



UniWater Education Limited

# Proposed MSc/PGDiploma in Hydrogeology and Water Resources Management

*A collaborative approach to assisting Africans to solve African water challenges*

Laurra Olmsted, MSc.  
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[www.UniWaterEd.org](http://www.UniWaterEd.org)



## 1. INTRODUCTION

### 1.1 Overview

Groundwater forms the most important source of water supply in the urban, peri-urban and rural areas of most sub-Saharan African (SSA) countries, thereby driving a country's socio-economic development. However, because it is below the earth surface and is not visible, groundwater flow and occurrence is poorly understood by most non-technical people. As a consequence, groundwater has not been developed to its full potential as a source of high quality water. In some locations, rapid expansion of urban areas has occurred resulting in an increased risk to groundwater quality in areas of recharge. Climate change in the past several decades has resulted in unpredictable rainfall events which can affect groundwater recharge quality and quantity as well as control of surface water. This creates enormous challenges, and poses threats to groundwater that may negatively affect continued provision of adequate and safe potable water in the future. To address this, UniWater Education Limited (UniWater) has developed a generic M.Sc./PGDip programme in Hydrogeology and Water Resources Management to provide advanced training of professionals in hydrogeology to promote the sustainable use of groundwater for today's water needs and to protect the resource for the future.

The programme curriculum includes the following aspects of water resources:

- technical hydrogeology and hydrochemistry;
- social community water supply;
- integrated water resources management (IWRM); and
- governance.

The intent is to encourage development of the programme at numerous host universities in Sub-Saharan Africa to increase the number of training programmes offered in-country to African nationals. The programme will be applicable to both an MSc level degree which consists of course work plus a research project, or as a post-graduate diploma which would be earned with only the course work component. It is expected that each host university will customize the programme to fit their format and requirements. The first three programmes are currently in the final stages of getting approval by their University Senate Committees and are expected to begin within the 2015/2016 school year. Concurrently, UniWater is proceeding with the initial consultation process to evaluate the next three host universities. It is anticipated that three new programs will be initiated each successive year for at least the next eight years. The initial programme consists of 'core courses', but as time allows, elective courses will be added to those offered in order to allow the host university to customize their program based on local issues and faculty expertise. The content of the core courses will also be updated periodically by UniWater with new technologies and developments. Any updates will be available to the host universities.

An important aspect of the UniWater programme is the connection to a mentoring university. At this time, the University of Toronto Scarborough in Canada is the mentoring university for the three initial programmes. As the number of programmes increases, partnerships with other mentoring universities will be formed as required.



It is proposed that the students at the mentoring university will host an annual fundraiser to raise proceeds in support of scholarships, equipment or resource material at the host university, although this is up to the mentoring university to arrange with assistance from UniWater.

## 1.2 Aims of the Programme

The UniWater program is based on the ability of graduates to be able to *solve problems* that they encounter in the water sector in Africa. Examples provided in Appendix A include the following:

- ✓ Working to reduce the distance that women and children walk to collect water;
- ✓ How to create safe drinking water supplies from man-made and natural contamination; including sourcing, storing and mixing techniques;
- ✓ How to safe-guard water supplies in an era of climate change;
- ✓ How to set up a data-sharing system and governance to manage the resources into the future; and
- ✓ How to communicate technical information to lay-people to bring about practices that reinforce habits that support health, protect the environment, and lays the groundwork for a sustainable economic future in the water sector.

The programme emphasizes scientific facts, social and economic values and ethics that are essential in determining an appropriate course of sustainable use of groundwater resources.

Furthermore, the overall intent of the programme is:

- To create and improve awareness of the occurrence of groundwater resources.
- To improve the level of understanding of the integration between surface water and groundwater to more effectively develop, utilize and manage the resource.
- To work with water supply agencies in improving access to safe drinking water for all people in the country, regardless of where they live and independent of their social-economic status.

## 1.3 Target Group

The programme is targeted at persons interested in working with water-related agencies including river basin organizations and catchment management authorities, water utilities, environmental and natural resources sectors, Non-Governmental-Organizations (NGOs), consultants and researchers.

## 1.4 Admission Criteria

Applicants shall be eligible for registration in the Master's degree in Hydrogeology and Water Resources Management if he/she has: A bachelor degree (with a minimum of second class or its equivalent) in Geology or Hydrogeology or Geography from a recognised institution or any other related field, e.g. Civil Engineering, Environmental Engineering, or Environmental Sciences (with 'A' level Mathematics/Geography). In cases, where the applicant does not have the above qualifications, the publication of a research article in a peer reviewed journal on any topic in this field, and/or relevant



work experience exceeding five years, may be considered with letters of recommendation from his/her agencies.

