Department *of* Environment,
Agriculture, Parks & Recreation

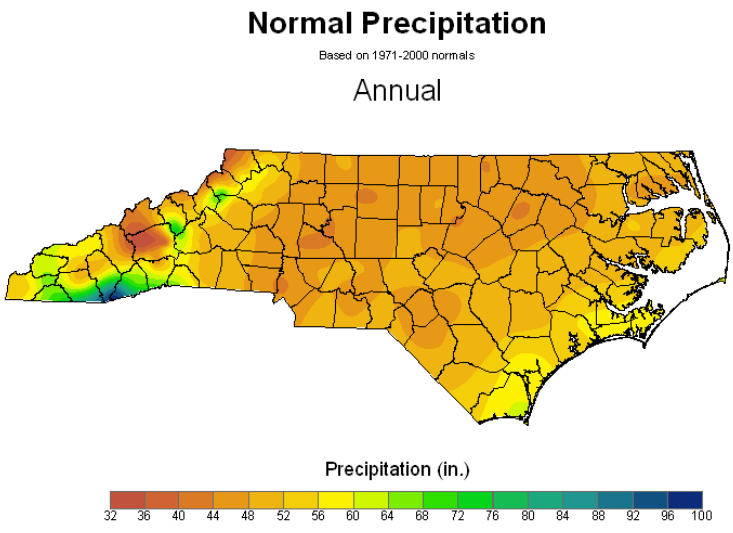
2012 Annual Report

Orange Well Net

The Orange County Groundwater Observation Well Network

June 2012

TABLE OF CONTENTS



Annual Precipitation Figure from State Climate Office of North Carolina.

North Carolina Division of Water Quality drilling rig installing regolith groundwater observation well in southern Orange County during 2011.

Introduction

In May 2005, the adopted Water Resources Initiative proposed the creation of a groundwater observation well network in Orange County to continue the work of the previous decade of groundwater research in the county, and provide a network for the collection of information on local groundwater quality and quantity.

Groundwater in the Piedmont of North Carolina can be found within the fractured bedrock that underlies this region as well in the overlying unconsolidated material, which is known as regolith. Older hand dug and bored wells accessed the groundwater present in the near-surface regolith, which because of the shallow depth of this water often contained bacteria and other contaminants originating from the ground surface. More recent water wells are drilled into the deeper fractured bedrock aquifer until an adequate quantity of groundwater is found. This groundwater is located only within the fractures present in the bedrock. Hydrogeologists often refer to regolith groundwater as water that is in storage since it is this water that effectively recharges the deeper fractured bedrock aquifer that is tapped by water supply wells.

The goals of the groundwater observation well network involve the utilization of a combination of bedrock and regolith wells spread across the nine main types of generalized bedrock geology present in Orange County. Regolith wells, completed in the near-surface unconsolidated material that is present above bedrock, are designed to monitor natural stresses on the quantity of groundwater available in storage that are caused by variations in climatic conditions. Bedrock wells are utilized to monitor changes in groundwater levels in the bedrock across the county. Taken together, the Orange Well Net (OWN) is designed to collect information concerning the amount of groundwater available locally in Orange County.

Project Progress

Early in the project, a decision was made to identify and utilize existing bedrock wells instead of incurring the expense of installing new wells. Six out-of-use bedrock wells were secured for use in the OWN and groundwater level data collection began in late March 2010.

A more recent cooperative arrangement allowed Orange County to begin utilizing three new regolith wells installed in 2011 for the collection of groundwater level data from the shallow aquifer. Data collection began from three regolith wells in southern Orange County in June 2011.

Table 1 lists the well construction details for all of the wells included in Orange Well Net. Figure 1 illustrates the locations of the wells. Figure 2 illustrates the locations of the wells in relation to the generalized bedrock geology of Orange County. This map is based on the recent work of the North Carolina Geological Survey, which updated the knowledge of bedrock geology in the county.

Staff downloads groundwater level data periodically from each of the observation wells in Orange Well Net. The collected data is formatted and then uploaded to the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (DWR) groundwater level database web site:

http://www.ncwater.org/Data_and_Modeling/Ground_Water_Databases/leveltable.php?tl=1&net=orange&inactive=

This web site is available to the general public and includes significant information regarding groundwater level conditions across North Carolina, including the information collected from Orange Well Net.

Unfortunately, the use of the Rocky Ridge bedrock well was terminated in April 2012. All equipment was removed from this well and no further data will be collected from this location.

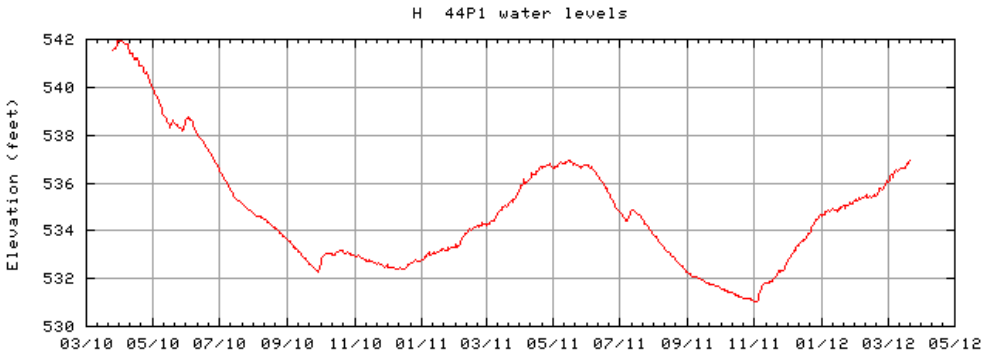
Regolith groundwater observation well installed in 2011 in southern Orange County.

