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May 31, 2007

MEMORANDUM

To: Aquifer Protection Section Central Office
Aquifer Protection Section Regional Supervisors
Construction Grants and Loans Section
Interested Parties

From: Ted L. Bush, Jr., Chief
Aquifer Protection Section TB

Subject: Hydrogeologic Investigation and Reporting Policy

In response to the need for consistent evaluation of land based utilization and disposal sites as well as other subsurface investigations, the Aquifer Protection Section has adopted the subject policy dated May 31, 2007, to be utilized by both consultants preparing applications and Division review staff. The subject policy reflects recent changes in the non-discharge rules with the adoption of Subchapter 02T. This policy provides additional detail to the requirements in Subchapter 02T. In addition this policy will assist with the preparation and review of other subsurface investigations needed for reports submitted for Division review.

<u>All permit applications and other site reports shall be reviewed in accordance with the attached document for any application received on or after August 1, 2007.</u> For any application received prior to that time, staff should review the application for adherence to the policy and discuss with the applicant and/or their consultants to encourage consistency with the policy.

Hydrogeologic Investigation and Reporting Policy

May 31, 2007

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Introduction and Purpose of the Policy

Hydrogeologic investigations are often required in conjunction with the design of non-discharge waste treatment and disposal systems pursuant to Subchapter 15A NCAC 02T as well as investigations related to groundwater quality under the Division of Water Quality's (Division) regulatory purview. This policy is intended to supplement those and other Division rules when conducting hydrogeologic investigations. This policy does not supersede Division rules.

The purpose of this policy is to improve the quality of hydrogeologic investigations submitted to the Division, to better define the criteria used to evaluate proposed systems, and thereby better protect the waters of the State. Past permit applications have revealed the need for consistent Division policy, and this policy is intended to provide direction for all permit applications and/or hydrogeologic investigations required by the Division. Adherence to this policy is mandatory, and not following it may result in prolonged review, further site characterization, and/or additional analysis.

Elements of a Hydrogeologic Investigation

The hydrogeologic investigation process involves five steps that are discussed individually in the following paragraphs. Documentation of the investigation process and report preparation is outlined in the next section.

In general, the hydrogeologic investigation should disclose sufficient site information to characterize the geologic and hydrogeologic character of the area of interest, and, where appropriate, lead directly to the proper construction of a groundwater flow and transport model. The data required by the groundwater modeling process should be acquired in the hydrogeologic investigation and documented in the hydrogeologic report. The following are the five steps that should be included in the formulation of professional hydrogeologic reports:

(1) Define study objectives
(2) Collect required data to prepare a hydrogeologic description
(3) Develop hydrogeologic conceptual model
(4) Merge hydrogeologic conceptual model into a groundwater predictive model
(5) Report hydrogeologic investigation results

(1) Define study objectives

In this critical first step, complete and detailed objectives of the hydrogeologic investigation should be specified. These objectives will dictate the level of detail necessary in the investigation. These objectives should:

(a) Adequately address the regulatory requirements regarding documentation required in the non-discharge permit application, and

(b) Adequately address the regulatory requirements regarding the minimum design requirements for the non-discharge wastewater treatment and disposal system which, in general, address the following concerns:

(i.) ensure that the groundwater quality standards will be maintained at the facility's compliance boundary or at the point of discharge for systems with no compliance boundary,

(ii.) estimate the zone of influence around an infiltration gallery/injection well to ensure that the system does not result in a violation of the groundwater quality standards beyond the compliance boundary or affected area; and

(iii.) ensure that the one foot water table separation will be maintained during system operation.

(iv.) document areas of groundwater discharge to surface waters.

By defining the objectives in this manner, the professional should know whether or not minimum design requirements can be met.

