PROFESSIONAL GEOSCIENTISTS ONTARIO

PROFESSIONAL PRACTICE GUIDELINES FOR GROUNDWATER RESOURCES EVALUATION, DEVELOPMENT, MANAGEMENT AND PROTECTION PROGRAMS IN ONTARIO

October 18, 2004

Under Review

This guideline was developed by PGO's Environmental Geoscience Subcommittee

PGO
PROFESSIONAL GEOSCIENTISTS ONTARIO

TABLE OF CONTENTS

PROFESSIONAL PRACTICE GUIDELINES FOR GROUNDWATER RESOURCES EVALUATION, DEVELOPMENT, MANAGEMENT AND PROTECTION PROGRAMS IN ONTARIO

1. Introduction

These professional practice guidelines have been prepared by the Association of Professional Geoscientists (APGO) to assist Professional Geoscientists (P.Geo.) in the planning, implementation, inspection and review of studies and projects related to the evaluation, development, management and protection of groundwater resources. These guidelines have also been prepared to assist Professional Engineers (P.Eng.) who are qualified to practise professional geoscience in accordance with The Professional Geoscientists Act, 2000.

Groundwater resources studies/projects are typically undertaken to address issues related to groundwater supply, often developed for public consumption, the role of groundwater in maintaining sensitive environmental features (such as fish habitat, baseflow contribution to wetlands and other surface water features and ecological functions) and groundwater control measures during construction.

The guidelines have been prepared under the direction of the Environment Committee of APGO, with input from the general members of APGO. These guidelines describe minimum requirements in undertaking groundwater resources programs. It is expected that P.Geo. will use their judgement to determine when and where additional requirements are warranted. It is also expected that P.Geo. practising in this specialty area will be familiar with the appropriate technical literature, regulations and various technical standards that apply.

The professional practice guidelines for groundwater resources studies and projects represent one in a series of guidelines that have been prepared under the APGO General Professional Practice Guidelines for Environmental Geoscience. As such, the General Professional Practice Guidelines for Environmental Geoscience are considered an integral component of the guidelines for groundwater resources studies and projects.

These professional practice guidelines are also recommended for use in the planning and execution of environmental geoscience programs where there is a regulatory provision for a Qualified Person (QP).

The P.Geo. may base the environmental geoscience program on such geoscientific premises and interpretation of existing information as the P.Geo. decides to be appropriate, based on relevant experience and professional judgment. In planning, implementing and supervising environmental geoscience work, the P.Geo. should ensure that the practices are generally accepted in the industry and/or can reasonably be justified on scientific grounds.

The guidelines are not intended to inhibit the original thinking or application of new approaches that are relevant to environmental geoscience work. The guidelines recognise that geoscience is a discipline that is evolving along with new or innovative technologies and methodologies employed by Professional Geoscientists.

2. Areas of Professional Practice in Groundwater Resources

Five areas of professional practice in groundwater resources are identified in this document:

1. Wells and Well-head Security
2. Aquifer Definition and Characterization
3. Groundwater Resources Management and Development
4. Groundwater Protection
5. Construction Dewatering and Groundwater Control

Each area of professional practice is discussed below. Some components are common and applicable to more than one area of professional practice. The professional geoscientist should recognize the geoscientific framework and adopt the appropriate components to achieve the objective(s) of the study/project.

2.1 Wells and Well-head Security

This area of professional practice includes the siting, design, inspection during construction or maintenance/upgrades of water supply wells and monitoring wells, as they relate to water supply and the prevention of groundwater/well contamination. The following components should be considered in this area of professional practice:

2.1.1 Type of Well

Determine the category of the well as follows:

- Potable water supply well versus non-potable water supply well
- Domestic, communal, municipal, industrial/commercial or irrigation water supply well
- Recharge, dewatering, remediation, groundwater control or heat exchange wells
- Monitoring wells

Well Location and Grading

- Water wells used for drinking water should be sited away from existing or potential sources of contamination
- Siting of the drinking water supply well should take into account the relationship or potential relationship with surface water; appropriate grading should be performed to prevent ponding of surface water in the sanitary protection zone
- Siting of the well should recognize geoscientific factors, including zones or areas, that may have an undesirable influence on wells
- Recording of the well position should be performed, using GPS or other appropriate surveying technique, to ensure that the wells can be relocated

