

Course catalogue

Master's programme

Water Science and Management

2014-2015

**Faculty of Geosciences
Willem C. van Unnikgebouw
Heidelberglaan 2
Postbox 80.115
3508 TC Utrecht
The Netherlands
Telephone +(31)30-253 2359**

Utrecht, June 2014

Content

Preface	3
1 Profile of the programme	
1.1 Profile of Water Science and Management	4
1.2 Mission.....	4
1.3 Degree requirements	5
1.4 Competence profile.....	5
1.5 Career prospects	5
2 Structure and content of the programme	
2.1 Programme structure	7
2.2 Master's thesis Internship.....	8
2.3 Tailor-made course and other electives	9
2.4 Young Leaders League	10
2.5 Entrance requirements Water Science and Management courses	10
3 Didactics, study management and practical matters	
3.1 Educational format	13
3.2 Study planning and advice.....	14
3.3 Course registration and automatic graduation	15
3.3.1 Semesters and blocks	15
3.3.2 Timeslots.....	15
3.3.3 Course registration	15
3.3.4 Grade Point Average	16
3.3.5 Automatic graduation.....	17
3.4 Study abroad	18
4 Organisation	
4.1 Organisation at programme level.....	20
4.2 Organisation at faculty level.....	20
4.3 Evaluation and quality assurance.....	21
4.4 Student facilities.....	22
4.5 Computer facilities.....	23
5 Course information	
5.1 Course schedule Water Science and Management 2014-2015.....	24
5.2 Course descriptions	25
GEO4-1433 Hydrogeological Transport Phenomena	25
GEO4-1434 Principles of Groundwater flow	27
GEO4-2301 Sustainable Development: Integrating Perspectives	29
GEO4-2302 Transdisciplinary Case Study.....	31
GEO4-2303 Ecosystem Modelling.....	33
GEO4-2323 Environmental Ethics and Sustainable Development.....	34
GEO4-2331 Sustainability Science: Modelling and Indicators	36
GEO4-4403 Coastal Zone and River Management	38
GEO4-4404 Land Surface Hydrology	40
GEO4-4417 Unsaturated Zone Hydrology.....	42
GEO4-6001 Quantitative Water Management	43
GEO4-6002 Water Policy, Governance and Law	45
GEO4-6003 Drinking Water and Sanitation.....	46
GEO4-6004 Master's thesis Internship.....	48
GEO4-6005 Tailor-made course	50
ECMSE Sustainable Entrepreneurship.....	51
6 Appendices	
Appendix I Rules for choosing optional courses	54
Appendix II Teaching periods institutes IEES and ES	55
Appendix III UU-time table 2014-2015	56

Preface

Welcome to the Master's programme Water Science and Management!

The Master's programme Water Science and Management is part of the Graduate School of Geosciences and is jointly organised by the Teaching Institute of Innovation, Environmental and Energy Sciences and the Teaching Institute of Earth Sciences. The programme aims to teach you the specialised knowledge and professional attitudes and skills needed to become a first class professional in the field of water science and management. The international setting of the Master's programme, combined with the small scale of the groups and the pleasant working atmosphere will contribute to this aim.

We hope this course catalogue will help you to find easily the relevant information you need as a student in the Master's programme. First a general description of the programme, the structure, the components and some organisational matters are presented. This is followed by a description of all courses of the two year programme. Information about procedures and the UU-time table are also included in the catalogue. The teaching and examination regulations 2014-2015 (OER) and the Regulations of the Board of Examiners will be published separately on the Utrecht University website.

At any time during your studies you will need two course catalogues: one of the year you started your Master's programme in Water Science and Management (this shows the examprogramme that you need to follow) and one of the most recent academic year, which shows the current Rules & Regulations.

You can find more information on the website at: <http://studenten.geo.uu.nl>. Still, if you have some (personal) questions, you can contact the Student Advisor of the programme.

On behalf of the staff we wish you an inspiring, pleasant and successful new academic year!

Dr. Paul Schot, Programme Leader Master Water Science and Management
(Environmental Sciences),
Prof. Dr. Marc Bierkens, Programme Leader Master Water Science and Management
(Earth Sciences),
Dr. Hans de Bresser, Director of Education Earth Sciences
and
Dr. Margien Bootsma, Director of Education Innovation, Environmental and Energy
Sciences

1 Profile of the programme

1.1 Profile of Water Science and Management

Water Science and Management is an academic Master's programme that integrates knowledge from the natural and the social sciences as a response to (emerging) needs in the professional field. The trend of more holistic approaches, stemming from the pursuit for sustainable development, participation of stakeholders and economic accountability, increasingly complicate the tasks of water managers. This has given rise to a need for water managers with a broad societal focus on water management issues, operating next to and in cooperation with more traditional and technical water managers.

The Master's programme Water Science and Management focuses on students from the natural sciences with an interest in water management. These students are both interested in the scientific analysis of the water system, but also in the application of water science in integrated and complex societal problems that occur in contemporary water management.

This 2-year Master trains students to become water professionals with both the knowledge of the technical aspects of water management and the ability to implement this knowledge with an eye for societal needs. They view water management in light of sustainable development, taking into account the functions water fulfils for mankind and nature, and consider technical innovations in view of societal costs and benefits. Graduates have a solid basis in water science in conjunction with the ability to apply their knowledge in policy formulation.

Eligible for admission to the programme Water Science and Management is the holder of a Dutch or foreign degree who has knowledge, insight and competences on university bachelor level and who can prove to have the following specific knowledge, insight and competences:

- a) Knowledge in the area of Earth Sciences, Environmental Sciences or Natural Sciences at or equal to the advanced level of the major Earth Sciences, Environmental Sciences or Natural Sciences of Utrecht University.
- b) Insight in Earth Sciences, Environmental Sciences or Natural Sciences at or equal to the advanced level of the major Earth Sciences, Environmental Sciences or Natural Sciences of Utrecht University.
- c) Academic skills and research skills at or equal to the major Earth Sciences, Environmental Sciences or Natural Sciences of Utrecht University.

Selection of students will be based on judgment of the following core competences of the applicant:

- a) Motivation and talent (also based on GPA and study progress);
- b) Level of relevant knowledge and command of methods and techniques of the relevant study area;
- c) General academic level of thinking and working;
- d) Command of the language(s) used in the programme.

1.2 Mission

The mission of the Master's programme Water Science and Management is to educate academic water professionals that are able to make a substantial contribution to sustainable development, through their scientific water knowledge and their ability to apply this knowledge in water management policies.

1.3 Degree requirements

The following general qualifications apply to the programme Water Science and Management as a whole. The graduates are able to:

- analyse technical and societal issues, and the relations between them, relevant to contemporary and future water management aimed at sustainable development;
- understand, and perform basic calculations on, natural and technical processes related to water quantity and water quality issues;
- design, carry out and report on scientific research on the issue of water management in a creative and independent way;
- engage in a scientific, social and administrative debate on the issue of water management;
- communicate on the issue of water management verbally and in writing to a wide audience of water specialists and non-specialists alike.

1.4 Competence profile

The Master's programme trains students to become academic professionals in the field of water management aimed at sustainable development. They are complementary to more traditionally educated water specialists with a natural sciences focus, thus filling the demand in the professional field for more holistic water managers characterised by:

- insight in the full breadth of contemporary water management, and notably in the relations between different scientific and professional perspectives;
- ability to work with specialists from different backgrounds on complex, integrated water management projects and planning.

Graduates are characterised by:

- overview of natural and technical processes related to water quantity and water quality;
- overview of relevant aspects of integrated water resources management;
- insight in the approach of more specialised technical water managers;
- technical competences in a limited number of quantitative water management skills (e.g. modelling);
- insight in the approach of social scientists (policy makers, legal advisors);
- insight in relevant legislation, policy frameworks and institutions for water policy and management in The Netherlands, in Europe and globally;
- insight in contemporary trends in water management and the ability to integrate this knowledge in policy documents for water management, physical planning and sustainable development;
- ability to work with specialists from different backgrounds on complex, integrated water management projects and planning.

1.5 Career prospects

The professional field consists of a wide variety of organisations in The Netherlands and abroad:

- Consultancy firms;
- Water boards;
- Governmental organisations;
- Utility companies;
- Water research institutes;
- NGOs;
- International development organisations.

The graduates have a number of technical skills which enable them to acquire junior positions at the start of their career. Based on their broad knowledge of contemporary water management they are expected to move relatively fast to more senior and strategic planning, policy and management positions, dealing with issues involving specialists from different backgrounds and/or societal stakeholders. Some graduates may also develop themselves further into more technical specialists while on the job.

2. Structure and content of the programme

2.1 Programme structure

The Master Water Science and Management is a two year (academic) Master. Students have to earn 120 European Credit Transfer System (EC) points.

The Master's programme may be followed along two, only slightly different, pathways:

- enrolling as Earth Sciences Master student with an accent on Water Science;
- enrolling as Environmental Sciences Master student with an accent on Sustainable Development.

The formal difference is that you will either get a Master's degree in Earth Sciences or Environmental Sciences respectively. Both degrees will indicate you followed the Water Science and Management Master's programme.

The substantial difference in the programme is limited to one course (period 2, year 1):

- Earth Sciences students acquire extra training in Water Systems by choosing one elective out of two relevant Water Science courses;
- Environmental Sciences students acquire extra training in methods of Sustainability Science.

The programme of the two different pathways is presented below. The course descriptions can be found in chapter 5.