(2) Collect required data to prepare a hydrogeologic description

Hydrogeologic descriptions are required under portions of several sets of rules, including the 15A NCAC 02T rules that address wastewater irrigation systems (e.g., 15A NCAC 02T .0504 (e)), reclaimed water systems (e.g., 15A NCAC 02T .0905(e)), residuals management systems (e.g., 15A NCAC 02T .1104 (e)(4)), groundwater remediation systems (e.g., 15A NCAC 02T .1604 (c)), and certain types of injection wells (15A NCAC 2C .0211(d)). Depending on site specifics, data collection could include the following:

(a) Published reports describing the regional geology and hydrogeology, reports on local hydrogeologic investigations performed by consultants and government agencies;

(b) Background information about the site, identification of the nature and extent of all contaminants, identification of possible receptors in the surrounding area, characterization of the geologic, hydrologic, and meteorological settings, first-hand field observations supported by aerial photography, detailed county soils maps, 1:24,000 USGS topographic map, and any other project maps to regionally locate the site and designate contaminant and receptor locations (required), rainfall data from nearby weather stations obtained to determine the nature of rainfall patterns and estimate groundwater recharge, streamflow records from nearby gauging stations to determine variability in flow if the risk to a stream is being modeled;

(c) Sufficient number of bore holes drilled at the site to characterize site stratigraphy, existing lithologies, and depth to bedrock or confining layers

[Note: The maximum depth of subsurface investigation is the maximum depth that can be used in any predictive calculations or groundwater model for the purposes of calculating groundwater mound height and for calculating contaminant transport. For example, if a hydrogeologic investigation terminates its subsurface investigation at a depth of 20 feet, the groundwater predictive model can only use a maximum subsurface depth of 20 feet also.] (See the http://www.ncwater.org/ website for regional stratigraphic information in the Coastal Plain);

(d) Sufficient number of wells or piezometers installed to determine prevailing hydraulic gradients in the area, both horizontal and vertical, and an assessment as to how these gradients may vary seasonally and over time (required); determine the hydraulic properties of the aquifer(s) and aquitard(s) including the transmissive and storage characteristics of the aquifer system, such as transmissivity, hydraulic conductivity, storativity, and specific yield. An assessment of heterogeneity and anisotropy over the aquifer domain for each property should be made, particularly in the Piedmont and Mountain regions of the State. Include one or more aquifer tests of 24-hour minimum duration with sufficient observation wells to characterize horizontal and vertical isotropy for determining aquifer parameters. Depending on the nature of the contaminants and investigation objectives, slug tests or other such methods may be adequate to estimate aquifer parameters;

(e) The depth to the seasonal high water table;

(f) An inventory of groundwater recharge sources (precipitation infiltration areas, influent ("losing") streams, surface water bodies, etc.) and groundwater discharge mechanisms (wells, springs, groundwater discharge areas, effluent ("gaining") streams, etc.) within the area, and records obtained from any major sources withdrawing water from modeled aquifers (site specific);

(g) Sufficient testing of the contaminants to characterize the nature of each pollutant, concentrations at the source, and current migration patterns within the aquifer. Such data for contaminant transport simulations should include:

(i) The horizontal and vertical extent of the contaminant plume(s).
(ii) Organic carbon content of soil or sediment.
(iii) History and mass loading or removal rates for contaminant sources and sinks.
(iv) The presence of all known and potential receptors in the model domain.

(3) Develop hydrogeologic conceptual model

A hydrogeologic conceptual model is an interpretation or working description of the characteristics and dynamics of the physical hydrogeologic system. Developing this conceptual model is a critical step in the groundwater modeling process, for if the investigator incorrectly conceptualizes the hydrogeologic environment, then groundwater model results will likewise be incorrect and will produce invalid predictions.

The purpose of the hydrogeologic conceptual model is to consolidate site and regional geologic, hydrogeologic and hydrologic data into a set of assumptions and concepts that can be evaluated quantitatively. The components of the conceptual model, as described below, can be illustrated using contour maps, cross sections, block diagrams, and channel networks. It is essential that the uncertainty associated with each property or component of the conceptual model be quantitatively estimated. (See LeGrand, 2004 for a more detailed description of the development of a conceptual model for sites in the piedmont and mountain regions of North Carolina.)

