North Carolina Ground Water Resources Monitoring Well Network
2006 Annual Report

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Executive Summary

Since 1998, the North Carolina Division of Water Resources (DWR) has monitored and maintained a statewide network of monitoring wells to assess North Carolina's ground water supply. The operation of this well network is an integral part of DWR's mission to ensure that North Carolina has an adequate water supply for its citizens.

The data collected from the network are presented to the public primarily through DWR's website, *www.ncwater.org*. These data include ground water levels, limited ground water quality data, well construction information, locations of ground water monitoring stations, and geophysical data collected at the monitoring stations and other locales.

The well network currently consists of 536 wells at 178 individual sites. Historically, the Coastal Plain has relied much more heavily on ground water supplies than the rest of the state. For this reason, most of the ground water monitoring and research has been in this area. However, DWR is investing more resources in monitoring Piedmont and Mountains ground water conditions to better understand the impact of drought cycles on ground water supplies and their contribution to surface water flow.

From January to May 2006, DWR monitored 536 individual wells, collecting 33,611 manual and daily water levels. The daily levels were collected using automatic water level recorders. We collected an additional 771,794 hourly water levels using these recorders. Extrapolated to an annual rate, these figures are comparable to the data collected during calendar year 2005. Some data was lost to automatic water level recorder malfunction and repair times. Additionally, we collected 14 chlorides samples and one geophysical log. We also began digitizing daily water levels from thousands of water level recorder charts obtained from the North Carolina Division of Water Quality. These charts contain water level data from the late 1960s to the early 1980s.

During Fiscal Year 2005-2006, DWR installed ten new monitoring wells, including one completely new monitoring station in western Pitt County. We replaced four existing monitoring wells that were yielding erroneous data due to poor well construction. We also added one former supply well in Bunn, North Carolina, to our well network. This well will be used to assess the impacts of drought and other climatic cycles on ground water supplies in the eastern Piedmont.

DWR uses primarily two types of automatic water level recorder to collect hourly and daily water levels from the network: shaft encoders and submersible pressure transducers. As of June 2006, we employ 51 shaft encoders and 226 pressure transducers. Additional transducers are currently being repaired and are not reflected in these totals.

Introduction

Over fifty percent of the state's population relies on ground water for potable supply. Additionally, the state has thousands of agricultural and industrial ground water users. Since 1998, the North Carolina Division of Water Resources (DWR) has monitored and maintained a statewide network of monitoring wells to assess North Carolina's ground water supply. The operation of this well network is an integral part of DWR's mission to ensure that North Carolina has an adequate water supply for its citizens.

DWR collects data from this well network for the following primary purposes:

1. Assess natural climatic influences on the state's ground water supply, including the effects of drought and recharge-discharge relationships.

2. Monitor human-induced effects on the state's ground water supply, particularly in the regional aquifers of the North Carolina Coastal Plain. These effects include local and regional water level declines and migration of fresh water-salt water interfaces in the aquifers.

3. Provide supporting data for enforcement and creation of current and future ground water use regulations, such as the Central Coastal Plain Capacity Use Area rules.

4. Provide high quality ground water data to local governments, ground water professionals, and the general public to use in making informed decisions in ground water related issues.

The data collected from the network are presented to the public primarily through DWR's website, *www.ncwater.org*. These data include ground water levels, limited ground water quality data, well construction information, locations of ground water monitoring stations, and geophysical data collected at the monitoring stations and other locales.

Purpose and Scope

This report is not intended to be a comprehensive treatise on the history and operation of the statewide monitoring well network. Rather, it is a summary of DWR's well monitoring and maintenance activities during the period from July 2005 through June 2006. Included in this report are summaries of 2005-2006:

1. Water level and water quality data statistics.
2. New monitoring well installations.
3. Faulty monitoring well replacements.
4. Monitoring equipment usage and evaluations.

Previous Investigations

The statewide ground water resource monitoring program was initially operated by the North Carolina Division of Water Quality (DWQ) and its predecessor agencies, which installed the first wells in the network in the 1960s. DWQ actively monitored the network through the early 1990s, collecting a portion of the ground water data currently in the various network databases. Approximately seventy-five percent of the monitoring wells in the network were installed by DWQ. The program was transferred to DWR in 1998.

The United States Geological Survey (USGS) has also contributed to the monitoring of the state's ground water resources under a cooperative agreement between the State of North Carolina and the federal government. Currently, the cooperative well network consists of twenty-one monitoring wells, many of which are also part of the DWR statewide network.