Groundwater Level Data

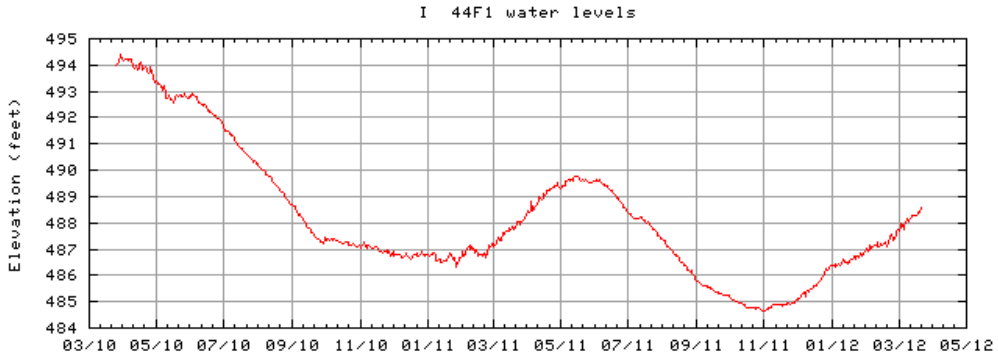
The groundwater level information collected from each of the six bedrock and three regolith observation wells can be viewed at the above listed web site. The hydrographs, or groundwater level records available at the DWR web site cover the interval from when data collection began through April 2012, and are provided below.

Bedrock Wells

Blackwood Farm Well Hydrograph

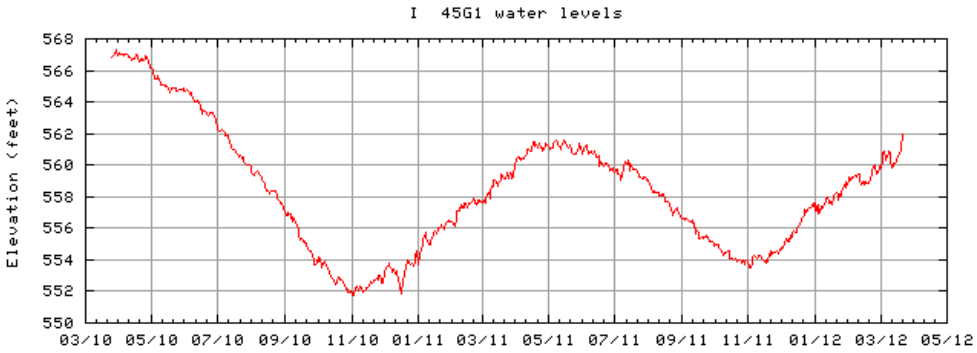


Millhouse Road Well Hydrograph

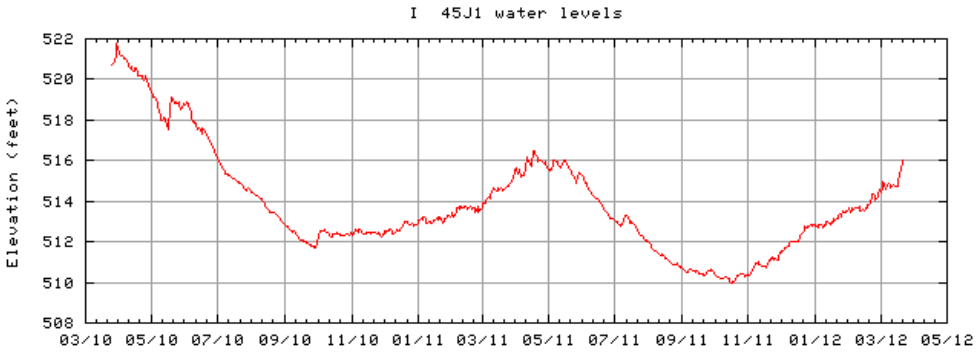


Permitted biosolids application field in southern Orange County in proximity of three regolith groundwater observation wells added to OWN during 2011.

