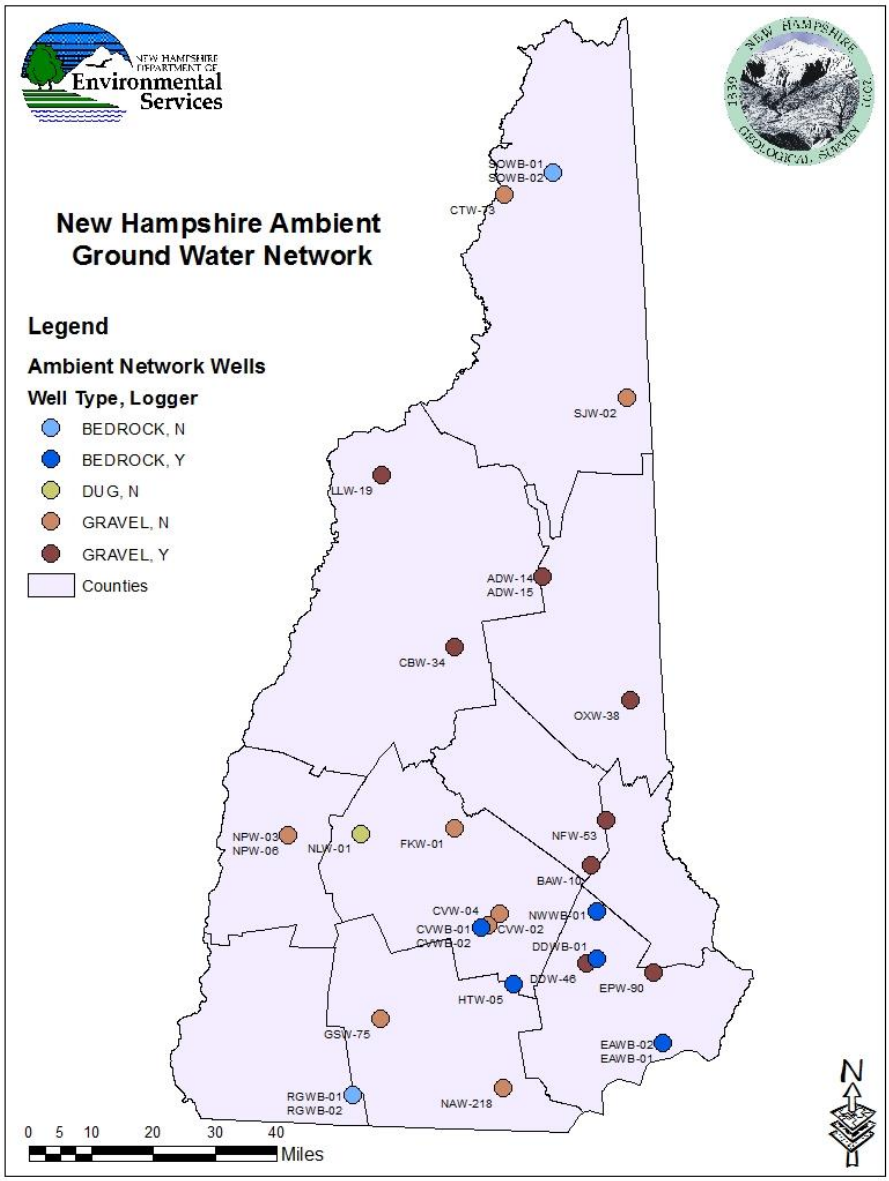

Figure 1 - Current NHGS Monitoring Network

Well Classification

The original well network was established by USGS efforts under the Collection of Basic Data Program and dates back to the late 1940's and early 1960's (see Table 1). During that early period, the network consisted of 12 wells. NHGS assumed responsibility for data collection in the mid 1990's and expanded the network to 22 wells by selectively adding wells that had been constructed as part of a cooperative statewide stratified-drift aquifer mapping program. In 2009, NHGS installed 9 bedrock monitoring wells. In 2010, NHGS was provided access to an additional bedrock well in Northwood, NH (see Figure 1 for the current network wells).

Measurements were discontinued for two wells (one from the original 12-well network and one other stratified-drift well) in 2011. The primary guiding principle for well selection and measurement that NHGS has consistently applied in managing the network has been that water levels recorded should be reflective of ambient groundwater conditions unaffected by anthropogenic or tidal influences. Based upon this initial criterion, our wells should fall within the NGWMN category of background condition monitoring. And, moreover, based on monitoring frequency, wells in the network are classified as trend monitoring wells.