2.1.2 Water Well Design and Construction

- Obtain and properly use appropriate geoscience data for the design of a water well(s), considering factors such as filter pack, seals, screen setting and slot size, casing, etc.
- Consider aquifer yield and anticipated water use in the design
- Recognize and apply appropriate methods for disinfection

2.1.3 Water Well Performance Testing and Rehabilitation

- Use of methods, such as a variable rate (step) pumping test, to evaluate well capacity and well yield decline
- Use of well video surveys or other geophysical techniques to evaluate well condition and diagnose problems (existing wells)
- Use of water quality testing (chemical and biological) to evaluate well condition and diagnose problems (existing wells)
- Use of the above information to design and implement a well rehabilitation program
- Rating of the well capacity (peak and sustainable capacity)
- Consideration of potential impacts on adjacent groundwater users or environmentally sensitive features that could result from testing, or the discharge of fluids, during testing
- Recognition of the potential for damaging the wells during testing, for example from pumping at rates that exceed the original design characteristics of the well

2.1.4 Well Decommissioning (Abandonment) Methods

- Recommend that unused wells be decommissioned
- Use of appropriate techniques to prevent movement of surface water into the well and the movement of groundwater and contaminants between aquifers and/or the surface
- Techniques for decommissioning should consider the movement of water, or potential movement of water, within the well casing and within the annular space created when the well was constructed

2.1.5. Well Site Management and Security

- Acknowledge or recommend appropriate protection mechanisms around wells
- Recommend that contaminants, or potential contaminant sources, not be located within the area of well site management
- Recommend environmental management systems and best management plans where contaminant sources are already present within the immediate well site management area or sanitary protection zone of the well
- Provide mechanical protection against impact and security from introduction of foreign objects etc. (such as the use of bollards, posts, fencing, secure well head completions, site grading)

2.2 Aquifer Definition and Characterization

This area of professional practice is usually a component of the other areas of professional practice identified in these guidelines. However, it has also been undertaken independently to serve as a technical resource for future activities that include decisions regarding land use. The following components should be considered in this area of professional practice:

2.2.1 Identification and Geologic Mapping of Aquifers and Aquitards (at local and regional scales)

- Review of published topographic mapping, geological and hydrogeological mapping/reports for the study area (i.e., Quaternary geology maps, bedrock geology maps, bedrock topography maps, groundwater resources study reports), aerial photography
- Use of reliable drill hole information (such as geologic or geotechnical logs prepared under the direction and review of a professional geoscientist or professional engineer, samples of geologic sediments, geophysical logs) for interpreting stratigraphy

- Review of water well record information and recognition of the limitations and errors
- inherent in the water well record information when used in the practice of geoscience

2.2.2 Identification and Mapping of Groundwater Flow Systems (at local and regional scales)

- Use of reliable groundwater and surface water level data to generate potentiometric or water table surface/contour maps for the aquifers undergoing study
- Use of potentiometric surface maps and water table maps to assess groundwater flow directions, estimates of groundwater velocity and groundwater time-of-travel
- Use of numerical or analytical model(s), where existing information and study
- objectives support such use, to improve the understanding of the groundwater flow system or to develop estimates of the response of the groundwater system to future stresses (predictive modelling)
- Use of isotopes and tracers for age dating and groundwater identification
- Use of tracers to demonstrate groundwater flow paths

2.2.3 Identification of Aquifer Recharge and Discharge Areas

- Compare the surface topography, water table surface and the potentiometric surface maps taking into account surface water features and stratigraphy and the relationship between groundwater and surface features
- Interpretation of stratigraphy and measurement and interpretation of the significance of hydraulic gradients
- Use of isotopes and tracers for age dating and groundwater identification
- Consider the water balance/budget and the influence of weather and climate

2.2.4 Estimation of Hydraulic Properties of the Aquifers and Aquitards (such as hydraulic conductivity, transmissivity, storativity, specific yield)