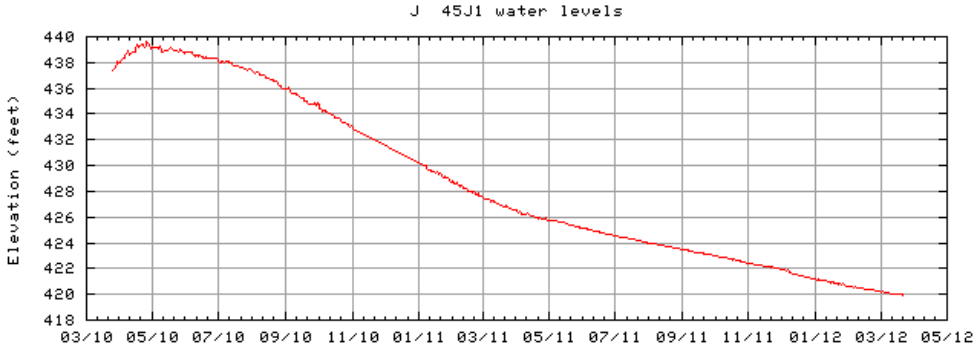
Rocky Ridge Road Well Hydrograph



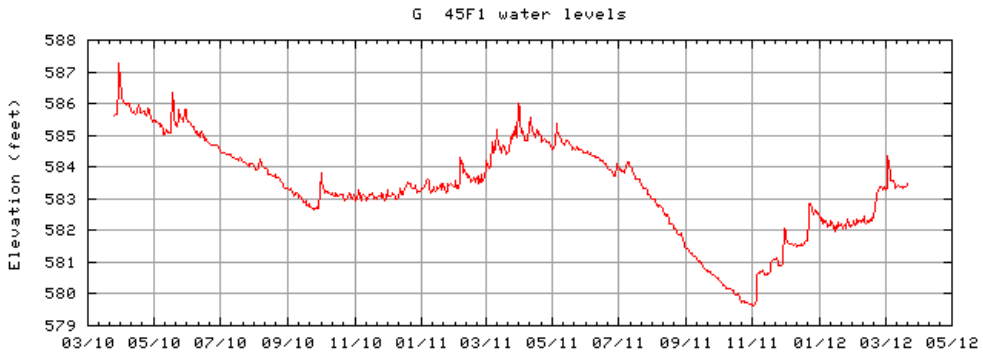
Eubanks Road Well Hydrograph



Ray Road Well Hydrograph



Eno Confluence Property Well Hydrograph



Bedrock Groundwater Data Summary

Data collected since the initiation of this project demonstrates that less groundwater recharge in the bedrock aquifer took place over the winter of 2010-2011 than occurred the previous year. Groundwater levels rose in four of the bedrock observation wells from January through May 2011 to levels that were up to seven feet less than the respective groundwater levels measured in early 2010, when data collection began.

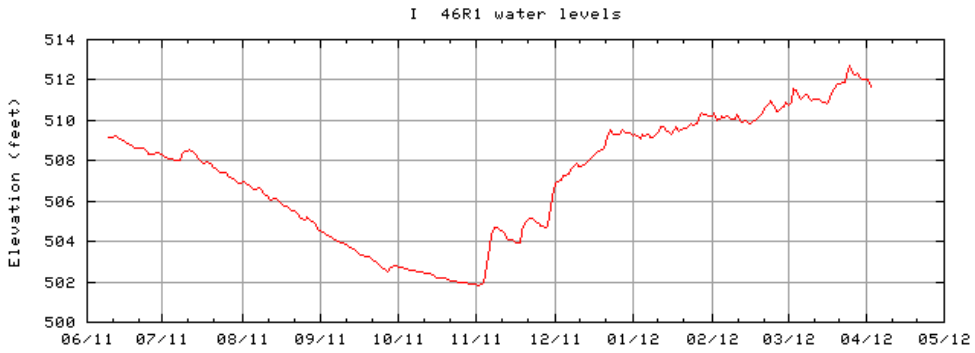
As expected, once recharge of the groundwater ceased in spring 2011, groundwater levels then decreased throughout the remainder of the 2011 growing season (April through October). The Blackwood Farm observation well experienced a groundwater level decrease of approximately seven feet from May through November 2011. The groundwater level in the Millhouse Road well fell nearly five feet during the same time interval. The Rocky Ridge observation well experienced a decrease of seven feet between May and November 2011. The groundwater level in the Eubanks Road well decreased approximately six feet from April through October 2011. The observation well located in southern Orange County on Ray Road experienced a decrease in groundwater level of five feet over the 2011 growing season. In fact, the groundwater level in this well has consistently decreased since May 2010, shortly after data collection began. Finally, the groundwater level in the Eno Confluence well decreased more than five feet from April through November 2011.

The collected data also shows that as of April 2012, groundwater recharge has occurred in most of the bedrock observation wells such that the groundwater levels measured in late spring 2012 are similar to those that were measured in spring 2011. The exception to this is the Ray Road well, as discussed above. Given the short period of record for the observation wells to date, it is difficult to derive additional conclusions.

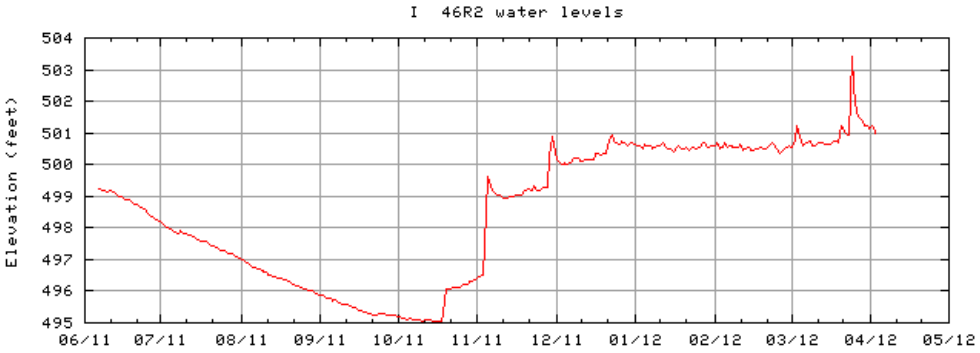
Collins Creek in vicinity of OWN regolith wells during dry summer months.