Overview of the DWR Monitoring Well Network

Description

The well network currently consists of 536 wells at 178 individual sites (Figure 1). Twenty of these wells are located in the Piedmont and Mountains physiographic provinces. The remaining 516 wells are in the Coastal Plain. Historically, the Coastal Plain has relied much more heavily on ground water supplies than the rest of the state. So, it follows that most of the ground water monitoring and research has been in this area. However, DWR is investing more resources in monitoring Piedmont and Mountains ground water conditions to better understand the impact of drought cycles on ground water supplies and their contribution to surface water flow.

Of the 178 monitoring stations, sixty are on state or federal property. Forty are located on property owned by local governments. The remaining seventy-eight are located on private property through agreements with the landowners. In the past, some wells have been abandoned at the landowner's request due to changes in land use or ownership. Since monitoring well stations are costly to construct and are most valuable when they can be continuously monitored over a period of decades, every attempt is made to put new stations in stable locations. DWR has developed a scale to rank new and existing sites for the potential that the wells will have to be abandoned in the future (Table I). New wells are normally installed at sites with a susceptibility ranking of 1 or 2.

Table I: DWR Well Site Susceptibility Ranking

Susceptibility Ranking	Description
1	Secure - on state or federal government property
2	Secure - on local government/school property
3	Moderately secure - on private property, but owner does not give any indication that land use or property ownership may change
4	Tenuous – site is on public or private property and landowner is giving indications that land use or property ownership may change
5	Imminent threat of losing site – landowner (public or private) desires abandonment of well station

Monitoring

The network is divided into five regions (Figure 1), with a single individual managing each region. DWR staff visit the wells quarterly to collect water level data and perform routine site maintenance. This maintenance includes changing batteries in automatic water level recorders, clearing vegetation, and ensuring the sites are kept in good working and cosmetic condition. Additional monitoring and maintenance visits are made as needed for special projects or situations.

DWR also collects chloride data from select wells in the Coastal Plain. These data are used to monitor the migration of the fresh water-salt water interface in Coastal Plain aquifers. Typically, synoptic chloride samples are collected every five years. Additional chloride data is collected when new monitoring wells are installed and as needed for special projects.

When installing wells at new sites in the Coastal Plain, DWR collects geophysical data from a test hole at the site. The geophysical data are correlated with lithologic data collected at the site and geophysical data from other sites to determine the identity and nature of the aquifers present at the site. These data, called geophysical logs, include natural gamma radiation, spontaneous potential, single-point resistance, and 16- and 64-inch normal resistivity.

DWR uses several different types of equipment for well monitoring. Manual water levels are collected using electronic water level indicators. Additionally, DWR employs automatic water level recorders to collect hourly water level data on almost 300 wells. We use primarily two types of automatic water level recorders: shaft encoders and submersible pressure transducers.

These hourly water level data are extremely valuable in assessing the nature of recharge to aquifers, the impact large storm systems have on ground water conditions, delineation of aquifer boundaries, and many other purposes. However, transmitting hourly data through our website would be extremely taxing, both to our servers and to the end user's computer system. For this reason, we typically publish only daily water level data from our recorders and manual tapedowns on our website. Hourly data is available upon request for specific wells.

2005-2006 Well Network Statistics

Ground Water Data Collection

While our budget year follows the state government fiscal year calendar (July to June), the operation of the well network is continuous. For this reason, the network statistics are not always broken down by fiscal year. Table II contains water level data collection statistics for calendar year 2005 and calendar year 2006 (through June 1). Second quarter data collection was completed from late April through the end of May, so the year-to-date statistics for 2006 do not reflect a full five-month's data at all wells.

Table II: Ground Water Data Collection Statistics 2005-2006

Parameter	2005	2006 (through June 1)
Wells monitored	536	539
Daily/Manual Water Levels	91,695	33,611
Hourly water levels	2,143,574	771,794
Chloride samples	17	14
Geophysical logs	2	1

Figure 2 compares the number of wells monitored and the water levels collected from the well network from 1967 to present. Hourly water level data is not included in this graph. Calendar year 2005 represents the most water level data collected in a single year in the history of the network. This is largely due to DWR's increasing reliance on automatic water level data collection. The data shown for calendar year 2006 is only for January through April/May, for most wells. If the figures shown were annualized, they would be comparable to the data collection in 2005. There will be some variance due to water level recorder malfunction and periods of repair, which result in reduced data collection.