	<i>Earth Sciences student</i>		<i>Environmental Sciences student</i>	
period 1	Principles of Groundwater flow	SD: Integrating perspectives	Principles of Groundwater flow	SD: Integrating perspectives
period 2	Unsaturated zone hydrology or Hydrogeological transport phenomena	Ecosystem modelling	Sustainability Science Modelling and indicators	Ecosystem modelling
period 3	Quantitative Water Management	Coastal Zone and River management	Quantitative Water Management	Coastal Zone and River management
period 4	Water policy, governance and law	Drinking water and Sanitation	Water policy, governance and law	Drinking water and Sanitation
period 5	Land surface hydrology	Transdisciplinary Case Study	Land surface hydrology	Transdisciplinary Case Study
period 6	Master's thesis Internship or Elective	Master's thesis Internship or Elective	Master's thesis Internship or Elective	Master's thesis Internship or Elective
period 7	Master's thesis Internship	Master's thesis Internship	Master's thesis Internship	Master's thesis Internship
period 8	Master's thesis Internship or Elective	Master's thesis Internship or Elective	Master's thesis Internship or Elective	Master's thesis Internship or Elective

The programme schedule consists of two semesters and each semester consists of two blocks. In each block 2 courses of 7,5 EC are followed, each running half-time over about 10 weeks. Please note that due to the combination of Earth Science courses and Environmental Science courses in the WSM programme, your courses in each period may not start and end in the same weeks. Therefore, *always check the course manual for each course carefully to see when your classes, exams and resits are!*

The first year is dedicated to basic knowledge and skills which are acquired in 8 courses. In the second year the emphasis is on application of the acquired knowledge and skills in real world situations in the professional field outside the university. This application emphasis is realised in two main ways:

- the Transdisciplinary Case Study. In this course students work on a multidisciplinary assignment for a real world client. They work in groups with students from different scientific backgrounds in order to acquire skills to effectively communicate and design solutions in a multidisciplinary setting for societal clients and stakeholders.
- the Master's thesis Internship. This course consists of a research assignment performed at a relevant external organisation. Further details are described in paragraph 2.2.

2.2 Master's thesis Internship

The Master's thesis Internship may be followed for 45 or 30 EC. The amount of EC has to be motivated by the student in relation to the work needed; e.g. gathering new empirical data from the field may require more time than analysing an existing database. No other amount than 30 or 45 EC is possible. It is not possible to change the number of EC after the research proposal has been approved by the Board of Examiners. The academic report of the Internship is the student's Master's thesis.

The Master's thesis Internship represents the culmination of the study, and provides the proof of the capability of the student to formulate and carry out (semi) independent research. On-site training during the Internship is considered to be an important part of the programme as it allows the student to obtain insight into the demands and constraints of doing research within the day-to-day practice of the professional water manager. It determines to a great extent the specialisation of the student within the broad spectrum of the study available.

Internships provided by organisations in the professional field will be posted on a designated website within the e-learning environment on Blackboard. However, students are also encouraged to arrange their own internship, especially if they want to do an internship abroad or at a specific organisation. This process must be started at an early stage (preferably at the end of the first year) as it usually takes some time before all arrangements have been finalised. Consult the programme leader at an early stage if you have plans to arrange your own Internship, to determine whether your idea is likely to be approved. He may also have useful contacts or ideas on possible Internships. Every internship has to be pre-approved by the Board of Examiners, based on a proposal (including time schedule) submitted by the student and supported by a proposed supervisor from the academic staff.

To start the Master's thesis Internship the minimum requirement in terms of EC obtained in the programme is 60 EC. Note that this is only the minimum requirement. Usually, the student is expected to have completed more course modules.

For information on procedures regarding the Master's thesis Internship see the course manual Master's thesis Internship WSM. For any other information contact the programme leader:

- for Earth Sciences students: Prof. Marc Bierkens (M.F.P.Bierkens@uu.nl);
- for Environmental Sciences students: Dr. Paul Schot (P.P. Schot@uu.nl).

2.3 Tailor-made course and other electives

With a Master's thesis Internship of 30 EC, there is room for 15 EC extra master activities. These activities may, in principle, be any activity that aids to the competences of the student in relation to the degree requirements of the Master's programme. Examples are research projects, workshops, summer schools, extra courses, or the Tailor-made course.

Tailor-made course

The student takes the initiative to formulate a proposal for a Tailor-made course (GEO4-6005) and must find a staff member willing to provide guidance and grading during the course. The proposal must be approved by the Board of Examiners and should contain at least the following elements:

- a) start with "*Proposal for a Tailor-made course within the master programme Water Science and Management*";
- b) Name and studentnumber;
- c) Date;
- d) Supervisor (staff member);
- e) Title for your course;
- f) Requested EC (in principle 15);
- g) Intended learning outcomes;
- h) Relation of learning outcomes to master programme degree requirements;
- i) Short description of activities;
- j) End products;
- k) Mode of assessment;
- l) Time planning.

After the proposal has been written, it must be signed by the staff member who is supervising and grading the course, and then be sent to the Board of Examiners. Please note that these procedures take time, so start with organising your Tailor-made course well ahead of the start date. The Board of Examiners may take a maximum of 6 weeks to assess your proposal. If you have any questions regarding the possible content of your Tailor-made course please contact your master programme leader.

Other electives

The Tailor-made course is not the only option to fill 15 EC of elective courses in the programme. With your electives you can specialise in a field of your interest, possibly related to your graduation topic. The only restriction on the choice of optional courses is that their relevance for the field of WSM has been made clear, and that they are part of a Master's programme or of a comparable level. The procedure for choosing electives is described in Appendix I.

Optional courses can also be followed at other universities. Please note that students with non-EEA nationalities may have to pay a steep fee in order to take optional courses at another Dutch university. This fee cannot be paid for or reimbursed by Utrecht University.

The Babel Talen Institute offers a short course in English for Academic Purposes. This course aims to practice the writing and presenting skills students need in their Master's programme. It does not offer any credits but you can take the course outside your WSM programme, at your own expense. Please see <http://www.babel.nl/language-courses/open-courses/english/course-english-for-academic-purposes/?lang=en> for more details.

2.4 Young Leaders League

Utrecht University offers the Young Leaders League to high-achievers with leadership potential. Young Leaders League is a selective 15 EC honours course at graduate level, to be taken on top of any master's programme. This course is about leadership and innovation skills, about responsibility and ethics, and it is structured around major challenges of modern societies in a globalizing world:

- Sustainability and Growth
- Globalization and Identity
- Entrepreneurship and Ethics
- Stability and Change

These multifaceted themes demand the joint efforts of experts from the sciences, social sciences and humanities. They require knowledge of energy, climate dynamics, food, technology, and health. But insight into the dynamics of societies, law and economics, languages and cultures, or history and philosophy are just as essential.

The issues transcend national and cultural borders. Therefore the programme is conducted entirely in English and aims at a substantial participation of international students.

Participants will:

- become part of a community that serves as an inspiring learning environment and will provide the basis for a professional network;
- work in interdisciplinary teams on topics within the themes above;
- participate in monthly seminars on various topics and aspects of leadership ranging from leadership styles and ethics to entrepreneurship and innovation;
- participate in 2 masters classes per semester by leaders in the corporate world and public governance
- receive coaching for personal development;
- present their work at a final conference
- enhance their international profile by taking part in a Summer School at a university abroad

Interested in this programme? Learn more about the admission requirements?

<http://www.uu.nl/university/international-students/EN/YLL/Pages/default.aspx>

2.5 Entrance requirements Water Science and Management courses

Some courses in the WSM programme require prior knowledge, to be gained by passing or at least attending certain previous WSM-courses. In the table and in the course descriptions (chapter 5) you will find which courses carry which entrance requirements.

In case of a discrepancy between the entrance requirements and/or recommended pre-requisites mentioned in this course catalogue and the ones mentioned in the electronic UU course offerings database 'Osiris', the entrance requirements and/or recommended pre-requisites mentioned in the table below are leading.

Course	Entrance requirement
Hydrogeological Transport Phenomena (GEO4-1433)	<ul style="list-style-type: none">- BSc or equivalent degree in Earth Sciences or related field;- having followed Principles of Groundwater Flow or an equivalent Masters-level course. Recommended prerequisites: <ul style="list-style-type: none">- basic knowledge of hydrology, geology and geochemistry.

Principles of Ground Water Flow (GEO4-1434)	<ul style="list-style-type: none"> - Letter of acceptance MSc Earth Sciences or MSc Water Science and Management. - Basic knowledge of physics, calculus, ordinary and partial differential equations. <p>Recommended pre-requisites:</p> <ul style="list-style-type: none"> - Basic knowledge of hydrology, introductory geology and/or environmental sciences.
SD Integrating Perspectives (GEO4-2301)	Letter of acceptance MSc Sustainable Development or MSc Water Science & Management
Transdisciplinary Case Study (GEO4-2302)	<ul style="list-style-type: none"> - Letter of acceptance MSc Sustainable Development or MSc Water Science & Management. - At least 30 EC gained in the master SUSD or WSM, including SD: Integrating Perspectives (GEO4-2301).
Ecosystem Modelling (GEO4-2303)	Recommended prerequisites: For students from other programmes: mathematics and modelling, level 1; e.g. Wiskunde & Systemanalyse (GEO1-2202), please contact the co-coordinator before enrolment in Osiris.
Sustainability Science: Modelling & Indicators (GEO4-2331)	Letter of acceptance MSc Sustainable Development or MSc Water Science and Management. Recommended prerequisite: Sustainable Development: Integrating Perspectives (GEO4-2301)
Coastal Zone and River Management (GEO4-4403)	Students should have appropriate physical geography or geology courses, particularly in fluvial and coastal geomorphology and/or sedimentology. They have to appreciate the role of interdisciplinary science and the role of (applied) sciences in societal issues and coastal zone and river basin management problems and challenges.
Land Surface Hydrology (GEO4-4404)	Letter of acceptance MSc Earth Sciences or MSc Water Science and Management. Recommended prerequisites: Basic knowledge of quantitative analysis, including statistics, mathematics (differentiation, integration) and physics (mechanics).