Regolith Wells

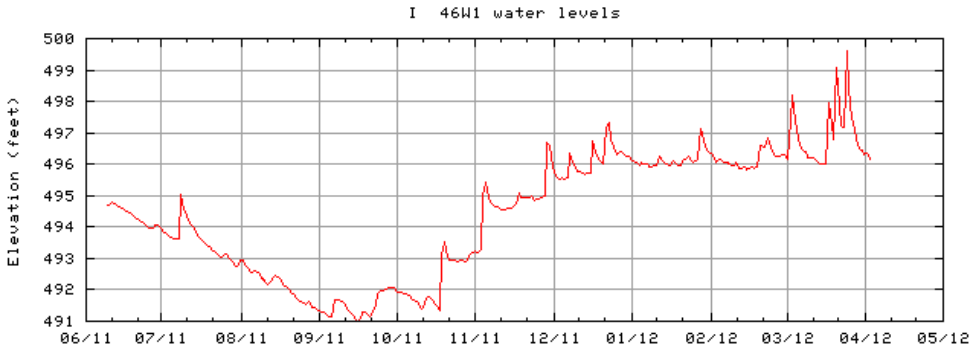
COL-1 Well Hydrograph



COL-3 Well Hydrograph



COL- 4 Well Hydrograph



Regolith Groundwater Data Summary

Groundwater level data collected from each of the three new regolith wells included in OWN depict the same general trend, namely a decrease in groundwater level from the initiation of data collection in early June 2011 through the summer months until October to November 2011. Recharge of the regolith groundwater began in fall 2011 (October to November) and continued through April 2012. The hydrographs for the three regolith wells demonstrate that most of the recharge that took place occurred between mid-October 2011 and January 2012. Differences in the characteristics of recharge are apparent in the three hydrographs. Recharge of COL-1 appears to have been fairly steady through March, while the COL-4 hydrograph contains many rapid upward and downward changes in the groundwater level. The hydrograph for regolith well COL-3 contains three large peaks in the groundwater level with an approximately two month period (late December 2011 to March 2012) of very little change.

Groundwater Data Discussion

Usually, groundwater levels decrease during the months of the growing season, due to a reduction in groundwater recharge. Groundwater recharge is reduced in part due to increased evaporation as a result of higher ambient temperatures. Another important factor is the increased use of water by plants during the growing season (transpiration). These factors normally result in significantly lower groundwater levels during the summer months in North Carolina and elsewhere in the Northern Hemisphere. The non-growing season, November through March, is the period during which most significant groundwater recharge occurs. Recharge takes place when precipitation infiltrates into the ground and reaches the water table, rather than runoff, evaporate, or get used by plant life. This infiltration increases the amount of groundwater held in storage, raising groundwater levels in the regolith (upper) aquifer and then the underlying bedrock aquifer. Typically this recharge is then available for use during the subsequent growing season. Periods of drought or dry weather can, of course, reduce recharge which could then impact the amount of groundwater available during the growing season.

According to information posted on the Orange Water and Sewer Authority (OWASA) web site, as of April 25, 2012, 39.45 inches of precipitation had fallen in the previous twelve months at its Carrboro location, while the average annual precipitation in Carrboro is 45.72 inches. Thus 39.45 inches is 86 percent of the average annual amount for the preceding 12 months. The USGS raingage on Berry Andrews Road is in proximity of the three regolith wells that are included in OWN. This gage documented that 32.9 inches of precipitation fell at this location in the twelve months between April 26, 2011 and April 25, 2012, as shown in Figure 3. It is not known what the average annual precipitation is at this specific location, but it is likely to be in the vicinity of 45 inches. As a result, 32.9 inches of precipitation is probably significantly less than the amount of precipitation that usually falls in this area.

Figure 4 is a summary of the percent of normal annual precipitation for the eastern half of North Carolina. This figure illustrates that Orange County received approximately 75 to 95 percent of the normal annual precipitation In total, this information indicates that Orange County experienced slightly decreased precipitation then is typical over the last twelve months.

One consequence of a decrease in precipitation is a reduction in the amount of water available to recharge groundwater. Evidence of reduced recharge is seen in the bedrock observation well hydrographs presented above. These records demonstrate that groundwater levels were lower in spring 2011 and spring 2012 than they were in spring 2010, indicating a decrease in recharge in 2011 and early 2012, when compared to the same time in 2010. It should be noted that further analysis of groundwater trends is constrained by the limited amount of data that has been collected to date. Groundwater level monitoring is a long-term process.

United States Geological Survey (USGS) Circular 1217, entitled *Ground-Water-Level Monitoring and the Importance of Long-Term Water-Level Data* (2003) states; "Typically, collection of water-level data over one or more decades is required to compile a hydrologic record that encompasses the potential range of water-level fluctuations in an observation well and to track trends with time." Once a hydrograph contains enough information, statistical evaluation of water levels can begin. Figure 5 is an example of the statistical information that is available on the DWR web site for the observation wells that are included in OWN. Graphs for all wells are available once a minimum of twelve months of data are posted to the web site, however, as more water level data is added to the record for each well, the statistical analysis is also updated and as a result becomes more relevant.

The reduced recharge that took place in early 2012 is probably not highly significant due to the amount of rain that fell in early May 2012 while this report was under preparation. However, it will take some time for this increased precipitation to raise groundwater levels in the Orange Well Net observation wells. Additional groundwater level data collection will document this.

Several observations can be noted from the latest information presented herein. While recharge was observed in all three regolith wells between November 2011 and April 2012, there seems to be variety in the patterns of recharge in these wells. Most of the larger (>1 inch) precipitation events that took place between October 1, 2011 and the beginning of May 2012 took place before the end of December 2011, as shown in Figure 3. Variations in the responses to the larger precipitation events seems apparent amongst the three regolith observation wells. The groundwater level in regolith well COL-1 was mainly recharged in a steady gradual manner. The COL-3 hydrograph includes three large recharge events or steps. The COL-4 hydrograph illustrates many more steps in the groundwater level than those observed in the COL-3 hydrograph. Of the three regolith wells, COL-3 is both the farthest from Collins Creek and at the greatest elevation above the creek. These factors may have bearing on some of the differences in groundwater level records amongst the wells. Differences in lithology is also likely to be an important factor with respect to groundwater recharge of the regolith wells.