### 1.5 Duration

The programme could be offered on a full time basis for a maximum of two academic years, and will consist of the following:

- Course work in the first year (First academic year-8 months), and
- An independent research project (Second academic year- 8 to 12 months),
- Candidates who complete only the course work (First academic year) would be eligible for the award of a Postgraduate Diploma in water resources.

### 1.6 Mode of Delivery

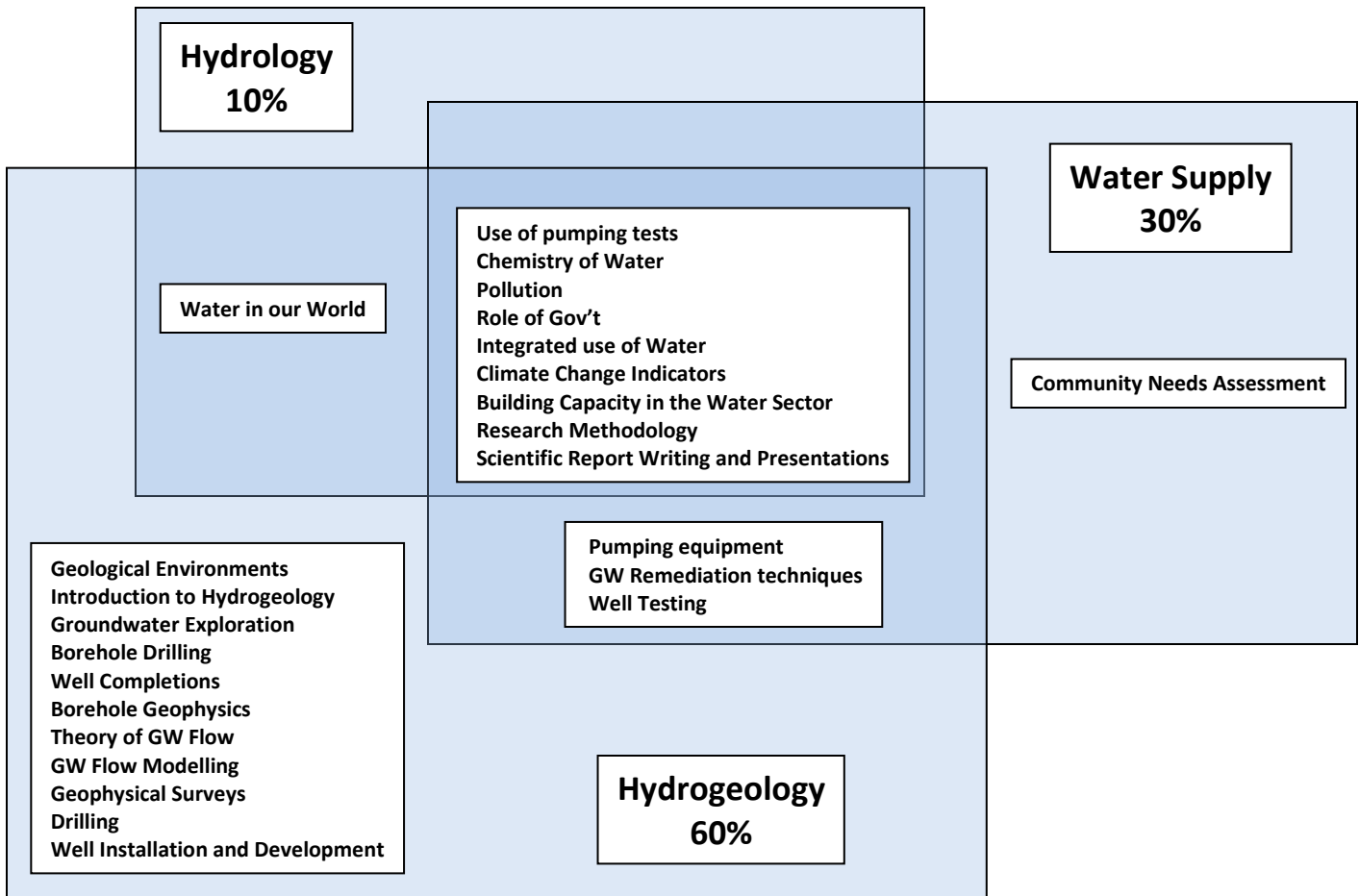
Each course is structured on a modular basis where students take classes over two semesters. Each module is assigned credit hours. The mode of delivery will be through lectures, practicals, self study and independent research. The Research Project will be undertaken independently with individual supervision by a faculty member or any practising hydrogeologist with an MSc or more advanced degree.