- Assessment, and the application of, appropriate analytical techniques, based on the geoscientific framework, to the data for deriving the estimated hydraulic parameters; provide rationale
- Use of aquifer tests (pumping tests), single well hydraulic tests (such as slug tests, constant head tests, packer testing) and laboratory tests, where appropriate, to provide data for estimating hydraulic properties

2.2.5 Evaluation of Groundwater Chemistry and Microbiological Characteristics

- Use laboratory analyses and field measurements to characterize groundwater chemistry and microbiology
- Use of an appropriate sampling program (such as sample locations, number and timing of sample collection, QA/QC); provide rationale for the sampling program

2.3 Groundwater Protection

This area of professional practice addresses the management of existing groundwater supplies and the development of additional groundwater supplies for use by the public. The following components should be considered in this area of practice:

2.3.1 Identification and Geologic Mapping of Aquifers and Aquitards (at local and regional scales)

- Review of published topographic mapping, geological and hydrogeological mapping/reports for the study area (i.e., Quaternary geology maps, bedrock geology maps, bedrock topography maps, groundwater resources study reports), aerial photography
- Use of reliable drill hole information (such as geologic or geotechnical logs prepared under the direction and review of a professional geoscientist or professional engineer, samples of geologic sediments, geophysical logs) for interpreting stratigraphy

- Review of water well record information and recognition of the limitations and errors
- inherent in the water well record information when used in the practice of geoscience

2.3.2 Identification and Mapping of Groundwater Flow Systems (at local and regional scales)

- Use of reliable groundwater and surface water level data to generate potentiometric or water table surface/contour maps for the aquifers undergoing study
- Use of potentiometric surface maps and water table maps to assess groundwater flow directions, estimates of groundwater velocity and groundwater time-of-travel
- Use of numerical or analytical model(s), where existing information and study objectives support such use, to improve the understanding of the groundwater flow system or to develop estimates of the response of the groundwater system to future stresses (predictive modelling)
- Use of isotopes and tracers for age dating and groundwater identification
- Use of tracers to demonstrate groundwater flow paths

2.3.3 Estimation of Hydraulic Properties of the Aquifers and Aquitards (such as hydraulic conductivity, transmissivity, storativity, specific yield)

- Assessment, and the application of, appropriate analytical techniques, based on the geoscientific framework, to the data for deriving the estimated hydraulic parameters; provide rationale
- Use of aquifer tests (pumping tests), single well hydraulic tests (such as slug tests, constant head tests, packer testing) and laboratory tests, where appropriate, to provide data for estimating hydraulic properties

2.3.4 Evaluation of Aquifer Yield and Well Capacity at Specific Sites

- Use of appropriate method(s) for estimating yield to guide the design of the testing program
- Implementation of an effective testing program
- Rating of the aquifer yield and well capacity based on testing program results
- Determination of a water balance, with estimates of infiltration developed considering regional runoff (such as stream baseflow), consumptive water use and discharge from the aquifer
- Recognising and explaining the uncertainties in the resulting estimates of aquifer yield and well capacity

2.3.5 Evaluation of Groundwater Chemistry and Microbiology

2.3.6 Evaluation of Groundwater Sensitivity and Vulnerability to Contamination

2.3.7 Identification and Evaluation of Environmental Features Dependent on Groundwater (such as streams, wetlands, ponds, baseflow)

2.3.8 Evaluation of Existing Groundwater Use and Cumulative Impacts of Groundwater Use within the Area of Influence or the Watershed

2.3.9 Evaluation of Well Capture Areas and Recharge

2.3.10 Assess Environmental Impacts of Existing and Future Groundwater Extraction

- Consider or affirm sustainable resource management including consideration of weather and climate variations
- Recognize cumulative impacts throughout the aquifer system and the role of groundwater in sustaining surface water features and aquatic habitat
- Consider options to reduce or otherwise manage a water taking to minimize impacts
- Design and implement appropriate monitoring to confirm impacts

- Identify appropriate mitigative measures to rectify adverse impacts that occur; develop a contingency plan to address potential adverse impacts
- Discuss the risks associated with such an undertaking, including uncertainties in the analyses/interpretations, the risks of failure of the mitigative, contingency and monitoring measures