It is also interesting to note that COL-1 does not seem to have experienced any appreciable recharge as a result of the nearly two inches of precipitation that fell from October 18th to 19th, 2011. It is possible that the quantity of precipitation at COL-1 was less than what fell at the other regolith well locations, but since the three wells are within one-half mile of each other, this does not seem highly likely.

Finally, the Ray Road and Eno Confluence bedrock well hydrographs appear noticeably different from the other bedrock well hydrographs. This indicates that factors that may not be important at the other four wells may be influencing the groundwater level in these two wells. The Ray Road observation well is located in proximity of University Lake, an OWASA reservoir. It is possible that the groundwater level in this well is influenced by the water level in the nearby reservoir. Further analysis of the groundwater level in the Ray Road well would be needed to determine if the lake level is impacting this well.

Similarly, the well located at the Eno Confluence Property is located in proximity to both the West and the East Forks of the Eno River. The hydrograph for this well, included above, appears to reflect a considerable amount of "flashiness" (rapid fluctuations, either up or down, in a short period of time) in the groundwater level. This is likely to be a result of fairly rapid increases and decreases in the flow of the Eno River as a result of precipitation in the upper Eno River watershed, indicating that the groundwater level in this area is fairly rapidly influenced by the water level in the Eno River.

Recommendations

- Groundwater level information should continue to be collected from the regolith and bedrock observation wells in the Orange Well Net. Currently, routine data collection from the five bedrock and three regolith wells is occurring and little, if any, further expense is needed at this time to continue this process. Additional data will significantly increase the quantity of available information for each of the observation wells, thereby also increasing the quality and usefulness of the hydrographs for each of the wells.

- If opportunities arise to add additional bedrock or regolith observation wells to Orange Well Net, evaluation and consideration of each well should take place. The original design of the observation well network included bedrock and regolith observation wells in each of the nine general bedrock lithologies in Orange County. The cost to incorporate additional existing wells into the well network would be relatively minor.

- Given the recent loss of the Rocky Ridge bedrock well, in addition to the questionable value of the groundwater level information collected from the Ray Road and Confluence Property bedrock wells, concerted effort should be made to incorporate additional suitable bedrock observation wells into the well network.

- The use of a co-located bedrock and regolith well pair would be a valuable addition to OWN. A pair of wells in the same location would provide detailed information concerning groundwater recharge and groundwater level response to precipitation events.

- Continue to upload groundwater level information to the DWR web site. This will allow the public to have access to the groundwater level information collected in Orange County at no cost to either the County or to members of the public.

- Pursue statistical analyses of collected groundwater level information as additional groundwater level data is collected and available.

- Continue to publicize Orange Well Net where appropriate. As more groundwater level information is collected, further use of the Orange Well Net data available on the DWR web site should be encouraged.

Acknowledgements

This project has been greatly aided by the assistance of the following organizations:

- Association for the Preservation of the Eno River
- Duke Forest
- North Carolina Department of Environment and Natural Resources - Division of Water Resources
- North Carolina Department of Environment and Natural Resources - Division of Water Quality
- North Carolina Geological Survey, in particular, Mr. Phil Bradley, Senior Piedmont Geologist
- The University of North Carolina at Chapel Hill
- United States Geological Survey, North Carolina Water Science Center

Table 1. Orange Well Net Well Details.

Bedrock Wells

	Bedrock Well Location	Casing Depth, ft.	Total Depth, ft.	Top of Casing Elevation, ft.	Bedrock Geology
1	Millhouse Rd	67	164.7	515.22	Epiclastics
2	Eno Confluence	37	175.5	609.27	Felsic tuff
3	Rocky Ridge[1]	67	560	576.28	Felsic lavas and tuffs (Dacite)
4	Blackwood Farm	100	302	557.44	Felsic lavas and tuffs (Dacite)
5	Ray Road	21	236.1	514.24	Felsic plutonics- E. Farrington Granite
6	Eubanks Road	33	145.7	531.15	Mafic plutonics (Gabbro)

Regolith Wells

	Regolith Well Location	Total Depth, ft.	Top of Casing Elevation, ft.	Geology
1	Andrews Rd. (COL-1)	33.0	528.00	Transition zone overlying felsic tuff bedrock
2	Hwy 54 (COL-3)	43.7	528.18	Transition zone overlying epiclastic bedrock
3	Orange Grove Road (COL-4)	35.2	504.86	Transition zone overlying epiclastic bedrock

1– Rocky Ridge observation well was removed from OWN in April 2012.