In addition to the above data, DWR discovered a figurative gold mine of historical ground water data from network wells. While current automatic water level recorders record data digitally, earlier generation recorders used long paper charts with pens that moved as the water level in the well moved while the chart was advanced by a clock. When DWQ operated the statewide network, it employed dozens of these older chart recorders. In late 2005, DWQ gave us thousands of water level charts with previously undigitized data. These charts contain water level data from the late 1960s to the early 1980s. Since April 2006, we have been manually digitizing daily water level data from these charts for inclusion in our online databases. We are also investigating possible means of extracting hourly water levels from the charts through the use of optical scanning technology.

Well Installation and Maintenance

Despite having 536 wells at 178 individual sites, the well network does not give a complete picture of the state's ground water resources. Additional wells are needed in the Piedmont and Mountains to better monitor the effects of drought and other climatic cycles. More wells are also needed in the Coastal Plain to adequately monitor ground water conditions, including assessment of existing and future problems related to ground water overuse. To this end, DWR continually installs additional wells at new and existing monitoring stations.

In addition, the network requires much maintenance to keep existing monitoring stations usable. Many of the wells in the network are over 30 years old and are constructed of materials that are highly susceptible to corrosion, especially in acidic or salty ground water. Many wells in the network were constructed with older, less desirable construction practices, such as backfilling boreholes with cuttings instead of neat cement or bentonite grout. Backfilling with cuttings forms an inadequate seal and allows other aquifers to influence the water levels and water quality in that well. Other wells in the network were constructed with telescoped casing, in which smaller diameter casing is used at depth in the well, ostensibly to save money during well construction. Telescoped wells are highly susceptible to becoming blocked in the smaller diameter portions or becoming unusable when the water level drops below the portion of the well with a larger diameter. For these reasons, we have implemented a long-term program for replacing damaged or unsuitably constructed wells with properly constructed, new monitoring wells.

Installation of new and replacement monitoring wells occupied a large portion of our resources during FY 2005-2006. Table III contains a summary of the wells installed during this period. Figure 1 shows the locations of these wells.

Table III: New and Replacement Wells Installed FY 2005-2006

Site Name (Quad ID)	Number of Wells Installed	Reason for Installation
West Research Campus (M24L)	6	Fill data gap in Pitt County
Halls (S35Q)	2	Complete monitoring of all aquifers at site
Magnolia School (X44K)	3	1 – replace improperly constructed well 2 – complete monitoring of all aquifers at site
Red Banks (X47K)	1	Replace improperly constructed well
Clarks (S22J)	1	Replace improperly constructed well
Wellfield 258 (W25F)	1	Replace improperly constructed well

At times, we are able to find suitable wells for monitoring that were initially installed for other purposes. For instance, many of the monitoring wells in the Piedmont and Mountains were initially installed as supply wells and later discontinued for that purpose. Bedrock supply wells are often more easily adapted for monitoring due to their construction than are screened wells typical of the Coastal Plain. During FY 2005-2006, we added one out-of-service supply well to the network, the Bunn well, or, I35K2. This well was formerly part of the water supply system for the Town of Bunn. Its location and construction made it ideal for filling a data gap in the eastern Piedmont and the Town of Bunn graciously agreed to allow DWR to monitor the well long-term. Once a sufficient period of record is collected from this well, it will be used to assess climatic impacts, particularly from droughts, on the ground water resources of this portion of the state.

While maintenance of the well network is of utmost importance, DWR did not perform any major well maintenance activities during the fiscal year, aside from the previously mentioned well replacements. We did perform routine maintenance, such as keeping well sites clean and clear of brush and debris, development of new monitoring wells, and video logging of existing wells to confirm construction or diagnose potential problems. We anticipate that we will have to perform some major well maintenance next fiscal year. These activities will be covered in next year's annual report.

Automatic Water Level Recorders

Automatic water level recorders play an integral role in our ground water monitoring program. They allow economical collection of far more data than is possible using manual collection techniques. DWR currently uses primarily two types of recorders, as shown in Table IV and Figures 3 and 4. The first is the shaft encoder. It employs a float and counterweight hung off a wheel attached to the shaft encoder. Both the float and counterweight are placed inside the monitoring well and the float sits on the ground water surface. As the water level changes, the wheel is turned and that movement is electronically translated into a water level, which is recorded on an integral data logger. All DWR's shaft encoders are Model 8400As, manufactured by the Sutron Corporation. They were all purchased six to seven years ago and Sutron has since discontinued their manufacture.

