SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ON

COURSE OUTLINE

COURSE TITLE; GROUNDWATER AND WELLS

CODE NO.: WTR 229-4 SEMESTER: IV

PROGRAM: WATER RESOURCES/ENVIRONMENTAL ENGINEERING TECHNOLOGY

AUTHOR: SUBHASH VERMA; P. Eng.

DATE: NOVEMBER 1997 PREVIOUS OUTLINE DATED: MAY 1996

APPROVED: i^Z^/yuK)^t<rA/J^ DATE
DEAN

TOTAL CREDITS: 4 nsc: 0 Mi

PREREQUISITE(S): WTR330

LENGTH OF COURSE: TOTAL CREDIT HOURS:

L PHILOSOPHY/GOALS:

On completion of this course, the student will have suflBcient knowledge about the occurrence and movement of the groundwater in the hydrologic cycle as well as the properties of water related to municipal and industrial water supplies. Well hydraulics as related to well design and testing water wells for evaluating drawdown and aquifer yield will be stressed. Methods of well construction and development, well testing and parameters affecting the well efBciencies will be discussed.

n. LEARNING OUTCOMES AND ELEMENTS OF THE PERFORMANCE:

(Generic Skills Learning Outcomes placement on the course outline will be determined and communicated at a later date.)

Upon successfiil completion of this course the student will demonstrate the following:

1. Understanding of the origin, occurrence and distribution of the groundwater.
   - define groundwater hydrology
   - describe the importance of this water resource
   - define the concept of safe yield

2. Describe the storage and transport processes of groundwater in the hydrologic cycle.
   - sketch the groundwater component of the hydrologic cycle
   - compare zone of aeration with zone of saturation
   - derive relationship between porosity and specific yield
   - diJBferentiate watertable aquifer and artesian aquifer
   - describe the main functions of an aquifer

3. Apply the principles of hydraulics to determine groundwater flow direction and quantities.
   - measure hydraulic head at a gjven point in an aquifer
   - interpret and apply Darcy's flow equation
   - explain the working of a permeameter
   - analyze particle size distribution and relate it to hydraulic conductivity

4. Apply equilibrium and non-equilibrium well flow equation to determine aquifer characteristics, predicting drawdown and well yield.
   - define the terms related to well hydraulics
   - apply equilibrium equation to determine transmissivity of an aquifer
   - determine aquifer parameters, specific yield by applying non-equilibrium well equation
   - develop distance drawdown and time drawdown relationships

n. LEARNING OUTCOMES AND ELEMENTS OF PERFORMANCE CONT'D

5. Describe the various methods of well drilling and development.
   - select the appropriate method of well drilling
   - collect representation samples of the formation
   - perform sieve analysis and interpret results

6. Size the various components of a well including casings, well screen and gravel pack.
   - select the optimum casing size
   - design the well screen based on grain size distribution of the aquifer material
   - design a gravel pack and select screen slot openings
   - describe the methods of well development

7. Perform a well test and describe the operation and maintenance of a water well.
   - measure water levels, drawdowns and pumping rates
   - perform a constant rate pumping rate test
   - identify the factors affecting well efficiency
   - describe the methods to rehabilitate the well

8. Identify problems related to groundwater quality and contamination.
   - evaluate the suitability of groundwater for drinking water supplies
   - describe the terms corrosion and scaling
   - select a proper sampling device for groundwater monitoring
   - collect a representative sample from a monitoring well
   - describe the various processes of contaminant transport
   - select the thickness of clay liners to control leachate from sanitary land fill

in. TOPICS:

	TOPIC	CHAPTER IN TEXT	NO. OF WEEKS
1.0	INTRODUCTION	1	1
	1.1 Definition and related disciplines		
	1.2 History		
	1.3 Use and significance		
	1.4 SafeTield		
2.0	OCCURRENCE	4	1
	2.1 Hydrologic Cycle		
	2.2 Groundwater Distribution		
	2.3 Types of Aquifers		
	2.4 Properties of Aquifers		
	2.5 Consolidated and Unconsolidated		
3.0	GROUNDWATER MOVEMENT	5	1
	3.1 Fluid Energy/Head		
	3.2 Energy Equation		
	3.3 Darcy'sLaw		
	3.4 Application of Darcy's Equation		
	3.5 Hydrostatics		
	3.6 Steady Vertical Flow		
	3.7 Penneameters		
4.0	WELL HYDRAULICS	9	3
	4.1 Definitions of Terms		
	4.2 Equilibrium Well Formulas		
	4.3 Determining Aquifer Permeability		
	4.4 Relation of Drawdown to Yield		
	4.5 Introduction to Non-Equilibrium Formula		
	4.6 Time drawdown curves		
	4.7 Distance drawdown curves		
5.0	WELL DRILLING	10	2
	5.1 Cable-tool percussion method		
	5.2 Hydraulic rotary drilling		
	5.3 Reverse rotary drilling		
	5.4 Driven wells		
	5.5 Analyzing sand samples		
	5.6 Grain-size distribution curves		

MID TERM TEST

m. TOPICS CONT'D

	TOPIC	CHAPTER IN TEXT	NO. OF WEEKS
6.0	WATER WELL DESIGN 6.1 Selection of casing size 6.2 Well screen design 6.3 Gravel-pack design 6.4 Sanitary protection 6.5 Factors affecting well efficiency 6.6 Mechanical surging 6.7 Hydraulic surging 6.8 Overpumping and backwashing	13	2
7.0	MEASUREMENTS IN WATER WELLS 7.1 Definition of Terms 7.2 Measuring Pumping Rates 7.3 Water Level Measurements 7.4 Aquifer Test Data 7.5 Estimating WeU rield 7.6 Type of pump tests	16	2
8.0	WELL EFFICIENCY AND OPERATION 8.1 Well Drawdown 8.2 Laminar and Turbulent Losses 8.3 Well efficiency 8.4 Well losses 8.5 Well hydrographs	19	1
9.0	GROUNDWATER QUALITY 9.1 Chemical Analysis 9.2 Quality and use 9.3 Common Problems	20	1
10.0	GROUNDWATER POLLUTION 10.1 Sources of contamination 10.2 Sampling 10.3 Sanitary Landfills		
	END TERM TEST		

IV. EVALUATION PROCESS/GRADING SYSTEM

Final mark in the course will be based on:

Mid Term Test	25%
Final Test	50%
Short Tests	25%

GRADING:

A +	=	90-100%
A		80-89%
B		70-79%
C		60-69%

To pass the course a minimum of 60% is required in the weighted average plus a minimum of 60% in at least one of the tests.

V. REQUIRED STUDENT RESOURCES

Johnson Division, Groundwater and Wells. Johnson Division, UOP Inc., St. Paul, Minnesota, 1985.

Verma, S.C, Course Manual, Sault College, 1996

VL ADDITIONAL RESOURCE MATERIALS AVAILABLE IN THE COLLEGE LIBRARY BOOK SECTION:

Hammer, Mark J. and K. A. MacKichan, Hydrology and Quality of Water Resources. John Wiley and Sons, Inc. Toronto, 1981.

Todd, D. K., Groundwater Hydrology. John Wdey & sons. Inc., New York, 1980.

American Water Works Association, Ground Water. Manual M21, AWWA, 6666 West Quincy Avenue, Denver, Colorado 80235.

Roscoe Moss Company, Handbook of Ground Water Development. John Wiley

Interscience.

Vn. SPECIAL NOTES:

- Eighty percent attendance is required for anyone to be considered for supplementary examination.

- Home assignments are due one week after they are assigned. Late submissions will be penalized.

- Ifrequired changes will be made. However, students will be notified prior to any changes.

- Special Needs
  If you are a student with special needs (eg. physical limitations, visual impairments, hearing impairments, learning disabilities), you are encouraged to discuss required accommodations with the instructor and/or contact the Special Needs Office, Room El204, Ext. 493, 717, 491 so that support services can be arranged for you.

- Retention of Course Outlines
  It is the responsibility of the student to retain all course outlmes for possible future use in acquiring advanced standing at other post-secondary institutions.

- Substitute Course Information is available at the Registrar's Office.

- Any Other Special Notes appropriate to your course.

Vm. PRIOR LEARNING ASSESSMENT

Students who wish to apply for advanced credit in the course should consuh the instructor.