<p>Unsaturated Zone Hydrology (GEO4-4417)</p>	<p>Letter of acceptance MSc Earth Sciences or MSc Water Science and Management. Recommended prerequisites:</p> <ul style="list-style-type: none"> - Knowledge of groundwater hydrology: GEO2-4203 Physical hydrology or GEO4-1434 Principles of groundwater flow (or equivalent); - basic physics/mathematics skills.
<p>Quantitative Water Management (GEO4-6001)</p>	<p>Letter of acceptance of a Master's programme. Recommended prerequisites:</p> <ul style="list-style-type: none"> - A bachelor level natural sciences background. - One or more of the following courses: GEO2-4203 Physical Hydrology; GEO3-4307: Fluid mechanics 1; GEO4-1434 Principles of groundwater flow; GEO4-4404: Land surface hydrology. <p>Students without a natural science Bachelor's degree should contact the course coordinator <i>before</i> registering for the course.</p>
<p>Water Policy, Governance and Law (GEO4-6002)</p>	<p>Letter of acceptance of a Master's programme.</p>
<p>Drinking Water and Sanitation (GEO4-6003)</p>	<p>Letter of acceptance of a Master's programme. Recommended pre-requisite: A bachelor level natural sciences background. Students without a natural science Bachelor's degree should contact the course coordinator <i>before</i> registering for the course.</p>
<p>Master's thesis Internship (GEO4-6004)</p>	<p>Letter of acceptance MSc Water Science and Management. At least 60 EC passed <i>within</i> the programme.</p>
<p>WSM Tailor made course (GEO4-6005)</p>	<p>Letter of acceptance MSc Water Science and Management. At least 60 EC passed within the WSM programme.</p>

3. Didactics, study management and practical matters

3.1 Educational format

Activating education

The educational philosophy of the Master's programme is problem-orientated, which calls for a proactive teaching format. Problem-orientated education takes a concrete problem as the point of departure for the learning process. The acquisition of knowledge and skills is related to the analysis and/or solution of the problem in question. "Activating education" is a form of teaching whereby the students themselves are largely in control of the learning process. They take their education into their own hands by doing individual or group assignments, taking part in debates or simulation games, and applying the methods they have learned. A proactive educational format calls for intensive back-up on the part of the instructor in the form of study guidelines, instructions, manuals, and feedback on the students' performance. During contact hours, the students mainly work in small groups.

Active input of instructors and students

The objective of the Master's programme is to offer an inspiring and high-quality environment for study. The goal is to work together with the student to maximise the transfer of knowledge. All of the instructors and support staff involved in the programme operate on the assumption that if the student is fully dedicated to the study, they can offer the greatest possible guarantee that the student will pass all of the individual courses.

Required attendance

For various parts of the study, attendance is mandatory. This applies to working groups, field trips, simulation games, etc. The course manual for each course stipulates exactly which sessions the student is required to attend. As stated in article 4.4 of the Education and Examination regulations, exceptions to mandatory attendance can only be made if the student can prove that his absence is due to reasons beyond his control (special circumstances due to e.g. illness or family circumstances).

Report ill in time

If you cannot attend a preliminary or other exam, lecture or working group, please phone the department's secretariat *prior* to the meeting, and by 9.30 a.m. at the latest. Environmental Sciences students have to notify the IEES secretary's office: 030-253 1625 or 030-253 2359. Earth Sciences students have to contact the Earth Sciences secretary's office: 030-253 5050.

As soon as you are back you have to hand in some **proof of illness or other special circumstances** (e.g. a doctor attest or a copy of the medical file) to the secretariat's office. Only then you can make the exam at a different time or during the re-sit.

Absence or illness does not relieve you of your obligation to perform to the best of your ability. In other words, if you have not been able to complete a paper or give a presentation, contact the Course Coordinator to find out if it can be rescheduled for another date.

If the quality or quantity of your attendance has been insufficient, the Course Coordinator may exclude you from the remainder or part of the course.

Testing

There are multiple points during a course in which the student is tested. Thus, the final evaluation for a course does not depend solely on a final exam. As a rule, there are opportunities for feedback and improvement, depending on how the course is designed. These opportunities are set forth in the course manual. If during the course the student

satisfies all the effort requirements and does not receive a satisfactory grade but does receive a final grade of at least 4.00 before rounding, he or she will be given one opportunity to take a supplementary test. The specifics can be found in the Teaching and Examination Regulations and the course manuals.

Plagiarism, Code of Originality

Since science is about developing new knowledge, in all phases of the Master's programme, much attention is paid to the originality of the students' achievements, for instance with the aid of advanced software. All scientific research, including that of a student, builds on the results of the work of other researchers, either in positive or in negative sense. Those other researchers deserve the credits for their work, in the form of a correct acknowledgement.

This implies: referring to or quoting other work is allowed (and even necessary), but copying other researchers' work and presenting it as if it were one's own, is plagiarism. This is considered a huge sin in science. Therefore students have to sign a Statement of Originality when they submit the Master's thesis. Students, who plagiarise, run severe risks: in the worst case they are expelled from the programme for a year. The Teaching and Examination Regulations of the programme lists the sanctions with which a student who is caught plagiarising will be confronted.

3.2 Study planning and advice

During your studies, you will be guided and supervised by the programme leaders and the Study Advisors of the programme.

The programme leaders (dr. Paul Schot for Environmental Sciences and prof. Marc Bierkens for Earth Sciences) advise their students on the choices that can be made within the Master's programme. These choices pertain to optional courses and options for internships and thesis research, for instance.

You can turn to the Study Advisors (drs. Pieter Louwman¹ for Environmental Sciences and drs. Franca Geerdes for Earth Sciences) for confidential meetings about everything that might hold you back from a sound study progress or for mediation in a possible dispute with one of your professors. You can also turn to them for any questions about your study planning, for instance if you wish to follow part of the programme abroad or when you want to engage in a side activity that might influence your studies.

The Study Advisors have insight in your registration and study results and they occasionally receive feedback from professors. The Study Advisors can take initiative to invite you for a meeting, when they come across something worrying or unclear. The purpose is to find out if there is a (potential) problem and if so, what can be done to solve it. Often you are able to resolve the matter with the Study Advisor, but he or she can also advise you to consult a student counselor, student psychologist, or contact the university's Centre for Study Choice.

When you encounter personal circumstances, such as long-term illness or extraordinary family affairs that might cause your studies to stagnate, it is often mandatory to consult a Study Advisor in order to receive special concessions. As a rule, the earlier you involve the Study Advisor, the more options you will have.

Pieter Louwman is located in the Van Unnik building, room 10.27. No appointment is necessary: You can see him on a drop-in basis on Mondays and Wednesdays from 13.00 till 14.30 hours for short questions. Outside these hours, or in case of more complex questions, an appointment is recommended. Feel free to take initiative to make such an appointment at the IEES secretary's office (van Unnik building room 10.20) or by phone: 030-253 1625/2359.

¹ Ir. Monica Gorska is a (temporarily) additional study advisor. Any questions about study advice and planning can also be addressed to her. Her office is 10.30 and her telephone number is (030) 253 7404.

Franca Geerdes is available during open consultation hours on Mondays from 13.00 – 15.00 hours or by making an appointment. She can be contacted by phone: 030 - 253 5152 or E-mail: F.E.M.L.Geerdes@uu.nl. She is located in room 118 in the BBL-Building, Princetonplein 5.

The Study Advisors are members of the Dutch National Society of Study Advisors and work according to the code of conduct of this professional society, see www.lvsa.nl for details.

3.3 Course registration and automatic graduation

3.3.1 Semesters and blocks

Classes take place during two semesters, each of which can be divided into two blocks, or periods of 9 or 10 weeks. In Appendix II and III you will find the start and end dates of each block for this academic year. Please note that due to the combination of Earth Science courses and Environmental Science courses in the Water Science and Management programme, your courses in each period may not start and end in the same weeks. Therefore, *always check the course manual for each course carefully to see when your classes, exams and resits are!*

3.3.2 Timeslots

At Utrecht University a so-called timeslotmodel is used to schedule courses to fit into fixed parts of the week. Using this model prevents overlap in a schedule. In this way it is easy to see if two courses can be taken in the same period.

The Utrecht University timeslotmodel consists of five slots (A, B, C, D, E).

Timeslot A = Monday morning and Wednesday morning
Timeslot B = Tuesday morning and Thursday afternoon
Timeslot C = Monday afternoon and Thursday morning
Timeslot D = Wednesday afternoon and Friday
Timeslot E = Monday evening until Friday evening

Morning = 09.00-12.45 hours, afternoon = 13.15-19.00 hours, evening = 18.00-21.45 hours.

Periods and timeslots have been put into the course schedule (5.1). Changes to the course schedule are still possible. The final scheduling (time and lecture room) of each courses will be made public via studenten.geo.uu.nl > roosters. Also check the Blackboard e-learning environment of your course for latest changes in the course programme.

3.3.3 Course registration

In order to participate in a course, you need to be registered for it: if you are not, you will not have access to the course and its supporting facilities such as Blackboard; neither will results be registered. No registration = no participation = no result.

As a student, **course registration is your own responsibility!** You decide which courses (optional and mandatory) you want to take in each block. Keep in mind possible entrance requirements to a course; students that do not adhere to entrance requirements cannot register for the course and/or will be removed from the course.

Course registration is **only possible via internet**, www.uu.nl/Osirisstudent and **only within the official registration periods**, which usually fall in the beginning of the

previous block (for the dates of the Faculty of Geosciences, please see Appendix III). You can register for no more than 2 courses (15 EC) of the Faculty of Geosciences per period (code GEO*-*). Students that register on time are generally secured of a place in the course; however, courses that have a limited capacity have certain placement rules. Just before the start of the block, there are 2 days for late registration, in case you want to switch courses. Please note: this is only possible for courses that are not full yet; participation is therefore not guaranteed.

If you want to register for a course outside the Faculty of Geosciences, there could be different registration dates; at some Faculties, students register only once per semester.