2.4 Construction Dewatering and Groundwater Control

This area of professional practice includes the development and implementation of groundwater protection plans and strategies for the maintenance and enhancement of water quantity and water quality. Groundwater protection programs normally include an evaluation on a local, regional and watershed scale. The following components should be considered in this area of professional practice:

2.4.1 Identification and Geologic Mapping of Aquifers and Aquitards (at local and regional scales)

- Review of published topographic mapping, geological and hydrogeological mapping/reports for the study area (i.e., Quaternary geology maps, bedrock geology maps, bedrock topography maps, groundwater resources study reports), aerial photography
- Use of reliable drill hole information (such as geologic or geotechnical logs prepared under the direction and review of a professional geoscientist or professional engineer, samples of geologic sediments, geophysical logs) for interpreting stratigraphy
- Review of water well record information and recognition of the limitations and errors
- inherent in the water well record information when used in the practice of geoscience

PROFESSIONAL GEOSCIENTISTS ONTARIO

2.4.2 Identification and Mapping of Groundwater Flow Systems (at local and regional scales)

- Use of reliable groundwater and surface water level data to generate potentiometric or water table surface/contour maps for the aquifers undergoing study
- Use of potentiometric surface maps and water table maps to assess groundwater flow directions, estimates of groundwater velocity and groundwater time-of-travel
- Use of numerical or analytical model(s), where existing information and study objectives support such use, to improve the understanding of the groundwater flow system or to develop estimates of the response of the groundwater system to future stresses (predictive modelling)
- Use of isotopes and tracers for age dating and groundwater identification
- Use of tracers to demonstrate groundwater flow paths

2.4.3 Estimation of Hydraulic Properties of the Aquifers and Aquitards (such as hydraulic conductivity, transmissivity, storativity, specific yield)

- Assessment, and the application of, appropriate analytical techniques, based on the geoscientific framework, to the data for deriving the estimated hydraulic parameters; provide rationale
- Use of aquifer tests (pumping tests), single well hydraulic tests (such as slug tests, constant head tests, packer testing) and laboratory tests, where appropriate, to provide data for estimating hydraulic properties

2.4.4 Evaluation of Groundwater Velocities and Identification of Time-of-Travel Zones

2.4.5 Evaluation of Groundwater Sensitivity and Vulnerability to Contamination

- Consider the hydrogeology (occurrence and distribution of aquifers and aquitards)
- Prepare a potential contaminant sources inventory
- Consider the use of various methods to assess potential contaminant migration and changes within the hydrogeologic environment

PROFESSIONAL GEOSCIENTISTS ONTARIO

2.4.6 Consider Natural Environmental Features Dependent on Groundwater and Surface Water (such as streams, wetlands, ponds, baseflow)

2.4.7 Groundwater Under the Direct Influence of Surface Water (GUDI)

- Evaluate the time of travel for surface water to reach the well completion interval; compare the estimated time of travel with appropriate criteria for the survival of pathogenic organisms (such as the 50-day criteria used by the Ontario Ministry of the Environment in 2001 – 2003)
- Evaluate the level of in situ filtration for those groundwater supplies that are considered GUDI
- Assess microbial water quality
- Consider use of microscopic particulate analysis as a tool to demonstrate in situ filtration
- Emphasize the protection of public health
- Identify Well Head Protection Areas

2.5 Construction Dewatering and Groundwater Control

This area of professional practice is one where there is often considerable liaison with the services provided by a professional engineer with expertise in geotechnical engineering and with dewatering contractors. Construction dewatering most often involves installation of temporary facilities to lower the water table or to depressurize an aquifer to enable construction. The following components should be considered in this area of professional practice:

2.5.1 Evaluate and Document Existing Site Conditions

- Review of local groundwater and surface water use, and identification of local natural features that are dependent on groundwater and surface water

- Review of published topographic mapping, geological and hydrogeological mapping/reports for the study area (such as Quaternary geology maps, bedrock geology maps, bedrock topography maps, groundwater resources study reports), aerial photography
- Use of reliable drill hole information (such as geologic or geotechnical logs prepared under the direction and review of a professional geoscientist or professional engineer, samples of geologic sediments, geophysical logs) for interpreting stratigraphy
- Review of water well record information and recognition of the limitations and errors inherent in the water well record information when used in the practice of geoscience
- Use of data and information to predict the potential impacts of dewatering on groundwater and surface water resources; use of a numerical or analytical model(s) should be considered to develop estimates of the impacts of dewatering on the groundwater system