### 1.7 Structure of the Programme

The structure of the core programme is as given below:

Semester	Course code	Course title	Credit unit
First	GLG 651	Water and its Occurrence	3
	GLG 661	Borehole siting, drilling and completion	3
	GLG 671	Groundwater Flow in Aquifers	3
	GLG 681	Groundwater Chemistry and Pollution	3
Second	GLG 652	Integrated Water Resource Management	3
	GLG 662	Groundwater Modelling	3
	GLG 672	Research Methodology	3
	GLG 682	Field School	3
Third	GLG 600	Research Project	6

At the current time, the programme consists of approximately 60% hydrogeology, 30% water supply and 10% hydrology. The following schematic indicates the modules contained in the courses, and how the content overlaps these three disciplines.



### 1.8 Financial Considerations

Funding to create the programme curriculum has been generously provided by Grand Challenges Canada, a program created by the Government of Canada to provide ***Bold Ideas with Big Impact™ in global health.***

The intent is to provide the programme curriculum at a minimal charge to approved host universities that meet the following requirements:

- Currently have an accredited undergraduate science-based program with higher-level mathematics;
- Currently have, or will have by the beginning of the programme, sufficient staff to teach the curriculum, with at least one PhD level professor who specializes in Hydrogeology in a senior position on the faculty team.
- Have sufficient classroom and laboratory space for instruction purposes.
- Have access to computers for the computer modelling module, and books for reference purposes.



It is necessary for the host university to provide the staff, equipment and physical space to present this programme. It will also be the responsibility of the prospective host university to fulfill all senate requirements to ensure this programme is accredited by the university.

While funding has not yet been secured beyond development of the curriculum, UniWater is confident that additional funding will be secured by partnerships with corporations or government programs to proliferate the programme to successive host universities beyond 2015.

## **2. Module Details**

### **2.1 GLG 651 - Water and Its Occurrence**

#### **Rationale**

The student will learn the concepts of geology and the occurrence of both surface water and groundwater. They will learn the specifics of hydrogeology and the language of hydrologists and hydrogeologists.

#### **Learning Objectives**

*Upon Completion of the module participants will be able to...*

1. Understand how/where water exists on earth and beneath the ground surface.
2. Demonstrate an understanding of the dynamics of surface water and groundwater flow
3. Become familiar with the language used by hydrogeologists and the tools used to communicate technical information.

#### **Teaching Methods**

Two one-hour lectures per week, plus one three-hour practical per week.

#### **Topics and Learning Activities**

##### **A. Geological Environments**

An introduction to igneous, sedimentary and metamorphic rocks, geologic structures; weathering processes, soil formation processes and constituents; aspects of soil mineralogy, physics and chemistry.

##### ***Learning Activities***

Formal lectures

- Groundwater in Africa

Laboratory practicals

- identification of igneous, sedimentary and metamorphic rocks
- Geology of Africa, Regional Geology of host country
- Hydrogeologic/geologic map reading and development of cross sections



Field trip

- Examination of regional aquifers in outcrops, if possible. Identification of springs

**B. Water in Our World**

The hydrologic cycle; the potential use of groundwater vs surface water; regional vs local flow (Toth model); geothermal springs; the water budget.

***Learning Activities***

Formal Lectures

- MOOC lectures from UNESCO-IHE
- Water for Roads

Laboratory practicals

- Examination of the use of groundwater globally
- The water budget
- Climate change impacts

Field trip

- Basin-wide water balance
- Toth flow model
- Effects of climate change

**C. Introduction to Hydrogeology**

Aquifers and aquitards; nature of head; Darcy's law; porosity, hydraulic conductivity/permeability (field vs lab measurements); groundwater flow towards a well; isotropic and anisotropic aquifers; homogeneous and heterogeneous aquifers; estimation of hydraulic conductivity from particle size distribution; field tests for permeability (pumping tests); use and construction of flow nets.

***Learning Activities***

Formal lectures

Laboratory practicals

- Understanding of Darcy's law, velocity of groundwater flow
- Field and lab hydraulic conductivity measurements, using slug tests, sieve analysis, permeameter tests
- Flow to a well using analog models (electricity)
- Flow to a well in a homogeneous and heterogeneous aquifer (tank test)
- Flow net construction



### Lecturing Material

Texts  
Handouts  
Powerpoint presentations

### Assessment

Assignments 30%  
Field trip 10%  
Written exam (closed book) – 60%

### Hours Allocation

UniWater Education Groundwater and its Occurrence – GLG 651								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Geological Environments	6	15	4	20	25	45	
	Water in Our World	8	9	4	20	21	41	
	Introduction to Hydrogeology	10	15		20	25	45	
	Total	24	39	8	60	71	131	

## 2.2 GLG 661 - Borehole Siting, Drilling and Completion

### Rationale

Exploration for and development of an invisible commodity is difficult. Therefore, it is important that the development of drilling programmes is consistent with sustainable use of the resource. It is critical that boreholes are drilled in a manner to optimize the resource and that wells are installed properly to ensure maximum water supply. Borehole geophysics will also be taught to provide tools on strata interpretation and screen placement. Well development, maintenance and rehabilitation will provide tools for extending the life of a well.