Each period (or block) you can register for a maximum of two courses (15 EC) of the Faculty of Geosciences via Osiris (code GEO4-*). Any student that wants to take a third course, needs permission of the programme. If the 3rd course is a course of one of the Master's programmes of the department of Innovation, Environmental and Energy Sciences or the department of Earth Sciences, you can fill out a digital form on: <https://fd8.formdesk.com/universiteitutrecht/additionalcourseGEO>.

Your request needs to be submitted **before or during the regular registration period**. After that and during late registration periods, no requests for taking a 3rd course will be dealt with and therefore they will always be denied. Only as an exception and based on sufficiently important reasons will the programme allow a student to take three courses in one period.

A request for taking a 3rd course will need to address the criteria mentioned below and these will be checked:

- Motivation: what is the student's motivation?
- Circumstances: are there any special, personal circumstances?
- Urgency: is it, at this point in time, necessary that the student takes three courses at once?
- Feasibility: can the student handle taking three courses at the same time? The following issues will be looked at in order to check this criterium:
 - o Study progress.
 - o Study results so far.
 - o Has the student taken three courses before and if so, were they all completed successfully?
- Is the Master's thesis one of the three courses the student wishes to take? If this is the case, the request will not be granted.
- Timeslot: if the 3rd course falls in the same timeslot as any of the other courses you will be taking, the request for a 3rd course will never be granted.

Students that do not adhere to the registration periods can only under very special circumstances be placed in a course after permission from the Board of Examiners, which can be reached via examencommissie.geo@uu.nl. Always give our student number when communicating with the Board of Examiners. The Board of Examiners (NOT the lecturer of the course) decides whether you have a valid reason for not registering during the registration periods. If the Board of Examiners decides you do not have a valid reason, you cannot attend a course and no course results will be registered.

In other words: register early, as early as possible, for the courses that you want to take in the next block! *This also applies to the obligatory courses!*

3.3.4 Grade Point Average

The final Grade Point Average (GPA) is stated on the International Diploma Supplement, and represents your academic performance. The final GPA is the average figure from the results achieved within the course's examinations programme, weighted by course

credits and expressed on a scale of 1 to 4 with two decimals.

The calculation of the final GPA works as follows:

- all applicable examinations achieved as part of the examinations programme of the Master's degree, are converted into quality points;
- quality points are the applicable examination result x the number of course credits (EC) for the section in question;
- the total number of quality points achieved divided by the total number of course credits obtained (EC) gives the average examination result;
- the average examination result is converted into the final GPA as shown in the table below:

Dutch exam grades		Corresponding letter grades	Grade Points
From 8.60	to 10	A+	4
8.00	8.59	A	4
7.70	7.99	A-	3.7
7.40	7.69	B+	3.3
7.00	7.39	B	3
6.70	6.99	B-	2.7
6.40	6.69	C+	2,3
6.00	6.39	C	2
5.60	5.99	C-	1.7
5.40	5.59	D+	1.3
4.50	5.39	D	1
0	4.49	F	0

3.3.5 Automatic graduation

When you are due to finish your programme, you will receive a message from the student administration about your graduation. After it has been verified that you have fulfilled all requirements of your programme, the Board of Examiners will be asked to judge your file. Please note: in order to graduate, you need to have fulfilled all requirements: all grades are known and registered in Osiris, you have paid all tuition fees, hard copies of any earlier decisions taken by the Board of Examiners have been handed in to the Studiepunt Geosciences (if applicable) and you have uploaded your thesis to Igitur: (<http://www.uu.nl/university/library/EN/igitur/student/Pages/default.aspx>).

Under certain conditions, it is possible to postpone your graduation, see article 6.1.6 of the Teaching and Examination Regulations 2014-2015.

In order to actually receive your degree certificate or to pick it up at the Studiepunt, you need to fill out an exam-registration form. If you want to attend a graduation ceremony, strict deadlines regarding registration and handing in of any documents will be maintained.

Automatic graduation does not mean you will be de-registered automatically from the programme. You will need to take care of this yourself and this cannot be done until you have received formal confirmation of your graduation from the Board of Examiners.

3.4 Study abroad

Studying abroad means broadening your horizon, meeting new people, exploring different cultures, and expanding your field of study. If you are interested in going abroad there are many possibilities. You can follow courses, do an internship or conduct research. Make use of what the university in general, but the Faculty of Geosciences in particular, has to offer you.

A lot to organise?!

Don't worry, just make sure to start planning your period abroad in time. Do you want to study abroad? Start via the Faculty International Office Online: www.uu.nl/geo/studyabroad.

Answer these questions:

- Where would you like to go to?
- Does this university have an agreement with UU?
- Which courses would you like to attend?
- When would you like to go?

Once you have found an answer to these questions, contact your Study Advisor to connect your period abroad to your study plan in Utrecht.

After you have consulted with your Study Advisor, The International Office of Geosciences is there to guide you through the process. For all your practical questions, please contact international.geo@uu.nl or visit the Studiepunt/ International Office at the ground floor of the Van Unnik building. Open from Monday to Thursdays from 09.30-12.00 and 13.00-16.30 hrs.

Besides, please visit our study association EGEA (Ruppert Building), or visit <http://www.egea.eu/entity/utrecht>. EGEA members generally have a lot of experience with studying abroad. They can help you out with a lot of practical matters (such as housing, experiences and tips & tricks).

In October and November several orientation meetings take place organised by the International Office. Find out more on: www.uu.nl/geo/studyabroad.

Practical matters

Once you've decided to study abroad, you can apply through the regular procedure. Please do keep in mind the deadlines for application! More information about how to apply and which deadline to bear in mind can be found on the General International Office website: www.uu.nl/students/exchange (UU partners) and the Faculty International Office website: www.uu.nl/geo/studyabroad.

Good to know

- Eligible for studying abroad during their master are all students with formal permission from their programme coordinator. To obtain permission please use the 'study plan for studying abroad' (available via: www.uu.nl/geo/studyabroad).
- After your programme coordinator has signed the study plan, upload it in Osiris
- Credits obtained at partner universities can quite often easily be transferred to your academic record in Utrecht: study abroad doesn't necessarily cause delay in your programme!
- If your destination is within Europe, either for courses (exchange) or an internship, you are eligible for an ERASMUS grant. Monthly financial support to make your study abroad easier than it already is.
- If your destination is outside Europe, please have a look at www.beursopener.nl and find out if you are eligible for the options mentioned.

- If you're going abroad, you'd better put your OV student chip-card on hold (public transport card for Dutch students). By doing this, you can apply for a monthly travel allowance. Forms for this allowance are to be signed by the Studiepunt/International Office.

4. Organisation

4.1 Organisation at programme level

For the day-to-day management of the Master's programme the following contact details may be useful.

Contact for Earth Sciences students:

- Education information desk: Student desk Geosciences (studiepunt.geo@uu.nl, phone: +31 30 253 9559)
- Study Advisor: Ms. drs. Franca Geerdes (F.E.M.L.Geerdes@uu.nl, phone +31 30 253 5152)
- Programme leader: Prof. Marc Bierkens (M.F.P.Bierkens@uu.nl, phone +31 30 253 2777)

Contact for Environmental Sciences students:

- Education information desk: Student desk Geosciences (studiepunt.geo@uu.nl, phone: +31 30 253 9559)
- Study Advisor: Drs. Pieter Louwman (P.A.Louwman@uu.nl, phone +31 30 253 2349)
- Programme leader: Dr. Paul Schot (P.P.Schot@uu.nl, phone +31 30 253 2218)

4.2 Organisation at faculty level

Utrecht University is managed at three levels: the University, the faculties and the departments. Each level involves the participation of the scientific, technical and administrative staff as well as the students. For the Faculty of Geosciences the following organizational units are of interest:

Faculty of Geosciences Board

Dean: prof.dr. R. van Kempen

Vice-dean: prof.dr. P. Hoekstra

Faculty director: dr.ir. C.L.M. Marcelis

Student member: M. Bouwmans

Faculty office: room 723, W.C. van Unnik building, Heidelberglaan 2, Tel: 030 - 253 2044

E-mail: faculteitsbureau@geo.uu.nl

Faculty council

The faculty council has fourteen members: 50% are students and 50% is staff.

Secretary: dr. L.E.G. Rietveld, Tel: 030 - 253 2044

E-mail: l.e.g.rietveld@uu.nl

Teaching Institute

The Teaching Institute is responsible for the organisation, coordination and quality management of the educational elements of the various courses offered by the Geosciences departments.

Teaching Institute Earth Sciences:

Chairperson: dr. J.H.P. de Bresser, Tel: 030 – 253 4973

Clerk: I. Beekman, Tel: 030 – 253 5010

Member: dr. T. Behrends, Tel: 030 – 253 5008

Member: dr. M.R. Hendriks, Tel: 030 – 253 2054

Student member: B. Vaes

Student member: S.A.H. Weisscher

Teaching Institute Environmental Sciences:

Chairperson: dr. M.C. Bootsma, Tel: 030 – 253 2650

Clerk: drs. E.B. Dijkma, Tel: 030 – 253 8462

Member: dr. F. van Rijnsoever, Tel: 030 – 253 7484

Member: dr. P.P. Schot, Tel: 030 – 253 2318

Member: dr. W.G.J.H.M. van Sark, Tel: 030 – 253 7611

Member: dr. S. Negro, Tel: 030 – 253 7166

Board of Studies

Within the Utrecht Graduate Division (UGD) the Master's programme Water Science and Management is part of the Graduate School of Geosciences, to which all Master students and PhD-students of the Faculty of Geosciences belong. The School supervises the quality of the programme and the admission of its students. All Directors of Education and Directors of Research of the Faculty of Geosciences are members of the Graduate Board of Studies, as well as a PhD student and a student from one of the MSc programmes of the Faculty. Chairman is the dean of the Faculty, prof. dr. Ronald van Kempen; the Board's secretary is mr. Diederik Gussekloo (d.gussekloo@uu.nl).