(a) Geologic/Soil Framework

The geologic framework describes the distribution, configuration, and physical structure of underlying aquifers and confining units. Important factors to consider are the thickness and continuity of aquifer/confining units, representative lithologies within units, and the unit's geologic structure. The soil framework describes the various soils at the particular site that overlay and merge into the geologic framework. For many types of land application systems, the restrictive soil horizons (e.g., B soil horizon, a hard-pan horizon) are equally important to document as the underlying geologic units.

(b) Hydrologic Framework

The hydrologic framework describes the movement of water and other fluids within the geologic/soil framework. Factors to consider are:

(i) whether flow is primarily through porous media, fractures, or solution cavities;
(ii) what hydraulic boundaries exist within the flow domain;
(iii) the horizontal and vertical hydraulic gradients within the system;
(iv) how the fluid potential or head is distributed and how it varies over time (seasonally or otherwise);
(v) the rate and direction of predominant groundwater flow;
(vi) the locations of groundwater recharge and discharge areas;
(vii) the configuration of the groundwater flow lines and their tendency to change over time;
(viii) the existence and stability of groundwater divides within the area;
(ix) the existence of a restrictive soil horizon that will impact the overall vertical infiltration to the surficial groundwater table; and
(x) the existence of a semi-confined aquifer below the surficial aquifer that is having a pronounced affect on the overall water movement, such as vertical leakage into the semi-confined aquifer.

In the Piedmont and Mountain regions of the state, care should be given to how the hydrologic framework is conceptualized and modeled because of the difficulties in modeling fractured rock media. Typically, the subsurface may be conceptualized as a shallow soil medium overlying a saprolite (decomposed bedrock) zone, followed by a highly fractured bedrock transition zone, with an underlying less fractured bedrock zone. The groundwater table may lie in any of these zones (or fluctuate between them) depending on the site (See LeGrand, 2004; Daniel et al., 1997; and Harned and Daniel, 1992.). Special attention should be given to known underlying discrete faults, diabase dikes, and other distinct geologic features that potentially have hydrologic significance.

(c) Hydraulic Properties

Hydraulic properties include the transmission and storage characteristics of the aquifer system, such as transmissivity, hydraulic conductivity, storativity, and specific yield. Field and laboratory measurements of these properties should be documented (along with their uncertainties) and compared to accepted ranges for the medium under investigation. An assessment of heterogeneity and anisotropy over the aquifer domain for each property should be made, particularly in the Piedmont and Mountain regions of the state. The Division’s document entitled *Performance and Analysis of Aquifer Slug Tests and Pumping Tests Policy* should be referred to regarding the performance and analysis of aquifer tests.

(4) Merge hydrogeologic conceptual model into a groundwater predictive model

The hydrogeologic conceptual model should lead the investigator into selecting an appropriate groundwater flow and/or transport model for demonstrating (through model prediction) compliance with the seasonal high water table separation rules, any discharge areas to surface waters, and with the groundwater standards (15A NCAC 02L .0202) at the compliance boundary or receptor area. The modeling method selected may be simple to complex, depending on the complexity of the hydrogeologic and soil framework. The Division's document entitled *Groundwater Modeling Policy* should be referred to regarding modeling details.

(5) Report hydrogeologic investigation results

All hydrogeologic investigation data should be clearly documented. Maps should clearly present the layout of the site, showing all features including surface water bodies, property lines, compliance boundaries, review boundaries, structures, subsurface borings, pumping and observation wells. The general geologic setting should be described, as well as information describing the current utilization of groundwater resources in the immediate area. All drilling logs for exploratory borings should be provided, in addition to the available construction details of any nearby wells. Geologic and hydrogeologic cross sections should be provided. Predictive calculations for groundwater mounding and/or hydaulic breakout should be performed. Descriptions of all aquifer testing data (elapsed time and concurrent drawdown measurements) and analyses should be provided (see *Performance and Analysis of Aquifer Slug Tests and Pumping Tests Policy*). Any information obtained from the US Geological Survey or other agencies should be accurately referenced. The hydrogeologic investigation report must lead smoothly and directly into the predictive calculations or modeling documentation, where the appropriate conclusions are drawn regarding the regulatory minimum design requirements.

References

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