### Learning Objectives

*Upon Completion of the module participants will be able to....*

1. Assess and survey an area in need of a water well
2. Determine the appropriate drilling location, drilling method, collect available information for planning the drilling program.





3. Prepare an effective drilling contract, be knowledgeable of how to hire and supervise a drilling contractor.
4. Know what information to record and how to keep proper records of the drilling process and well completions.
5. Know how to construct a water well, maintain it, and rehabilitate an ineffective well.

### **Teaching Methods**

Two one-hour lectures per week, plus one three-hour practical per week.

### **Topics and Learning Activities**

#### **A. Groundwater Exploration**

The use of geological information and geophysics (remote sensing, airborne and surface methods) to delineate the best drilling locations.

##### ***Learning Activities***

Formal lectures

Laboratory practicals

- Remote sensing, airborne geophysics (EM, LandsAT)
- Electrical Resistivity
- Seismic
- Gravity
- Magnetic
- Tomography

#### **B. Borehole Drilling**

Methods and optimum geologic environments for use of manual methods, low cost mechanized methods (cable tool) and high cost mechanized methods (rotary, auger, percussion).

##### ***Learning Activities***

Formal lectures

#### **C. Well Completions and Development**

The purpose of each well component, selection of appropriate materials (casing, screen, gravel pack, grout/seal, apron). Use of piezometers/monitoring wells. Purpose of pack development, Rehabilitation methods (symptoms, physical methods, acidification, shock chlorination).



***Learning Activities***

Formal lectures

Laboratory practicals

- Well design

**D. Borehole Geophysics**

Use of caliper, temperature, conductivity, spontaneous potential, resistivity, natural gamma, neutron, CCTV

***Learning Activities***

Formal lectures

Laboratory practicals

- Geologic correlation using borehole geophysics and geology

**E. Pumping Equipment**

Selection of appropriate pumping equipment (size, material, water storage considerations, hand pumps, maintenance, electrical considerations).

***Learning Activities***

Formal lectures

Laboratory practicals

- Selection of pumping equipment

**Lecturing Material**

Texts

Handouts

Powerpoint presentations

**Assessment**

Assignments 30%

Written exam (open and closed book) – 70%



## Hours Allocation

UniWater Education Borehole Siting, Drilling and Completion – GLG 661								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Groundwater Exploration	6	18		20	24	44	
	Borehole Drilling	3			5	3	8	
	Well Completions	2	3		10	5	15	
	Borehole Geophysics	8	6		15	14	29	
	Pumping Equipment	2	3		10	5	15	
	Total	21	30		60	51	111	

## 2.3 GLG 671 – Groundwater Flow in Aquifers

### Rationale

This course intends to create an understanding of how water flows in the subsurface. The course teaches the principles of conducting a pumping test to assess the potential for water supply, as well as assess the ability of the well(s) to deliver the volume of water desired in a given time.

### Learning Objectives

*Upon Completion of the module participants will be able to....*

1. Demonstrate an understanding of how water flows in the subsurface
2. Plan and execute a pumping test program, analyze the results for sustainable pumping of the aquifer, and present the information in 'layman's terms'.

### Teaching Methods

Two one-hour lectures per week, plus one three-hour practical per week.

### Topics and Learning Activities

#### A. Theory of Groundwater Flow in Confined, Leaky and Unconfined Aquifers

Radial flow to wells, definition of terms (porosity,  $T$ ,  $S_x$ ,  $S$ ,  $S_y$ , leakage factor), Confined aquifers (Theim for steady state, Theis and Jacob for transient flow), Leaky aquifers (Walton for steady state, Hantush-Jacob for transient) and Unconfined (Thiem-Dupuit for steady state, Neuman for transient). Effects of boundaries. Step tests. Well fields. Slug tests.



***Learning Activities***

Formal lectures

Laboratory practicals

- Confined aquifers (Theim, Theis and Jacob)
- Leaky aquifers (Walton and Hantush-Jacob)
- Unconfined (Thiem-Dupuit and Neuman)
- Boundaries
- Step Tests

**B. Practical Use of Pumping Tests**

Planning, data collection, filtering and analysis of data, recommendations based on results.