Board of Examiners

The Board of Examiners is responsible for the examination of students. The Board of Examiners will determine the examination results as soon as the student has submitted sufficient proof of the tests taken. This Board also decides about deviations (e.g. exemptions) in the programme, internships and the approval of optional courses (see Appendix I of this catalogue). Requests about exemptions, optional courses or other issues for the Board of Examiners, can be addressed to examencommissie.geo@uu.nl. Always include your student number when contacting the Board of Examiners.

4.3 Evaluation and quality assurance

The Faculty of Geosciences values the high quality of its programmes and has therefore set up a quality assurance system. Quality assurance provides information about the quality of individual courses and the programme as a whole, study climate and students' progress and performance. Its most important goals are improving education and organisation, and making the quality of the programme more visible.

One part of quality assurance which you as a student will be dealing with regularly is evaluations. Every course is evaluated afterwards and the results of this *course evaluation* are discussed in the Education committee and the Management team of the programme. It provides important information for the lecturer to improve his/her course. All Geosciences students may view the evaluation results of the Faculty of Geosciences on Blackboard. You can use this if e.g. you need to make a choice about electives.

During the running of the course, we also work on improving quality. *Course feedback groups* may be active in each course in order to mend any problems early on. For each course, such a group consists of 4-5 students that meet up with the lecturer in the break and talk about the course so far.

Its purpose is to find out what is being appreciated, what is going well and what practical issues can be improved. This does not concern aspects which are already fixed, such as the choice of literature, set up of tutorials or class times. It's all about fine-tuning, e.g. are the lecture slides readable, can everyone hear the lecturer, has information been put on Blackboard on time, etc. In the study guide of the course you can find further information about the course feedback group in your course.

Finally, at the end of each academic year (May/June) a written *year evaluation* is carried out among the students. The year evaluation it is not about an individual course but about issues that transcend the course, such as coherence/set-up of the programme,

electives, workload and effort, level, thesis supervision, challenge, atmosphere and lecturers.

The results of the year evaluation will be discussed in panel meetings with the education director, programme leaders and a student delegation.

4.4 Student facilities

Geosciences Student desk (Studiepunt)

The Student desk is the primary port of contact for students in the faculty of Geosciences. It provides students with general information and answers questions about registration for courses, course timetables, examinations, grades and credits, etc.

The Student Helpdesk is situated at the entrance hall at the W.C. van Unnik building, Heidelberglaan 2, Tel: +31-30-253 9559.

Opening hours: Monday – Friday: 09.30-11.30h and 13.00-16.30h.

During academic holidays opening hours may be limited.

Internet: <http://studenten.geo.uu.nl>

E-mail: studiepunt.geo@uu.nl

The Faculty's student organisations

The faculty of Geosciences has a long-standing tradition of hosting student organisations. These organisations arrange extra-curricular activities that encourage the social networking of their members and act as a special-interest group in the interaction between the educational and faculty boards. All student organisations offer books and other literature at discounted prices. As these discounts are more than the organisations' joining fees, membership is almost a hundred percent. A substantial number of the members are active in organising and participating in activities including conferences, seminars, study tours, theatre, music, sports and parties.

Increasingly, the student organisations cooperate in arranging joint activities. They also play a major role in the introduction of new students, helping them to find their way around the faculty and the university.

The student organisations are linked to the different academic programmes within the faculty. Further information can be found on each organisation's website.

Earth Sciences / Physical Geography:

- Utrechtse Aardwetenschappen Vereniging (UAV)

Address: Princetonplein 5, room 277, 030-253 2019

E-mail: uav@uu.nl, Internet: <http://uavonline.nl/>

Environmental Sciences:

- STORM

Address: Ruppert building, room 002 (open on Mon-Fri from 10.30-15.00 hours), 030-253 2164

E-mail: storm@uu.nl, Internet: <http://storm.geo.uu.nl>

International:

- European Geography Association (EGEA), Address: Marinus Ruppertbuilding Room 2 (left) , tel. 030 - 253 9708, E-mail: Egea@uu.nl, Internet: <http://www.egea.nl/Utrecht>

- Association des Etats Généraux des Etudiants de l'Europe (AEGEE) (<http://www.aegee-utrecht.nl>)

- Utrecht Erasmus Student Network (ESN) (<http://www.esn-utrecht.nl>)

- Studentenvereniging voor Internationale Betrekkingen Utrecht (SIB) (<http://www.sib-utrecht.nl>)

4.5 Computer facilities

Osiris

Osiris (https://www.osiris.universiteitutrecht.nl/osistu_ospr/StartPagina.do) is the student registration system for Utrecht University. You can log into the system using the internet and register for both courses and examinations. You can also check the results of your examinations and update your personal information (telephone numbers, postal address, etc.). Your data is confidential. You will be provided with a username and password to gain access to the system.

Student Email

Utrecht University provides each student with an e-mail address. The faculty uses this address to communicate information. Students are thus required to check their inbox regularly. Upon registration students receive a letter or an e-mail at their postal address with operating instructions and a password.

5. Course information

5.1 Course schedule Water Science and Management 2014-2015

Slot A = Monday morning and/or Wednesday morning

Slot B = Tuesday morning and/or Thursday afternoon

Slot C = Monday afternoon and/or Thursday morning

Slot D = Wednesday afternoon, Friday morning and/or Friday afternoon

Slot E = Monday evening, Tuesday evening, Wednesday evening, Thursday evening and/or Friday evening

Earth Sciences variant

Year 1 (intake 2014)

Period 1	(A+C) SD Integrating Perspectives, GEO4-2301	(D) Principles of Ground Water Flow, GEO4-1434
Period 2	(C) Unsaturated Zone Hydrology, GEO4-4417 <i>or</i> (D) Hydrogeological Transport Phenomena, GEO4-1433	(A+B) Ecosystem Modelling, GEO4-2303
Period 3	(A) Quantitative Water Management, GEO4-6001	(B) Coastal Zone and River Management, GEO4-4403
Period 4	(A) Water Policy, Governance and Law, GEO4-6002	(B) Drinking Water and Sanitation, GEO4-6003

Year 2 (intake 2013)

Period 1	(D) Transdisciplinary Case Study, GEO4-2302	(B) Land Surface Hydrology, GEO4-4404
Period 2	Master's thesis Internship (30 EC or 45 EC), GEO4-6004 Electives (15 EC in case of 30 EC thesis)	
Period 3		
Period 4		
Period 4		

Environmental Sciences variant

Year 1 (intake 2014)

Period 1	(A+C) SD Integrating Perspectives, GEO4-2301	(D) Principles of Ground Water Flow, GEO4-1434
Period 2	(C+D) Sust. Science: Modelling and indicators, GEO4-2331	(A+B) Ecosystem Modelling, GEO4-2303
Period 3	(A) Quantitative Water Management, GEO4-6001	(B) Coastal Zone and River Management, GEO4-4403
Period 4	(A) Water Policy, Governance and Law, GEO4-6002	(B) Drinking Water and Sanitation, GEO4-6003

Year 2 (intake 2013)

Period 1	(D) Transdisciplinary Case Study, GEO4-2302	(B) Land Surface Hydrology, GEO4-4404
Period 2	Master's thesis Internship (30 EC or 45 EC), GEO4-6004 Electives (15 EC; in case of 30 EC thesis)	
Period 3		
Period 4		
Period 4		

Recommended electives:

Tailor-made course, GEO4-6005, 15 EC (no fixed period or timeslot), or

period 1, slot A, Environmental Ethics & Sustainable Development, GEO4-2323

Recommended optional courses do not need to be approved by the programme leader but must still be approved *before starting* by the Board of Examiners.

5.2 Course descriptions

Note: in case of a discrepancy between the entrance requirements and/or recommended pre-requisites mentioned in this course catalogue and the ones mentioned in the electronic UU course offerings database 'Osiris', the entrance requirements and/or recommended pre-requisites mentioned in the table in § 2.5 are leading.

Course title	ES-Hydrogeological Transport Phenomena
Code	GEO4-1433
Programme	ES and WSM
Level	M
Status	Elective
Credits	7,5 EC
Period (slot)	2 (D)
Coordinator	prof.dr.ir. S.M. Hassanizadeh
E-mail	s.m.hassanizadeh@uu.nl
Phone	030 253 7464
Language	English
Open to other students	Yes
Entrance requirements	- BSc or equivalent degree in Earth Sciences or related field; - having followed Principles of Groundwater Flow or an equivalent Master's-level course.
Recommended pre-requisites	Basic knowledge of hydrology, geology and geochemistry.
Remarks	Students without a natural science Bachelor's degree should contact the course coordinator <i>before</i> registering for the course.
Objectives	This course aims at exposing the student to basic concepts and principles related to the movement of solutes in porous media, in general, and in soil and groundwater, in particular. Examples of relevant porous media are soil, paper, food, biological tissues, construction materials, diapers, wood, etc. Processes affecting the spreading of solutes in porous media will be described and corresponding governing equations will be introduced. The students will develop the ability to set up mathematical models for quantitative description of subsurface transport phenomena including spread of pollutants in soil, movement of viruses and colloids in porous media, and transport of adsorbing solutes. Simple analytical solutions will be discussed. Also, students will become familiar with the well-known codes MODFLOW and MT3D.
Content	Various ways of classification of pollutants; Modelling mass transfer processes such as decay, volatilization, dissolution, and adsorption; Transport of solutes by advection and diffusion; Hydrodynamic dispersion phenomenon; longitudinal and lateral dispersivity; Determination of flow velocity and dispersivity coefficients; Discussion of initial and boundary conditions; Description of adsorption: linear and nonlinear isotherms, kinetic adsorption; Determination of adsorption coefficients; Modelling dissolution and volatilization;

	Solute transport in double-porosity media; Degradation processes; Transport in unsaturated zone; Heat transport processes.
Modes of instruction	Lectures (required) and tutorials (required)
Assessment	See course manual
Literature	<p>Summary Lecture Notes will be provided</p> <p>Recommended Book Mayer, A.S. and S.M. Hassanizadeh, Soil and Groundwater Contamination: Nonaqueous Phase Liquids, American Geophysical Union, 224 pages, June 2005 (ISBN 0-87590-321-7).</p> <p>Recommended Book Fetter, C.W., Contaminant hydrogeology, Macmillan, New York, (2nd ed.). 1999.</p>
Academic skills	to be determined

Course title	ES–Principles of Groundwater flow
Code	GEO4-1434
Programme	ES and WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	1 (D)
Coordinator	prof. dr.ir. R.J. Schotting
E-mail	r.j.schotting@uu.nl
Phone	030 253 5112
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Earth Sciences or MSc Water Science and Management. Basic knowledge of physics, calculus, ordinary and partial differential equations.
Recommended pre-requisites	Basic knowledge of hydrology, introductory geology and/or environmental sciences.