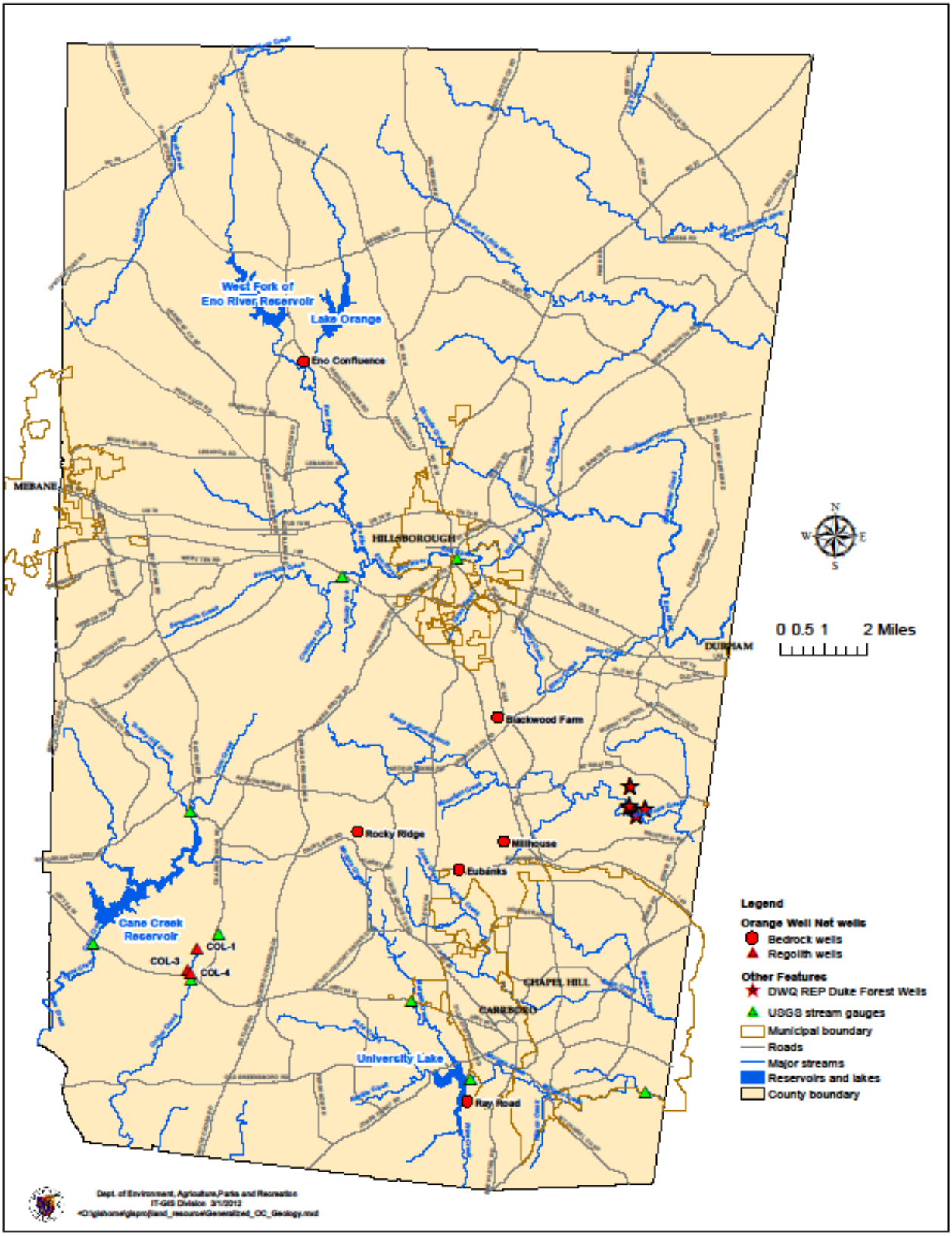


Figure 1. Map of Orange County showing the Locations of Orange Well Net Groundwater Observation Wells.