***Learning Activities***

Formal lectures

Laboratory practicals

- Well field
- Field trip planning
- Field trip data analysis
- Field trip results presentation

Field trip

- Conduct a pumping test in real-time, analyze data and present results and recommendations to class/community/client (pump calibration, step test, 24 hr pumping test, 24 hr recovery)

**Lecturing Material**

Texts – Freeze and Cherry (1979), Kruseman and deRidder (1991)

Handouts

Powerpoint presentations

**Assessment**

Assignments 45%

Field trip 25%

Written exam (closed book) – 30%



## Hours Allocation

UniWater Education Groundwater Flow in Aquifers – GLG 671								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Theory of GW Flow	18	24		24	42	66	
	Practical Use of Pumping Tests	6	12	36	0	30	54	
	Total	24	36	36	24	72	120	

## 2.4 GLG 681 – Groundwater Chemistry and Pollution

### Rationale

Living in today's world means that there is the potential for groundwater contamination. By knowing these hazards, groundwater can be protected from degradation. However, it is important to also understand how chemical interaction of water flowing within rocks in the subsurface may concentrate some chemical parameters in the water. Such chemical variations in groundwater can be used as a tool for understanding its flow paths in the subsurface.

### Learning Objectives

*Upon Completion of the module participants will be able to...*

1. Understand groundwater chemistry and what affects it, both natural and anthropogenic sources.
2. Determine whether a source of water is potable, or suitable for agricultural purposes.
3. Be able to ascertain whether contaminated water is a result of natural processes or contamination.
4. Be aware of remedial measures that can be used to deal with contaminated groundwater.

### Teaching Methods

Two one hour lectures per week and one three-hour practical per week.



## Topics and Learning Activities

### A. The Chemistry of Water

An introduction to hydrochemistry, how water is analyzed in a laboratory, the influences of sampling techniques, data presentation methods, natural processes that influence the chemistry in various locations, and the use of isotopes for groundwater dating and characterization.

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Analyzing water samples using field methods, mass spectrometer, atomic absorption
- Assessing data quality
- Data presentation methods – manually
- Data presentation using software
- Regional data review
- Isotopes

### B. Contaminant Hydrochemistry and Remediation

The impact of man on water quality, sources of pollution. Behaviour of organic and inorganic contamination. Sampling protocols for contaminant studies. Saline intrusion. Effects of oil and gas exploration/production, mining. The use and development of groundwater protection zones.

Groundwater remediation techniques including attenuation processes (sorption; filtration; microbiological degradation; dilution); pump and treat methods (setting goals; system design; containment and capture techniques; pumping considerations; groundwater treatment methods); isolation of contaminant (capping, barrier walls, funnel and gate); water treatment options for domestic supplies (point of use biosand filters, reverse osmosis, boiling, ceramic filters, chlorination, charred corn stalks).

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Saline intrusion
- Oil and gas exploration contaminant assessment
- Oil and gas operation contaminant assessment
- Mining assessment
- Remediation of organic compounds
- Remediation of inorganic compounds



- Treatment of domestic water supplies

Field trips

- Day trip to an oil and gas drill site to identify sources of impacts, then to a production facility to identify sources of contamination there.
- Day trip to a mining operation to identify sources of contamination or other impacts related to this industry that could ultimately impact water source and quality.

**Hours Allocation**

UniWater Education Groundwater Chemistry and Pollution – GLG 681								
Nr	Topic	Lecture	Lab work	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	The Chemistry of Water	9	18		9	27	36	
	Contaminant Hydrochemistry	9	12	16	9	37	46	
	GW Remediation Techniques	6	9		6	15	21	
	Total	24	39	16	24	79	103	

**2.5 GLG 652 – Integrated Water Resource Management**

**Rationale**

This course examines how groundwater and surface water need to be managed as one resource to ensure there is water for future generations. The effect of groundwater on manmade structures, and vice versa, will be examined in a bid to avoid detrimental interactions. Furthermore, getting community buy-in to a project is critical to long-term sustainability. Sources of water for domestic supply in addition to groundwater will be examined for their application to improving access to safe drinking water. Other social aspects related to the delivery of water in communities will be examined, including funding of water projects, working with NGOs and Community-Based-Organizations (CBOs), the role of government, and capacity building in non-technical aspects (ie the nine aspects of the RWSN manual drilling capacity building project) that will raise the ability of the entire water sector to fill the needs now and in the future.



## Learning Objectives

*Upon Completion of the module participants will be able to...*

1. Work with community groups and other stakeholders to work towards finding sustainable solutions to domestic or agricultural water supply problems.
2. Be able to present technical information in a format that everyone is able to understand.
3. Evaluate all sources of available water for use.
4. Be knowledgeable of all aspects that go into capacity building in the water sector.
5. Understand the role of government in protection of groundwater resources.

## Teaching Methods

Two one hour lectures per week and one three-hour practical per week.

## Topics and Learning Activities

### A. The Role of Government

Collection, storage and retrieval of groundwater and hydrologic data. The use of computer models for resource management and presentation of information. Basin studies, 'safe' yield, monitoring and protection mechanisms. The use of CBOs for public engagement. Conflict management and economics aspects of water management will be addressed. Transboundary water resource management instruments. Enabling partnerships.