Objectives	This course introduces the basic principles and methods necessary to quantify flow of water and transport of solutes through saturated porous media. In addition, students will be introduced to basic numerical methods and (professional) software for simulating groundwater flow.
Content	<p>The importance of groundwater as a resource and as a critical component in many environmental issues is widely recognized. Groundwater hydrology is a rapidly evolving science and plays a key role in understanding a variety of subsurface processes.</p> <p>A. Porous media properties such as porosity and intrinsic permeability, hydraulic conductivity, erosion, fractures, continuum approach, Representative Elementary Volume REV- concept, up-scaling from pore-to continuum scale, basic fluid mechanical concepts.</p> <p>B. Groundwater flow: Darcy's Law, hydraulic head, hydraulic conductivity, pore pressure, anisotropy, Dupuit assumptions, mapping of flow, flow in fractured media.</p> <p>C. Flow equations in confined and unconfined aquifers: combining the mass balance equation and Darcy's Law, boundary conditions, storage properties of porous media: compressibility of groundwater and compressibility of the solid phase, Boussinesq approximation, initial and boundary conditions, flow nets, dimensional analysis, analytical solutions of simple hydro-geological problems.</p> <p>D. Density-dependent flow, coastal aquifers.</p> <p>E. Super position principle, method of images, Analytical Element Method.</p> <p>F. Transient flow of groundwater, pumping tests, slug tests, constant head and falling head tests.</p> <p>G. Groundwater flow modeling, modeling approaches (schematization), simulation, evaluation model results, model verification and validation, finite differences, grids, integration in time, initial and boundary conditions, computer models, introduction to ModFlow, modeling exercises with ModFlow.</p> <p>H. Particle tracking in groundwater modeling.</p>

	I. Two excursions are an integral part of this course. In general a visit to a bank-infiltration water supply pumping station (De Steeg of Oasen) and a trip to a groundwater remediation site.
Modes of instruction	Lectures and tutorials (attendance required)
Assessment	During the course a variety of home works is presented to the students. Each home work contributes to the final grade. The idea of the home works is 'continuous assessment' of the students. In the final weeks of the course, the students are confronted with old exams, either as a graded homework or as an additional example to get acquainted with the examination style. The home works, including the computer homework(s) contribute to 25 % of the final grade. The written exam contributes 75%.
Literature	Charles R. Fitts, Groundwater science. Second edition, 2012. ISBN 0-12-257855-4.
Academic skills	to be determined

Course title	SUSD-Sustainable Development: Integrating Perspectives
Code	GEO4-2301
Programme	SD/WSM
Level	M
Status	Obligatory for all SUSD and WSM tracks
Credits	7,5 EC
Period (slot)	1 (A+C)
Coordinator	Dr. B. Wicke
E-mail	b.wicke@uu.nl
Phone	030 253 4299
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Sustainable Development or MSc Water Science & Management

Objectives	<p>After completion of the course, the student is able to:</p> <ul style="list-style-type: none"> - give a good overview of the concept of sustainable development and its history, and of various ways to operationalise it; - understand the contributions from relevant scientific disciplines and the ability to integrate these; - recognize key sustainable development issues and make an integral and critical assessment of available approaches and policy options; - look at real-world problems from multiple perspectives and understand that achieving sustainability needs contributions from different worldviews.
Content	<p>This course aims at providing an integrated systems perspective on current sustainable development issues. Students are being introduced to the major threats and to the main scientific concepts and methods needed to understand and respond to them. The emphasis is on seeing the larger picture.</p> <p>The course starts by elaborating the interactions between human societies and their environment from a historical perspective, Next, we discuss the concept of SD and its diverse definitions. We move on to an introduction of the scientific worldview and the role of values and worldviews in the interpretation and operationalisation of SD. Is SD primarily an objective topic of scientific enquiry, with facts and models, or a subjective aspiration, with an ethical component. It is both. With this in mind, the contribution of relevant scientific disciplines such as ecology, demography, energy and environmental science, agro-ecology, economy and social and political science is outlined.</p> <p>Throughout the course, the sustainability problem is approached from a wide perspective by looking more in-depth at cultural theory and worldviews. It will be shown that the perception of both problems and solutions depend on one's point of view and the frame of reference. That is why dealing with sustainability problems is a matter of combining scientific data about the world with value orientations and institutional realities.</p>

Modes of instruction	<ul style="list-style-type: none"> - Lectures - Assignments in small groups - Individual position paper - Simulation game
Assessment	Group assignments and final exam
Literature	<ul style="list-style-type: none"> - De Vries, B.J.M., 2012, Sustainability Science, Cambridge University Press - Articles/Reports/Extra materials – available online (Blackboard) - The World Commission on Environment and Development, <i>Our Common future</i>, 1987, Oxford University Press

Title	SUSD-Transdisciplinary Case Study
Code	GEO4-2302
Programme	SD/WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	1 (D)
Co-ordinator	Dr. P.P. Schot
E-mail	p.p.schot@uu.nl
Phone	030 253 2318
Language	English
Open to other students	No
Entrance requirements	- Letter of acceptance MSc Sustainable Development or MSc Water Science & Management. - At least 30 EC gained in the master SUSD or WSM, including SD: Integrating Perspectives (GEO4-2301).

Objectives	After completion of the course the student is able to: <ul style="list-style-type: none"> - contribute to the analysis of a multidisciplinary sustainable development issue from his/her disciplinary or track-specific background; - contribute to the design of an integrated research\action program aimed at resolving these issues; - take responsibility for, and be able to defend, the outcomes of the multidisciplinary analysis and the integrated research program.
Content	<p>This course focuses on the integration of insights from different knowledge domains which are necessary to realise sustainable development.</p> <p>Sustainable development issues are characterised by their multi-disciplinary character, and the fact that they are not merely an academic exercise but pertain to real-world problems. They show large complexity as a result of mutual interaction between social and biophysical systems. Regular or 'normal' scientific approaches tend to focus on more or less disciplinary aspects of the problem in isolation, using an 'objective' analytical perspective. In the contrary, it has been argued sustainable development issues are in need of a 'Post-Normal Science' in which there are multiple legitimate perspectives, related to values and world views of individuals or groups, and the full complexity including its uncertainty should be part of the scientific analysis (Functowitz and Ravetz, 1993). The multiplicity of world views also allows for non-scientific stakeholders to enter into the problem analysis and problem solving arena, enabling the addition of tacit knowledge to the formal scientific knowledge. The resulting networks involving public-private partnerships and the collaboration with community organisations have given rise to new forms of governance. Such participation of multiple stakeholders and scientific specialists involved in sustainability research and problem solving, necessitates forms of integration of the multidisciplinary knowledge being produced. Such research is often termed <i>transdisciplinary</i>.</p> <p>In this course students will enter the transdisciplinary arena. They will be confronted with a real-world problem of a real-world client. The students will work in multidisciplinary groups to</p>

	analyse the client's problem. They will analyse the multidisciplinary problem from their own (track-)specific background, and integrate their scientific knowledge with that of other students, and with the tacit knowledge of stakeholders.
Modes of instruction	There are a few lectures as an introduction to the course and the assignment. The main activities are by the students themselves and consist of group work and individual work. At the end of the course all groups present their results.
Assessment	The course grade is determined based on the Final Group paper as follows (% of final grade): a) specific (disciplinary) aspects of the case: 50% b) the mutual multidisciplinary parts of the group paper: 50%
Literature	Syllabus

Title	SUSD-Ecosystem Modelling
Code	GEO4-2303
Programme	SD/WSM
Level	M
Status	Obligatory (SD: track GCE)
Credits	7,5 EC
Period (slot)	2 (A+B)
Co-ordinator	Prof. dr. ir. M.G. Rietkerk
E-mail	m.g.rietkerk@uu.nl
Phone	030 253 2500
Language	English
Open to other students	Yes
Entrance requirements	None
Recommended prerequisites	For students from other programmes: mathematics and modelling, level 1; e.g. Wiskunde & Systeemanalyse (GEO1-2202), please contact the course coordinator before enrolment in Osiris.

Objectives	After completion of the course the student is able to: <ul style="list-style-type: none"> - understand the effects of (spatial) processes on ecosystem structure and dynamics; - model (spatial) processes in ecosystems and to critically evaluate (spatial) models.
Content	This course deals with the understanding and modelling of ecosystems and landscapes. Special attention will be paid to spatial processes such as flows of water and nutrient cycling, solute transport, dispersion of plants and movements of organisms. You will learn how to model complex mutual interactions by focusing on general principles and how to determine the relative importance of multiple factors. This is imperative to comprehend the effects that man has on ecosystems and landscape structure and functioning. The course consists of the following parts: <ul style="list-style-type: none"> - Matlab self study - Numerical solution of partial differential equations <ul style="list-style-type: none"> o Heat flow o Groundwater flow o Self-organizing systems - Cellular automata <ul style="list-style-type: none"> o Forest fires o Tiger bush - Final assignment
Modes of instruction	<ul style="list-style-type: none"> - Computer practicals - Lecture
Assessment	The final mark will be based on the average of the assignment and the exam
Literature	<ul style="list-style-type: none"> - Course reader - B. Malmfors et al., <i>Writing and Presenting Scientific Papers</i>. Nottingham: UP, 2004 (2nd edition).