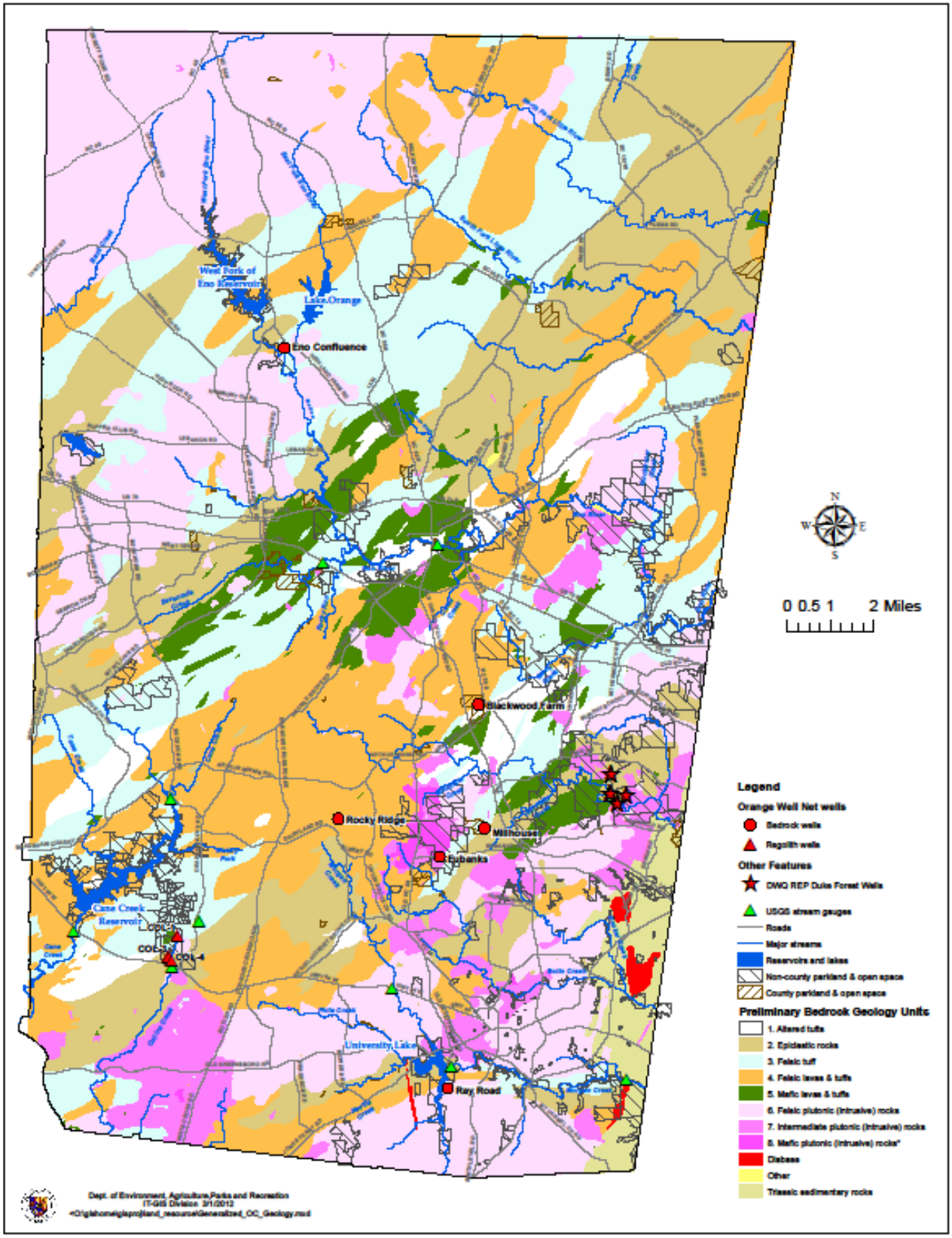


Figure 2. Generalized Geologic Map of Orange County with Locations of Orange Well Net Regolith and Bedrock Wells.

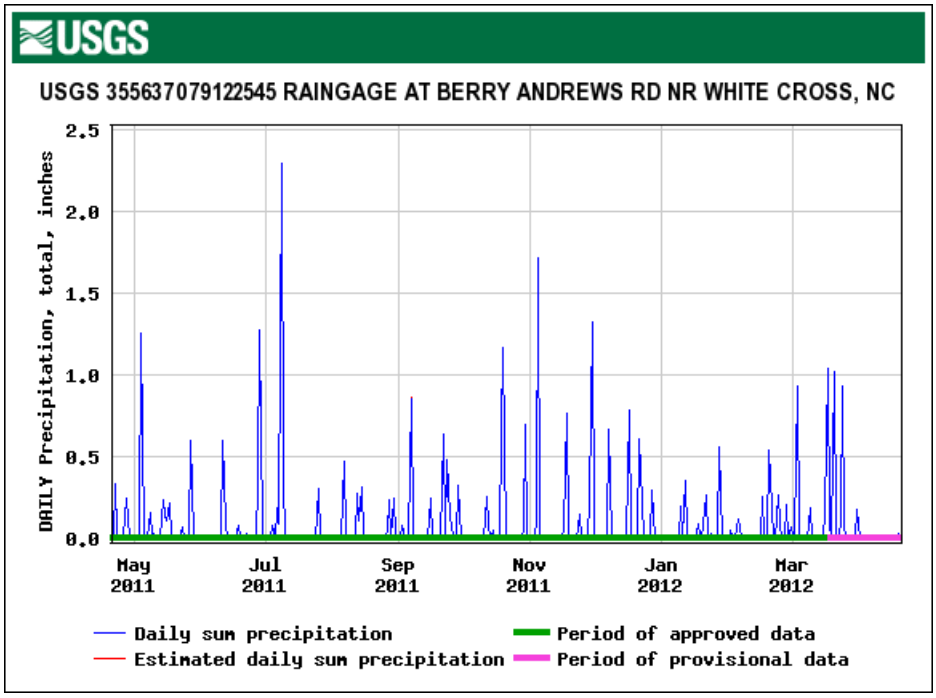


Figure 3. Graph of Precipitation Recorded at Raingage Located on Berry Andrews Road in Vicinity of OWN Regolith Wells.
Source: United States Geological Survey web site.