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Database management
- Basin analyses

Field trip

- Tour of Ministry of Water

### B. Integrated Use of Water

Rainwater harvesting, storm-water collection, water reuse, artificial recharge, water storage and delivery.

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Evaluation of various sources of water for a community
- Solutions for communities using water storage and distribution systems





### **C. Climate Change Indicators**

Examine trends over the last century/decade locally and identify indicators to monitor for future climate change impacts. Evaluate how groundwater is impacted, and how groundwater can be used to mitigate the impacts of climate change by managing its storage, recharge, changes in quality and demand.

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Small group discussions to find solutions and monitoring options

### **D. Building Capacity in the Water Sector**

Using the RWSN 9-stage programme for capacity building in the manual drilling sector, students will learn how capacity is created.

#### ***Learning Activities***

Formal lectures

Laboratory practicals

- Identify where manual drilling is appropriate
- Setting up a manual drilling industry
- On-going activity for manual drilling

### **Lecturing Material**

RWSN manual drilling programme.

Texts

Handouts

Powerpoint presentations

### **Assessment**

Assignments 35%

Field trip 5%

Written exam (closed book) – 60%



## Hours Allocation

UniWater Education Integrated Water Resource Management – GLG 652								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	The Role of Government	5	6	4	12	15	27	
	Integrated Use of Water	5	6		12	11	23	
	Climate Change Indicators	4	6		20	10	30	
	Building Capacity in the Water Sector	6	9		8	15	23	
	Total	20	27	4	52	51	103	

## 2.6 GLG 662 – Groundwater Modelling

### Rationale

Mathematical models in groundwater flow and contaminant transport are increasingly used to provide answers to hydrogeologic questions that arise at hazardous waste sites. While mathematical procedures in some models may be highly complex, and must be understood by the modeller to produce a useful simulation, the goal of modeling in this course is to provide an approximation of a site specific situation. Therefore, a qualified professional with a background in hydrogeology and experience in groundwater modelling will be best suited to determine whether a simulation is reasonable, and to present recommendations based on a modelling study.

### Learning Objectives

*Upon Completion of the module participants will be able to....*

1. Build a simple computer flow model and understand how each parameter affects the outcome of the results.
2. Understand how model calibration and sensitivity analyses impact the quality of the model.
3. Critically assess a model generated by someone else for usefulness in mimicking groundwater flow.

### Teaching Methods

One hour lecture per week and two three-hour practicals per week.

### Topics and Learning Activities

#### A. Introduction to Flow Models



Introduction to groundwater flow models, the types (finite difference and finite element) and descriptions (2 and 3-dimensions), purposes and process of building a model (conceptual model, grid development, calibration and sensitivity analyses, predictive uses); governing equations and numerical methods.

**Learning Activities**

Formal lectures

Laboratory practicals

- Examination of various flow models

**B. Building a Model**

Conceptual model, grid design, assigning parameters, data needs and assignment, kriging, boundaries, sources and sinks, solute transport.

**Learning Activities**

Formal lectures

Laboratory practicals

- Building a flow model based on a real project
- Presentation to the class

**Lecturing Material**

Texts

Handouts

Powerpoint presentations

**Assessment**

Assignments 70%

Written exam (closed book) – 30%

**Hours Allocation**

UniWater Education Groundwater Modelling – GLG 662								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Introduction Flow Models	3	3			6	6	
	Building a Model	9	57			66	66	
	Total	10	60			72	72	



## 2.7 GLG 672 – Research Methodology

### Rationale

In order to conduct research that is justified and provides results that can be replicated or verified, research methods need to be consistent in technique.

### Learning Objectives

*Upon Completion of the module participants will be able to...*

1. To formulate a problem and develop techniques for finding solutions to it.
2. Use literature to determine what research has been already done.
3. Develop a methodology for the research.
4. Present a research proposal.

### Teaching Methods

One hour lecture per week and two three-hour practicals per week.

### Topics and Learning Activities

#### A. Introduction to Research

The role of research in social, science and business. The steps taken to identify and formulate a research problem, development of questions, formulation of hypotheses, and literature review. Sampling techniques (theory, types, steps, error, sample size, advantages and limitations). Data for research (primary data, collection methods, schedule, pretest, pilot study, case studies, secondary data, limitations and cautions). Processing data (checking, editing, coding, transcriptions, tabulations, analyses).

#### *Learning Activities*

Formal lectures

Laboratory practicals

- Development of a thesis project

#### B. Scientific Report Writing and Presentations

The principles of presentation of data and interpretation of results, including formats, pagination, use of quotations, footnotes, abbreviations, tables and figures, referencing, documentations, appendices, indexing, presentations.