Title	SUSD-Environmental Ethics & Sustainable Development
Code	GEO4-2323
Programme	SD / SIM / WSM / ES / SBI
Level	M
Status	Optional
Credits	7,5 EC
Period (slot)	1 (A)
Coordinator	Dr. F. van den Berg
E-mail	f.vandenberg2@uu.nl
Phone	030-253 5898
Language	English
Open to other students	Yes
Entrance requirements	None

Objectives	<p>After completion of the course, the student is able to:</p> <ul style="list-style-type: none"> - describe the philosophical dimensions of sustainable development. - perform an in-depth analysis of the concepts 'sustainability' and 'development'. - give an overview of contemporary environmental ethics. - perform an integral and critical assessment of moral stances on environmental problems and sustainable development. - write an article for a general audience on environmental issues, using philosophical tools & knowledge
Content	<p>The present-day political and economic systems are not sustainable and we are heading for global environmental disasters (ecocide). The notions 'sustainability', 'development' and 'sustainable development' have gradually entered political and social debates, and scientific and philosophical investigations. It is rooted in concern about environmental degradation of our planet. Philosophical reflection about sustainable development and the human-nature relationship starts with clarifying key concepts of environmental science. Sustainable development should at least encompass three dimensions: (1) the environment (conservation and preservation), (2) economy (growth vs. steady state), and (3) the social structure (equity, welfare). These dimensions form the pillars of sustainable development and will be studied from a philosophical viewpoint in Blewitt's book <i>Understanding Sustainable Development</i>.</p> <p>This course aims at providing philosophical reflection on sustainable development-related issues as part of environmental philosophy. We start with reflection on three kinds of relationships from the perspective of sustainability: humans-humans, humans-animals, and humans-nature. During the course key concepts and methods of environmental philosophy are dealt with. We will explore concepts such as biodiversity and vulnerability, demographic transition and inter- and intragenerational (environmental) justice.</p> <p>The emphasis of the course is normative deliberation on the environmental crises and sustainable development. What insights can science and environmental philosophy give to sustain life,</p>

	future generations and a healthy ecosystem of planet Earth?
Modes of instruction	Lectures and seminars
Assessment	5 columns (700-1000 words), 5 newspaper comments (200-300 words), 1 presentation (15 minutes), 1 paper (2500-3000 words)
Literature	<ul style="list-style-type: none"> - Blewitt, John, <i>Understanding Sustainable Development</i> - Curry, Patrick, <i>Ecological Ethics</i>, Polity, 2011 <p>Recommended reading:</p> <ul style="list-style-type: none"> - Berg, Floris van den, <i>Philosophy for a Better World</i>.

Title	SUSD-Sustainability Science: Modelling and Indicators
Code	GEO4-2331
Programme	SD / WSM
Level	M
Status	Obligatory (SUSD: for all tracks)
Credits	7,5 EC
Period (slot)	2 (C+D)
Co-ordinator	t.b.c.
E-mail	
Phone	
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Sustainable Development or MSc Water Science and Management
Recommended prerequisites	Sustainable Development: Integrating Perspectives (GEO4-2301)

Objectives	<p>After completion of this course, the student is able to:</p> <ul style="list-style-type: none"> - apply a number of software tools that allow for an integrative assessment of sustainability issues; - apply basic knowledge of modelling techniques; - explain how the concepts taught in the previous course (GEO4-2301) relate to trend projections and scenarios; - describe and critically analyse the concepts and methodology of existent SD models and indicators.
Content	<p>To get a more in-depth understanding and appreciation of sustainable development threats and challenges, empirical observations and concepts and modelling techniques to interpret them are needed. In this course, the focus is on the use of software packages to construct simple models by the student and to apply the insights to a better understanding of the large and diverse sets of models that are used in studying and resolving sustainability issues. In particular, the role of SD-indicators will be explored in this context.</p> <p>The course will consist of several parts. We will start with system analysis and the use of simple models. Then we will use projections and scenarios and use large simulation models of global change. This is used to investigate the important subsystems (population, land use, resource use, climate) and their interactions. These Global Change (or World) models provide the basis for a meaningful exploration of future policy strategies. After that students will work on different sustainability indicators, such as: Environmental Performance Index, Human Development Index, Ecological Footprint, Happy Planet Index and quality of life indicators.</p> <p>Through a number of exercises, students get hands-on experience with modelling tools such as Excel and Stella software. This will help them link the theoretical concepts on system dynamics and global change from the GEO4-2301 course with the use of models and the projections and trends in international or governmental reports.</p> <p>The course is a sequel to the course SUSD-Sustainable</p>

	Development: Integrating Perspectives (GEO4-2301) and its content is assumed to be known.
Modes of instruction	Focus on work in small groups, practical sessions and tutorials. <ul style="list-style-type: none"> - Lectures - Computer exercises - Assignments in small groups - Individual assignments - Simulation and experimental games
Assessment	Assignments and Exam
Literature	Detailed information to follow

Course title	ES – Coastal Zone and River Management
Code	GEO4-4403
Programme	Earth Sciences/WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	3 (B)
Coordinator	Dr. A.P. Oost
E-mail	a.oost@uu.nl
Phone	030-253 7195
Language	English
Open to other students	Yes
Entrance requirements	Students should have appropriate physical geography or geology courses, particularly in fluvial and coastal geomorphology and/or sedimentology. They have to appreciate the role of interdisciplinary science and the role of (applied) sciences in societal issues and coastal zone and river basin management problems and challenges.
Recommended pre-requisites	None

Objectives	<p>At the end of the course the student has:</p> <ul style="list-style-type: none"> a) Developed a generic understanding of the physical, ecological, socio-economic, political and legal factors, processes and conditions that play a role in coastal zone and river management; b) learned about the interdisciplinary nature and context of coastal and fluvial problems; c) become familiar with the contribution that geoscientists can deliver to complex coastal zone and river management issues; d) become familiar with approaches, methodologies and tools for CZRM studies; e) knowledge of the role of decision makers, policymakers and stakeholders in developing and implementing coastal zone and river management strategies and solutions; f) applied this knowledge in realistic case studies.
Content	<p>This course focuses on the integrated management of two groups of wetlands: rivers and coasts. These areas are characterised by high ecological values, depending on the rich and dynamic interactions between hydraulics, sedimentation, morphology and biota. Furthermore, many major cities and harbours are located in these wetlands and large parts are in use for agriculture. Management of these wetlands poses considerable challenges, and involves both fundamental knowledge of the morphology and physical and ecological processes as well as understanding and negotiating among the different interests from the 'users' of these systems. Moreover, future climate change, sea-level rise and increasing societal demands further complicate a sustainable management of rivers and coasts. Emphasis is therefore on the various aspects of integrated management of such wetlands, with a sharp focus on the every-day practices, which will be discussed by a series of guest speakers. The students will be introduced to the key factors</p>

	and techniques which determine the development and execution of integrated management plans and will learn to develop a plan themselves. Furthermore, new techniques and philosophies are introduced.
Modes of instruction	Course activities include: <ul style="list-style-type: none"> • Lectures • Exercises (as part of report writing) • Excursion • Studying papers and internet material (as part of report writing) • Case study (including report writing)
Assessment	The result for the course is determined by: <ol style="list-style-type: none"> a) Workshops and minor deliverables and reports (total 10) on them, 25% (each paper/workshop is 2.5%) b) Case study report concept, 25% c) Case study final report, 50%
Literature	See course manual

Course title	ES-Land Surface Hydrology
Code	GEO4-4404
Programme	ES and WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	1 (B)
Coordinator	Dr. R. van Beek
E-mail	r.vanbeek@uu.nl
Phone	030 253 2776
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Earth Sciences or MSc Water Science and Management.
Recommended prerequisites	Basic knowledge of quantitative analysis, including statistics, mathematics (differentiation, integration) and physics (mechanics).

Objectives	<p>After completion of the course, students will be able to:</p> <ul style="list-style-type: none"> -characterize and quantify the hydrological processes that operate at various points and times within a catchment through measurements and modelling; -analyse total catchment behaviour by means of hydrograph separation and frequency analysis techniques; -perform simple river discharge routing and interpret the results of more complex schemes; -evaluate the consequences of errors and uncertainty in measurements and modelling of catchment hydrological behaviour; - interpret stream flow data for design and planning purposes.
Content	<p>This course covers the hydrological processes that interact with streamflow across a range of scales. It considers the mechanism of runoff generation in light of atmosphere and land surface interactions and changes in the travel time and storage as stream flow travels downstream along the drainage network. This course will impart the student with knowledge of the relevant physical processes and the implications thereof in the natural and built environment and the capacity to analyze these processes quantitatively through a variety of models.</p> <p>This course will be taught on the basis of a textbook and a reader comprising the exercises, additional background materials and articles. Details are published in the course guide.</p>
Modes of instruction	<p>Modes of instruction 14 hours of lectures, 8 hours of practicals, 28 hours of computer practicals. Computer practicals attendance required.</p> <p>Attendance at the first lecture is required and highly recommended for all others. Attendance at the practicals is compulsory.</p>
Assessment	see course manual
Literature	This course will be taught on the basis of a textbook and a

	<p>reader comprising the exercises, selected topics and articles and additional background material.</p> <p>Book S. Dingman Physical Hydrology, 2nd Edition (ISBN: 978-1-57766-561-8). Waveland Press: http://www.waveland.com/Titles/Dingman.htm</p> <p>Reader Land Surface Hydrology, available via the OSZ (Onderwijs- en Studentenzaken/Educational and Student Affairs; to be announced).</p> <p>Handouts Hand-outs of all lectures and solutions to the exercises are available as PDFs after each lecture / practical via Blackboard.</p>
Academic skills	<p>Once completed, the student</p> <ul style="list-style-type: none"> - is able to think / develop / apply (partly) original ideas in a (semi) research context; - has obtained the ability to integrate / interpolate / extrapolate (incomplete) knowledge at a high level including those gathered from research-articles; - has obtained expertise in the field of understanding / modelling / simulation of key underlying processes in the field of study; - demonstrates skills for pursuing (advanced) research in a (sub) field.