The second type of recorder we use is the submersible pressure transducer. These units operate on the principle of measuring water levels as pressure above the transducer. A transducer is lowered into the well, typically seven to fifteen feet below the water level. The transducer measures the water pressure as the water level in the well fluctuates. An integral data logger records these pressure changes, converting them to a water level as measured below the top of the well casing. The transducers automatically compensate for atmospheric pressure changes so that these changes are not recorded as water level fluctuations. Currently, Global Water Instrumentation, Inc. manufactures all our pressure transducers. As shown in Table IV, we employ three different models of their transducers, the WL15, WL15X, and WL16S.

TABLE IV: Automatic Water Level Recorders Used in the DWR Ground Water Monitoring Network As of June 2006

Recorder Manufacturer/Model	Number in Service
Sutron Corporation/8400A	51
Global Water Instrumentation, Inc./WL15, WL15X	195
Global Water Instrumentation, Inc./WL16S	31
OTT/Thalimedes (1)	2
OTT/Orphimedes (2)	1

NOTE: Because of the sheer number of recorders employed by DWR, there are always units that are being repaired or refurbished at any given time. These units are not reflected in the above totals.

(1) The Thalimedes was evaluated for suitability during FY 2004-2005, but was not selected for mass purchase and installation. The evaluation samples are currently used as back-up recorders.

(2) The Orphimedes was evaluated for suitability during FY 2004-2005, but was not selected for mass purchase and installation. The evaluation sample is currently used as a back-up recorder.

Periodically, DWR evaluates different automatic recorder technology to assess its compatibility with our monitoring program. This year, we evaluated the WL16S by Global Water Instrumentation, Inc. It is the latest in a related series of recorders, including the WL15 and WL15X. The WL16S operates on the same principles as its predecessors, but has some new features that aid its reliability and ease of use. These features include a more advanced microprocessor, onboard monitoring of battery voltage, and telemetry system compatibility. Our evaluation of this model has been favorable so far and we currently use 31 of these recorders.

DWR also evaluated the WL15X-060, which has a sensor range of sixty feet, for use in the network. Typically, we use transducers with ranges of fifteen or thirty feet. However, some wells in our network undergo large water level changes over short periods of time due to their proximity to pumping wells. We did not find the WL15X-060 suitable for our purposes, as the increased sensor range resulted in decreased water level precision. The evaluation model was returned to the factory to be rebuilt with a new sensor appropriate for our purposes.