**Learning Activities**

Formal lectures

Laboratory practicals

- Evaluation of various examples
- Preparation of a thesis proposal
- Presentation of the thesis proposal to the class

**Lecturing Material**

Texts

Handouts

Powerpoint presentations

**Assessment**

Assignments 70%

Written exam (closed book) – 30%

**Hours Allocation**

UniWater Education Research Methodology – GLG 672								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Introduction to Research	5	30		15	25	50	
	Scientific Report Writing and Presentations	5	30		5	25	40	
	Total	10	60		20	50	90	

**2.8 Field School**

**Rationale**

Hands-on learning is often the most practical. This **two** week-long field school will attempt to transform academic lessons into a real-life context of how they are conducted.



## Learning Objectives

*Upon Completion of the module participants will be able to...*

Conduct all field aspects of what would be expected of a professional hydrogeologist, including

- Surveying community needs and communicating effectively with the public
- Demonstrate an understanding of how geophysical surveys are conducted, and what the responses indicate.
- Survey physical locations of boreholes and other features.
- Supervise effectively drilling activities.
- Design and conduct aquifer pumping tests for assessing aquifer properties.
- Conduct contaminant assessments.
- Install and develop an effective borehole.

The communities selected will understand that they will benefit from working with the students on this project, but that it is a learning experience. The activities will be overseen by qualified people, and the drilling will be conducted by experienced drillers. Funding for these projects will need to be supplied by NGOs, such as UNICEF, or other interested parties.

## Teaching Methods

10 days of hands-on instruction in a field setting, supplemented with classroom instruction as necessary.

## Topics and Learning Activities

### **A. Community Needs Assessment (Day 1)**

Working with a CBO to assess the needs of a community and develop an action plan and budget.

#### ***Learning Activities***

- In groups of 3 to 4, work with CBO to assess current situation and work to develop possible solutions. Present findings to class and ask for feedback.

### **B. Geophysical Surveys (Days 2 and 3)**

Plan and conduct geophysical surveys to assist in understanding the subsurface and selection of drilling location.

#### ***Learning Activities***

- In groups of 4, decide which geophysical surveys to conduct, plan them out, conduct the surveys and analyze the results.
- Conduct spatial location surveys/GPS of local features.



**C. Drilling (Days 4 and 5)**

Review of drilling contract, supervision of drilling crew, logging of samples

**Learning Activities**

- In groups of 2 or 3, discuss existing contract, supervise all aspects of the drilling process, record progress and log samples. Decide when to stop drilling.

**D. Well Installation and Development (Days 6 and 7)**

Decide where and how to install the screen and gravel pack. Monitor installation, record notes. Develop gravel pack to remove fines.

**Learning Activities**

In groups of 2 or 3, supervise installation of screen and pack; development of well screen/pack, install seal and apron

**E. Well testing (Days 8 and 9)**

Conduct pumping tests to determine aquifer parameters.

**Learning Activities**

After allowing a well to recover to static levels, conduct pumping tests (pump calibration, step drawdown and constant rate tests) using any other neighbouring wells as observation wells, to determine the efficiency of the well, the safe pumping rate, depth of the pump, and the location of any boundaries. Determine whether the aquifer is unconfined, confined, or semi-confined. Use pumping test data as well as recovery data. Assess chemistry data for any changes during the test. Monitor barometric fluctuations, tidal influences (if applicable), and any uses of groundwater during the test.

**F. Presentations (Day 10)**

Compile all information and present it in 'layman's terms' to the people of the community.

**Learning Activities**

- Compilation of all technical information into a comprehensive technical report.
- Translate the results of the report into layman's terms, and prepare a presentation.
- Present the results to the class for feedback, make adjustments as necessary.
- Present the results to the community.

**Assessment**

Active participation in Field School 100%



## Hours Allocation

UniWater Education Field School – GLG 682								
Nr	Topic	Lecture	Practicals	Fieldtrip	Self study	Contact hrs	Load hrs	Lecturer
	Community Needs Assessment			8		8	8	
	Geophysical Surveys			16		16	16	
	Drilling			16		16	16	
	Well Installation and Development			16		16	16	
	Well Testing			16		16	16	
	Presentations			8	16	8	24	
	Total			80	16	80	96	

## 2.9 GLG 600 - Dissertation

### Rationale

Working in the real world will have challenges that aren't taught in a classroom. This project will include aspects of analyzing what the issue is and how to determine a way to solve the problem.

### Learning Objectives

For students to learn how to solve problems without the structured classroom activities.

### Teaching Methods

Each student will have an advisor for assistance, but the work will be conducted independently.

### Topics and Learning Activities

Project definition will be developed with the guidance of the advisor and will be approved before initial research is commenced. Wherever possible, real problems relating to increasing access to potable water supply will be encouraged.