Table 1 – Summary of Well Information

NHGS Well ID	Town	Meas. Start Year	Aquifer	Total Depth	Monthly Meas.	Hourly Meas.
ADW-14	Albany	1995	Stratified glacial drift	79.50	y	y
ADW-15	Albany	1992	Stratified glacial drift	18.00	y	y
BAW-10	Barnstead	1990	Stratified glacial drift	25.00	y	y
CBW-34	Campton	1988	Stratified glacial drift	107.00	y	y
CTW-73	Colebrook	1992	Stratified glacial drift	27.00	y	
CVW-02	Concord	1963	Stratified glacial drift	61.80	y	
CVW-04	Concord	1966	Stratified glacial drift	40.70	y	
CVWB-1	Concord	2009	Bedrock	480.00	y	y
CVWB-2	Concord	2009	Bedrock	315.00	y	y
DDW-46	Deerfield	1984	Stratified glacial drift	47.50	y	y
DDWB-1	Deerfield	2009	Bedrock	300.00	y	y
EAWB-1	East Kingston	2009	Bedrock	473.00	y	y
EAWB-2	East Kingston	2009	Bedrock	323.00	y	y
EPW-90	Epping	2005	Stratified glacial drift	37.80	y	y
FKW-01	Franklin	1966	Stratified glacial drift	52.30	y	
GSW-75	Greenfield	1995	Stratified glacial drift	68.00	y	
HTW-05	Hooksett	1965	Bedrock	102.70	y	y
LLW-19	Lisbon	1990	Stratified glacial drift	42.00	y	y
NAW-218	Nashua	1964	Stratified glacial drift	42.50	y	
NFW-53	New Durham	1986	Stratified glacial drift	60.00	y	y
NLW-01	New London	1947	Till	21.00	y	
NPW-03	Newport	1995	Stratified glacial drift	57.00	y	y
NPW-06	Newport	1995	Stratified glacial drift	20.00	y	y
NWWB-1	Northwood	2011	Bedrock	167.00	y	y
OXW-38	Ossipee	1995	Stratified glacial drift	114.70	y	y
RGWB-1	Rindge	2009	Bedrock	401.00	y	
RGWB-2	Rindge	2009	Bedrock	285.00	y	
SJW-02	Shelburne	1995	Stratified glacial drift	40.70	y	
SOWB-1	Stewartstown	2009	Bedrock	453.00	y	
SOWB-2	Stewartstown	2009	Bedrock	303.00	y	

Many years have passed since the initial siting of most of the network wells, representing a period of time during which New Hampshire has experienced significant population growth and development. This development has the potential to influence groundwater levels in the vicinity of these sites. With this in mind, NHGS undertook an analysis of the location of each well using a Geographic Information Systems (GIS). We quantified and analyzed metrics for each well of land cover/land use, hydrologic modification (road and sewage/drainage infrastructure), topographic position (hypsometry and manual observations) and documented groundwater withdrawals. These results were used to rank each well as to the potential for anthropogenic impacts. From these rankings, we emphasized scrutiny of well hydrographs. Hydrographs of each well were plotted and used to aide in determinations of anthropogenic impact. Initially, the plots were reviewed to determine the seasonality of hydrograph response. When warranted by suspicious changes in each well hydrograph, additional analysis was performed by using correlation analysis with daily precipitation records from the closest weather station. This allowed potential discrimination of anthropogenic impacts versus impacts from evapotranspiration, earth tides and barometric fluxes. The results of this analysis indicated that all but three wells are acceptable for a background conditions network. The wells that are likely impacted by anthropogenic effects are the Concord bedrock wells, CVWB-01 and CVWB-02, and NAW-218. The Concord bedrock wells show a clear, periodic impact from drawdown of the groundwater table likely due to a pumping well in the vicinity. NAW-218 in Nashua, NH is located fairly close to a drinking water reservoir whose outlet is regulated by a dam. Unfortunately, only monthly hand level measurements are collected from NAW-218 which is not frequent enough to validate this assumption. Despite these short-comings, these wells continue to be useful in measuring groundwater conditions in these areas New Hampshire and can be classified as Trend Monitoring Wells in a Suspected Changes subnetwork.

Web Services and Portal Setup

At present our Hydroserver has been installed on an outward-facing production server. Most of the data for each well has been loaded into the database and is available through the service. There are additional legacy data for NWWB-01 that need to be loaded into the system which will occur this month. This data upload has been delayed because a data logger needs to be permanently changed-out and the data loaded into the system. This upload is outside of our normal data handling procedures due to the type of data logger and so once the logger has been changed, these data will be uploaded in our normal monthly work-flow.

NHGS has become a registered contributor with the NGWMN data portal. We have created records for many of our network wells. However, USGS-Pembroke, NH has previously completed records for some of our network wells. NHGS, USGS-Pembroke, NH, and NGWMN

staff have agreed upon a transition plan that will allow those wells to be registered as NHGS wells and provide connection to our services. That transition period is coming to a close and will be final as NGWMN personnel switch data services.

Services for the well construction and lithology attributes have been completed through our instance of ArcGIS Server.

References:

Chapman, M.J., Almanaseer, Naser, McClenney, Bryce, and Hinton, Natalie, 2011, Fluctuations in groundwater levels related to regional and local withdrawals in the fractured-bedrock groundwater system in northern Wake County, North Carolina, March 2008–February 2009: U.S. Geological Survey Scientific Investigations Report 2010–5219, 60 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

Maidment, D.R. editor, July 12, 2008, CUAHSI HYDROLOGIC INFORMATION SYSTEM: Overview of Version 1.1, Center for Research in Water Resources, The University of Texas at Austin, 96 p.