Figure 1: Locations of Monitoring Wells
NCDWR Monitoring Well Network
June 2006

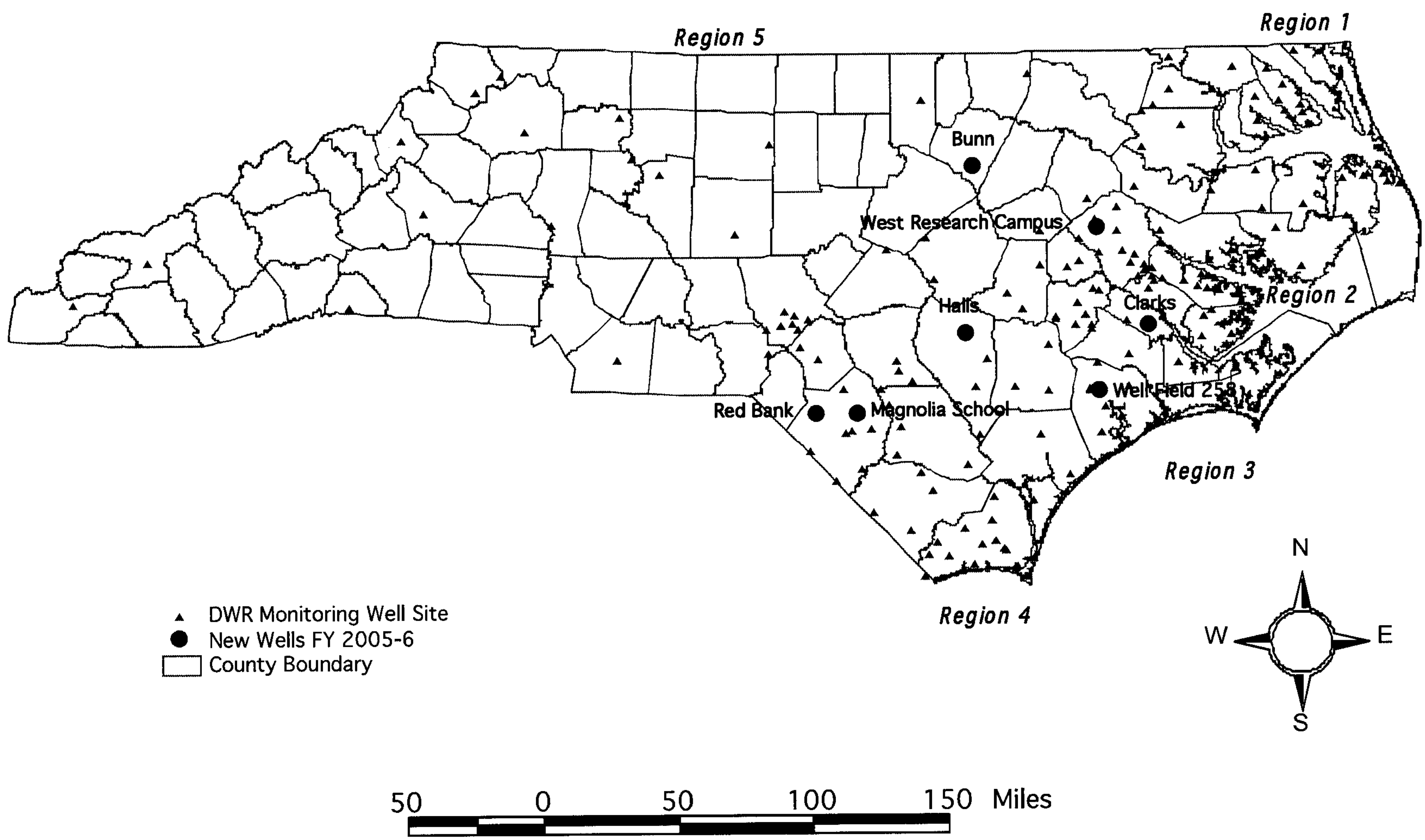
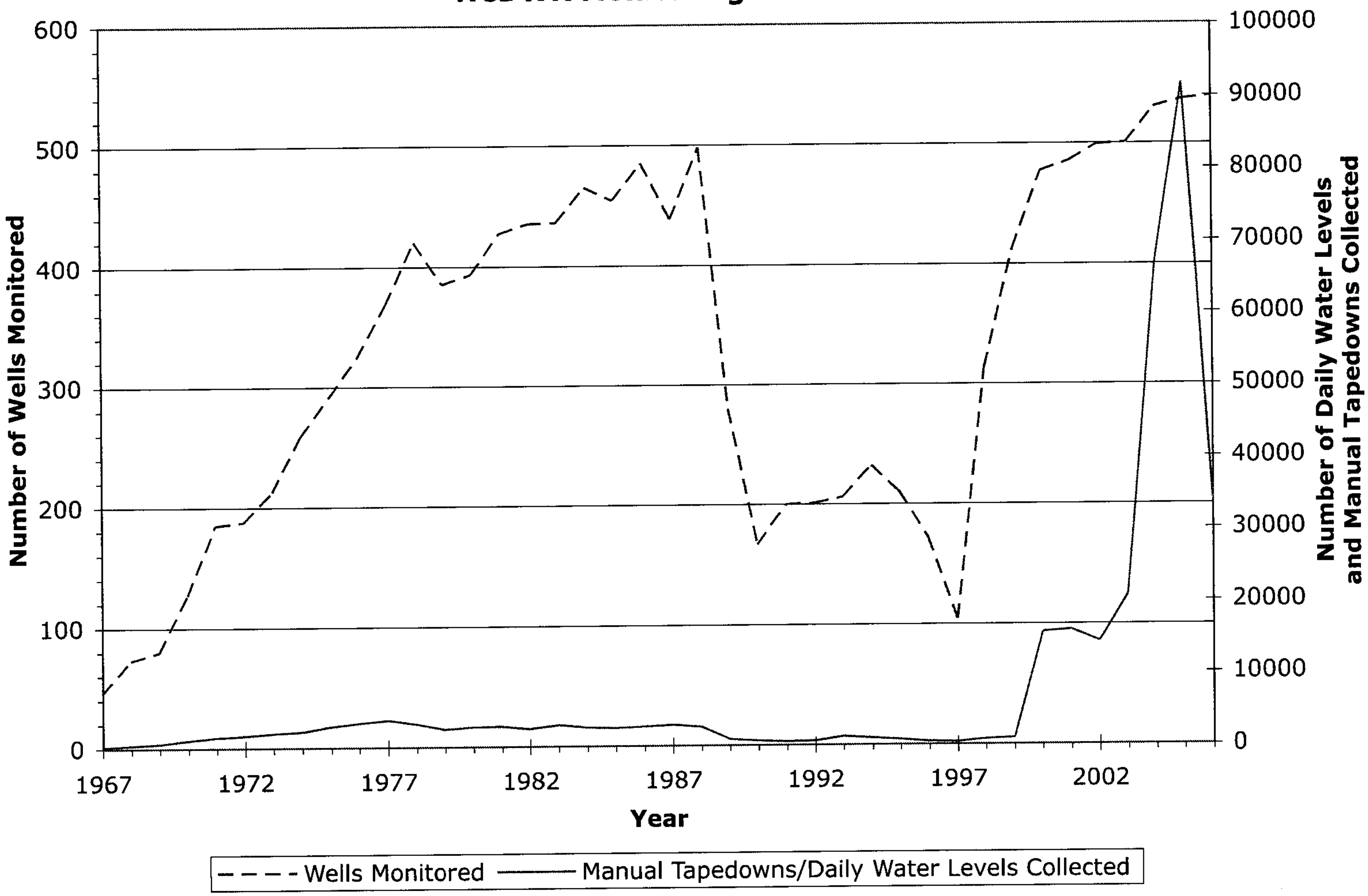