### Assessment

Continuous Assessment 50%

Final Examination 50%





### 3. Summary of Core Course Programme Hours

Course	Lecture Hrs	Practicals Hrs	Field Trips	Self Study	Contact Hrs	Load Hrs	Av Hr/wk Contact Hrs	Total Av Hr/wk
<b>Semester 1</b>								
GLG 651	24	39	8	60	71	131		
GLG 661	21	30		60	51	11		
GLG 671	24	36	36	24	72	120		
GLG 681	24	39	16	24	79	103		
<b>Total</b>	<b>93</b>	<b>144</b>	<b>60</b>	<b>168</b>	<b>273</b>	<b>465</b>	<b>22.75</b>	<b>38.75</b>
<b>Semester 2</b>								
GLG 652	20	27	4	52	51	103		
GLG 662	10	60			72	72		
GLG 672	10	60		20	50	90		
GLG 682			80	16	80	96		
<b>Total</b>	<b>40</b>	<b>147</b>	<b>84</b>	<b>88</b>	<b>253</b>	<b>361</b>	<b>25.3</b>	<b>36.1</b>

Note: Semester 1 consists of 12 weeks of classes, while Semester 2 consists of 10 weeks of classes for GLG 652, 662 and 672, followed by a 2 week field school (GLG 682). Exams can be scheduled at the end of Semester 1 (optional) and at the end of Semester 2, either before or after the field school (GLG 682).

### 4. Recommended Readings

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Apello, C.A.J., and Postma, D. (2005) Geochemistry, Groundwater and Pollution. Second Edition, Taylor & Francis.

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Brush, R. E. (1979) *Wells Construction*. Hand Dug and Hand Drilled. Information Collection and Exchange, Peace Corps, Washington D.C., USA.

Clack, I.D., Fritz, P. (1997) Environmental Isotopes in Hydrogeology. Illustrated, reprint, Lewis

Domenico, P.A. and Schwartz, F.W. (1997) Physical and Chemical Hydrogeology. Second Edition John Wiley and Sons Inc

Driscoll, F.G. (1986) Groundwater and Wells. Second Edition, Johnson Screens

Fetter, C.W. (2001) Applied Hydrogeology. Fourth Edition, Prentice-Hall



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Goddard, W. and Melville, S. (2004) Research Methodology: An Introduction. Second edition, Juta and Co. Ltd.

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Grafton, Q.R. and Hussey, K (2011) Water Resources Planning and Management. Illustrated Edition, Cambridge University Press.

Heathcote, I.W. (2009) Integrated Watershed Management – Principles and Practice. Second Edition, John Wiley and Sons Inc.

Hem, J.D. (2005) *Study and Interpretation of the Chemical Characteristics of Natural Water*. USGS, Water Supply paper 2254

Kothari, C.R. (2009) Research Methodology: Methods and Techniques. Second edition, New Age International Publishers

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McDonald, M.G. and Harbaugh, A.W., (1988) A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, USGS TWRI Chapter 6-A1, 586 p.

McClay, K. R. (1991). The Mapping of Geological Structures. Wiley

MacDonald, A., Davies, J., Calow, R. and Chilton, J. (2005) Developing Groundwater: A Guide for Rural Water Supply. Practical Action

Milsom, J. J., Eriksen, A. (2011). Field Geophysics (Geological Field Guide). Second Edition, Wiley.

Ranjit Kumar (2005); Research Methodology: A Step-by-Step Guide for Beginners. Second edition, SAGE Publishers Ltd

Rick Brassington (2006). Field Hydrogeology (Geological Field Guide). Third Edition, Wiley-Interscience.

Schneider, S. (2011) Water Supply Well Guidelines for Use in Developing Countries. Second Edition.

Schnieders, J (2003) Chemical Cleaning, Disinfection & Decontamination of Water Wells, First Edition, Johnsons Screens Inc.



Todd, D.K. and Mays, L.W. (2005). Groundwater Hydrology. International Edition, John Wiley & Sons Inc.

Telford, W. M., Geldart, L. P., Sheriff, R. E. (1990). Applied Geophysics. Second Edition, Cambridge University Press.

Wang, H.F. and Anderson, M.P. (1982) Introduction to Groundwater Modeling. W.H. Freeman and Company, San Francisco, CA.

Willis Weight (2008). Hydrogeology Field Manual. Second Edition, McGraw-Hill Professional.

Younger, P. (2006) Groundwater in the Environment: An Introduction. First Edition Wiley-Blackwell

## **5. CLOSING**

For further information please contact Laurra Olmsted, Executive Director, UniWater Education Limited at [lolmsted@uniwatered.org](mailto:lolmsted@uniwatered.org) or visit our website at [www.UniWaterEd.org](http://www.UniWaterEd.org).