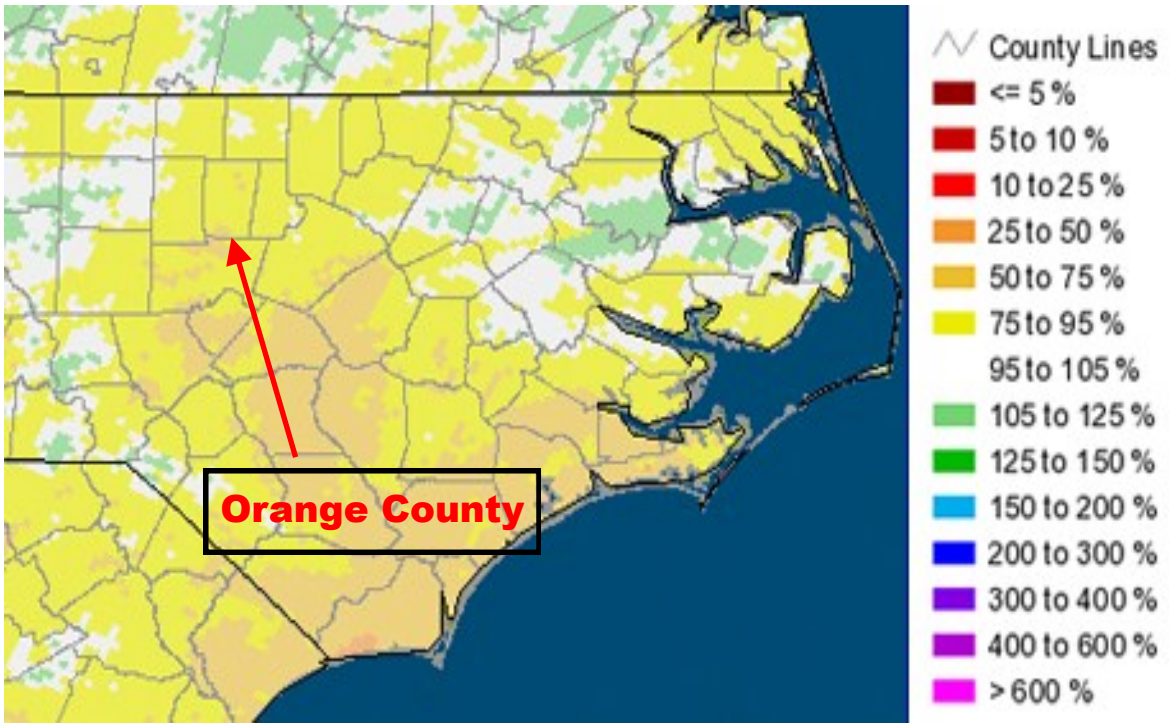


Figure 4. 2011 Annual Precipitation Percent of Normal.
Source: State Climate Office of North Carolina web site.
Based on estimates from NWS Radar. Data courtesy NWS/NCEP.

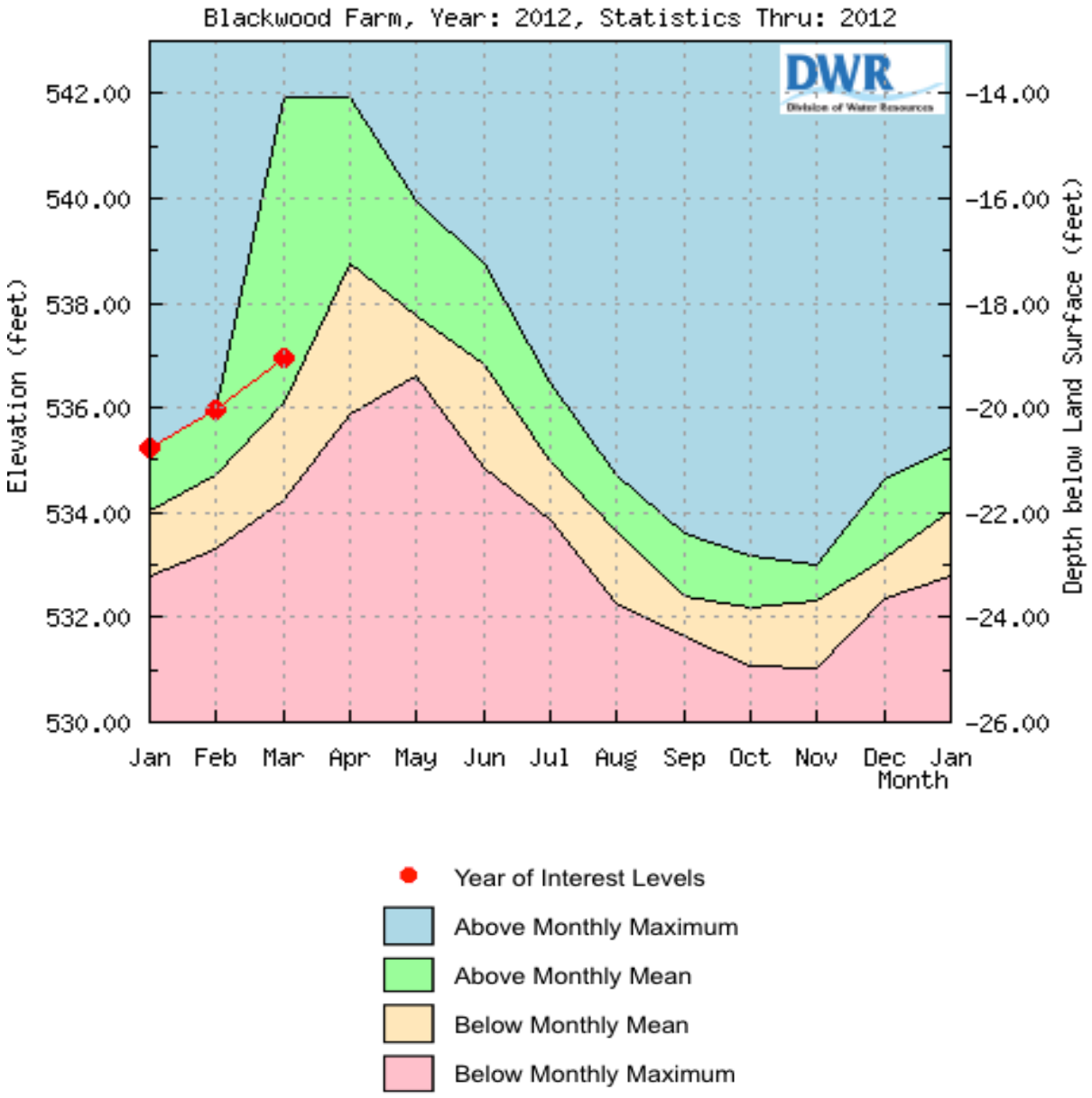


Figure 5. Graph of Blackwood Farm Bedrock Observation Well Statistical Information.
Source: North Carolina Division of Water Resources web site.