Figure 2: Water Level Data Collected by Year
1967 - May 2006
NCDWR Monitoring Well Network



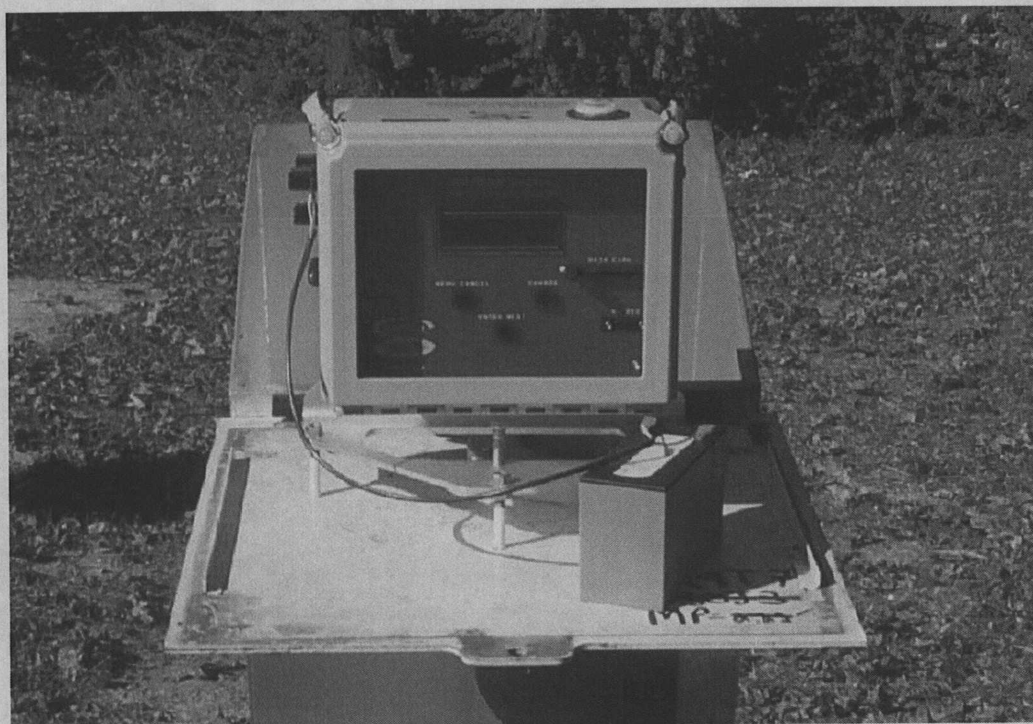


Figure 3: Sutron 8400A shaft encoder with integral data logger. Top picture shows front view of recorder. Bottom picture shows rear view with float and counterweight lines going into well.