2.5.2 Outline Proposed Development Features and Construction Activities

2.5.3 Define Construction Dewatering Requirements (using pumping tests where appropriate)

2.5.4 Implement Temporary or Permanent Dewatering Scheme

- Consider options to reduce or otherwise manage the water taking to minimize impacts
- Recognize impacts of discharge water quantity and quality on the environment
- Acknowledge the potential for the dewatering scheme to lower groundwater levels beneath other properties and the potential impact of that groundwater lowering on existing structures on those properties
- Recommend a monitoring program to confirm the effects of the dewatering scheme

2.5.5 Evaluate the Need for Remedial Measures and Make Recommendations

PROFESSIONAL GEOSCIENTISTS ONTARIO

3. General Methodology

In general, the following methodology applies to all groundwater studies and projects.

3.1 Review of Existing Information

As a general rule, groundwater resources studies and projects should begin with the collection and review of existing regional and site-specific information. This information will be used by the Professional Geoscientist to develop a conceptual interpretation of the hydrogeology and groundwater flow system. Sources of existing information that should be considered in this review include: geological mapping, hydrogeological mapping, water well record data, hydrogeologic or groundwater related reports available for the area, aerial photography, climatic data, topographic mapping and surface water mapping, stream flow data. Depending upon the objectives of the study or project and the quality of existing information, the Professional Geoscientist will identify additional data requirements.

3.2 Data Collection

Groundwater resource studies and projects require collection of data to address the components identified in the areas of professional practice. The Professional Geoscientist must identify and rationalize a program of scientific data collection based on the objectives of the study/project, the quality of the existing information, and professional judgement.

The types and methods of data collection that should be considered by the Professional Geoscientist include, but are not limited to the following: drilling of test holes, collection of sediment/bedrock samples; physical/hydrogeological/mineralogical laboratory analyses; installation of monitoring wells and test wells; monitoring of groundwater levels; collection and chemical/microbiological analysis of groundwater samples; borehole and surface geophysics; tracer tests; age dating of groundwater; pumping tests; and other hydraulic well tests (such as slug tests).

PGO
PROFESSIONAL GEOSCIENTISTS ONTARIO

3.3 Analysis and Interpretation

The Professional Geoscientist is responsible for the analysis and interpretation of the existing information and additional data collected as part of the study/project. Methods of analysis and interpretation that should be considered by the Professional Geoscientist include: preparation of hydrogeologic maps (i.e., potentiometric maps, geologic contact and/or isopach maps, groundwater sensitivity maps); preparation of hydrogeologic cross-sections; graphing and plotting of data (i.e., groundwater level data, groundwater chemistry data, pumping test data); calculation of hydraulic gradients and groundwater velocities; analysis of groundwater flow using analytical equations (i.e., Darcy equation) and/or numerical computer models; analysis of pumping test data and/or hydraulic well test data using analytical equations; and preparation of water budgets recognizing weather and climate extremes. The rationale behind the method(s) of analysis and interpretation used for a given study/project should be provided. The method(s) of analysis and interpretation should be based on science and professional judgement and not on conjecture or speculation. Where appropriate, the Professional Geoscientist should also provide reasons why other method(s) of analysis and interpretation were not used.

The data analysis and interpretation of the study/project results should determine whether the study/project objectives have been met and whether further work is necessary to meet the objectives.

3.4 Technical Reporting

A technical report should be prepared for each phase or milestone of a groundwater study/project. The report should present the data, methods of analysis, and interpretations in a clear and scientific way. Interpretation, conclusions and recommendations should be provided in the report. The report should be signed and sealed by a Professional Geoscientist.

4. Protection of the Public and the Environment

Groundwater resources evaluation, development, management and protection studies/projects should be conducted in a safe, professional manner in accordance with applicable regulatory requirements, and with due regard for public health, the natural environment, and the concerns of local communities.