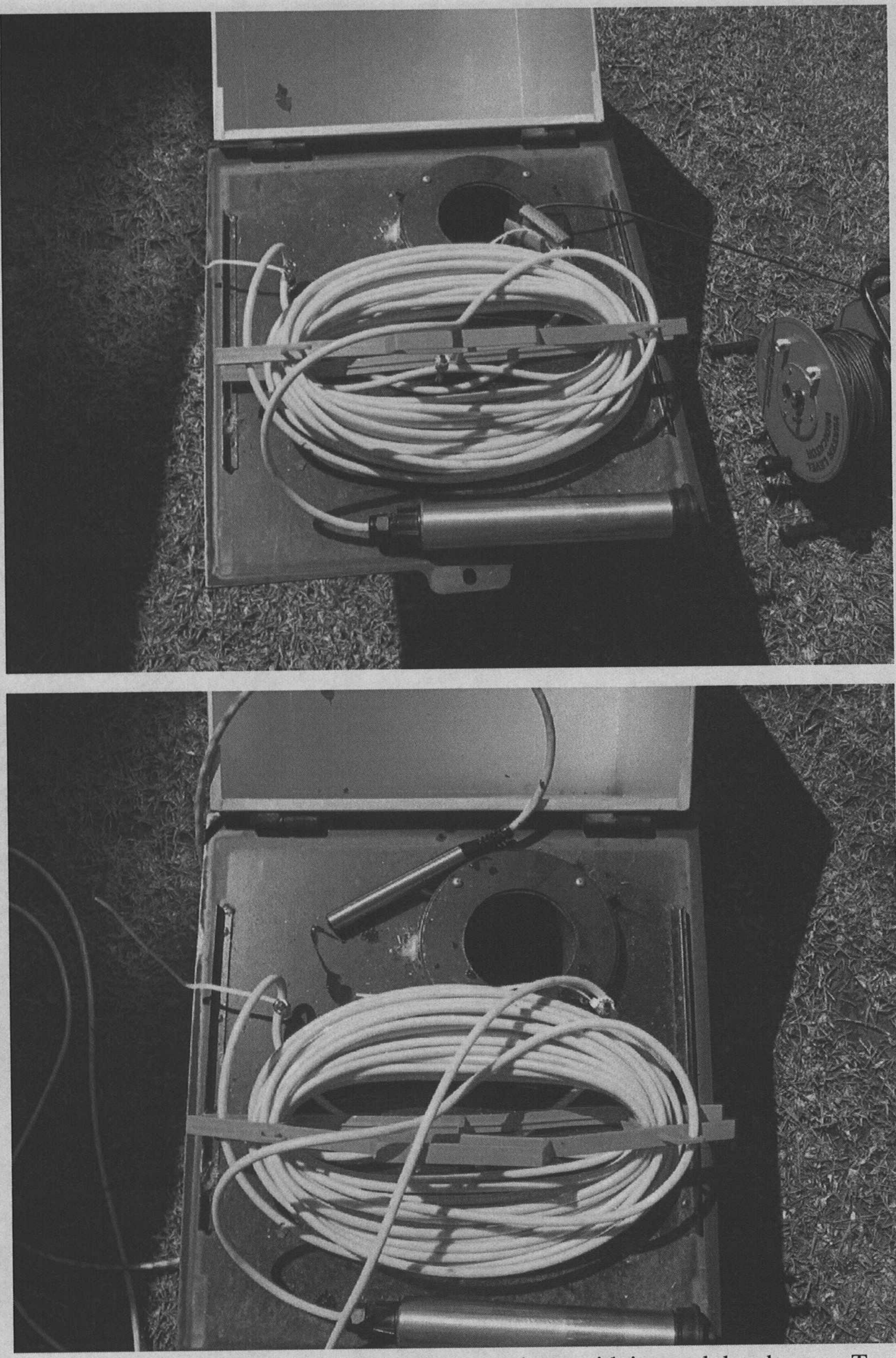


Figure 4: Global Water WL15X pressure transducer with integral data logger. Top picture shows unit as installed, with the transducer sensor in the well. The data logger is the silver tube on the edge of the shelter base. Also shown is a manual water level indicator, used to check the accuracy of the transducer. Bottom picture shows the transducer out of the well.