Course title	ES-Unsaturated Zone Hydrology
Code	GEO4-4417
Programme	ES/WSM
Level	M
Status	Elective
Credits	7.5 EC
Period (slot)	2 (C)
Coordinator	Dr. M.R. Hendriks
E-mail	m.r.hendriks@uu.nl
Phone	030 253 2054
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Earth Sciences or MSc Water Science and Management.
Recommended pre-requisites	<ul style="list-style-type: none"> - Knowledge of groundwater hydrology: GEO2-4203 Physical hydrology or GEO4-1434 Principles of groundwater flow (or equivalent); - basic physics/mathematics skills.
Objectives	After completing the course the student has in-depth knowledge of the topics mentioned below.
Content	This course covers the theory and principles of soil physics, soil moisture storage, unsaturated flow and transport, matric flow, infiltration, preferential flow and evaporation, the determination of soil physical parameters, soil moisture dynamics, the use of state-of-the-art 1D and 2D unsaturated zone models, and a critical evaluation of unsaturated flow theories.
Modes of instruction	Lectures, tutorials, and Hydrus computer practical
Assessment	see course manual
Literature	<p>Hendriks, M.R. (2010). Introduction to Physical Hydrology, Oxford University Press, 352 pp. ISBN 978-0-19-929684-2 http://ukcatalogue.oup.com/product/9780199296842.do : pages xi-xv, sections 2.6-2.7, Chapter 4, Boxes M8-M9, and part of 'Answers to the exercises'; in total: 89 pages, including Exercises 4.1.1-4.9 (12 exercises).</p> <p>Kutilek, M and Nielsen, D.R. (1994). Soil Hydrology, Catena Verlag, 370 pp. ISBN 3-923381-26-3 http://www.catena-verlag.de/get263.htm : sections 3-3.2.5, 4.3, 5.3.2, 6.2.2.2, 9.2-9.4.1, and 9.5-9.5.1.2; in total: 77 pages.</p> <p>Syllabus (pdf), and URLs on Blackboard.</p>

Course title	WSM-Quantitative Water Management
Code	GEO4-6001
Programme	WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	3 (A)
Coordinator	Prof. Dr. M.F.P. Bierkens
E-mail	m.f.p.bierkens@uu.nl
Phone	030 253 2777
Language	English
Open to other students	Yes
Entrance requirements	Letter of acceptance of a Master's programme.
Recommended pre-requisites	<ul style="list-style-type: none"> - A bachelor level natural sciences background. - One or more of the following courses: GEO2-4203 Physical Hydrology; GEO3-4307: Fluid mechanics 1; GEO4-1434 Principles of groundwater flow; GEO4-4404: Land surface hydrology.
Remarks	Students without a natural science Bachelor's degree should contact the course coordinator <i>before</i> registering for the course.

Objectives	<p>At the end of the course the student will be able to:</p> <ul style="list-style-type: none"> - present a complete overview of quantitative water management issues around the world and in the Netherlands in particular; - perform basic calculations to support flood protection and drainage system and irrigation system design; - understand the complex relationships between water quantity and chemical and ecological quality; - Reflect on current and future developments in quantitative water management in the context of global change.
Content	<ol style="list-style-type: none"> 1. <u>Flood protection</u> (Flood frequency analysis; dike construction & failure; failure probability and risk; climate change, adaptation). 2. <u>Drainage systems</u> (land reclamation, polders and boezems; polder design: ditch and drainage density, ditch and drainage size, pump capacity; salt water intrusion; drainage by gravity). 3. <u>Operational water management</u> (river water level control (weirs, sluices); operational management of small waters; fresh water redistribution and salt-water control). 4. <u>Irrigation systems</u> (types of water application; irrigation systems around the world; irrigation system design; socio-cultural dimension of irrigation systems) 5. <u>Water quality</u> (sources of nutrients in groundwater and surface water; fates of nutrients in groundwater and surface water; hydro-ecology of surface waters; role of sediments, erosion and morphology; relation morphology and ecology; water framework directive and groundwater directive).

Modes of instruction	to be determined
Assessment	to be determined
Literature	to be determined
Academic skills	to be determined

Course title	WSM-Water Policy, Governance and Law
Code	GEO4-6002
Programme	WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	4 (A)
Coordinator	dr. H.K Gilissen
E-mail	H.K.Gilissen@uu.nl
Phone	030-253 8092
Language	English
Open to other students	Yes
Entrance requirements	Letter of acceptance of a Master's programme.

Objectives	Gaining insight in the policy, governance and legal aspects of water management
Content	<p>Governance and Legal aspects will be discussed, taken the international, European and Dutch levels into account (multi-level governance). Normative, institutional and instrumental (including economic instruments) aspects of water management are part of the course, just as the relation with land use planning, environmental and nature conservation law.</p> <p>The relationship between several stakeholders (governments and private parties) will be discussed, and also the way they can be involved (public participation, private responsibilities and private and public enforcement).</p> <p>Typical water management topics like flood protection, waste water treatment, drinking water supply, fresh water supply, river basin management, urban water and urban developments are a major part of the course.</p> <p>During the course there will be attention for specific skills that are needed to deal with legal research and practice.</p>
Modes of instruction	Lectures, working groups, probably an excursion
Assessment	Individual and group assignment
Literature	H.F.M.W. van Rijswick and H.J.M. Havekes, European and Dutch Water Law, Europa Law Publishing, Groningen 2012 Reader with additional materials

Course title	WSM-Drinking Water and Sanitation
Code	GEO4-6003
Programme	WSM
Level	M
Status	Obligatory
Credits	7,5 EC
Period (slot)	4 (B)
Coordinator	Dr. Ing. C. Vink
E-mail	C. Vink@uu.nl
Phone	-
Language	English
Open to other students	Yes
Entrance requirements	Letter of acceptance of a Master's program.
Recommended pre-requisites	A bachelor level natural sciences background.
Remarks	Students without a natural science Bachelor's degree should contact the course coordinator <i>before</i> registering for the course.

Objectives	<p>At the end of the course the student will be able to:</p> <ul style="list-style-type: none"> • Describe the basic components of the urban water cycle and their linkages; • Describe the main techniques used for drinking water supply and sanitation in both developing and developed countries; • Describe energy and resource use and costs of different drinking water and sanitation techniques; • Describe principal chemical and biological hazards pertinent to drinking water supply and sanitation; • Understand the relations between drinking water provision, sanitation and water related health problems; • Understand and apply the principle concepts for design of ground water wells, sewerage systems, water treatment plants and distribution networks; • Demonstrate an understanding of multiple objective optimization trade-offs with respect to drinking water supply and sanitation; • Analyse the relations between the urban water cycle and the natural water system; • Evaluate and discuss water resources available and methods of protection; • Evaluate the sustainability of drinking water supply and sanitation techniques and practices.
Content	<ul style="list-style-type: none"> • Hydrological cycles and balances; • WASH: Water, Sanitation and Hygiene, water related health problems; • Water borne and water based diseases and health threats in developing countries; • Biological and chemical threats (causes of diseases) • History of sanitation; • Sewerage systems;

	<ul style="list-style-type: none"> • Drinking water demand, production, treatment, distribution, optimal supply; • Climate change effects on drinking water supply; • Water quality aspects of drinking water supply; • Drinking water source protection and treatment; • Modeling raw water quality; • Wells, well design; • Distribution, piped supply; • Sewage, design, estimating sewage system flow components; • Waste water treatment; • Drinking water supply and sanitation in sustainable cities; • Drinking water supply and sanitation in lower income countries.
Modes of instruction	Lectures, seminars, one excursion.
Assessment	One individual assignment, one duo-presentation, one group assignment, all with a presentation, one written exam.
Literature	<ul style="list-style-type: none"> • De Moel P.J., J. Q. J.C. Verberk and J.C. van Dijk (2012); Drinking Water; Principles and Practices. Kiwa/TU Delft. • Design of distribution networks for drinking water, OCW TUD ct5550 (pdf) • Urban Drainage, (2011), OCW text book TUD - sanitary engineering - ct3420 (pdf) • Waste Water treatment (2011), OCW text book TUD - sanitary engineering - ct3420 (pdf) • Introduction drinking water, OCW TUD ct5550 (pdf)
Academic skills	Academic reasoning, conceptual thinking, analysing a problem, asking critical questions, thinking from different perspectives. Effective teamwork, oral presentation skills, writing skills.

Course title	WSM-Master's thesis Internship
Code	GEO4-6004
Programme	WSM
Level	M
Status	Obligatory
Credits	30 or 45 EC
Period (slot)	2/3/4
Coordinator	Dr. P.P. Schot (Environmental Sciences); Prof. M.F.P. Bierkens (Earth Sciences)
E-mail	P.P.Schot@uu.nl ; M.F.P.Bierkens@uu.nl
Phone	030 253 2318; 030 253 2777
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Water Science and Management. At least 60 EC passed within the programme.

Objectives	<p>After completion the student is be able to:</p> <ul style="list-style-type: none"> - translate a problem as described at the place of internship in the field of water science and management into a research question, based upon relevant scientific and other literature; - develop a research plan, choosing and justifying appropriate methodologies for data collection; - conduct the empirical work needed and analyse the collected data; - interpret the findings in the light of solving the given problem; - write a scientifically sound report about the findings geared to the target audience at the place of internship; - conduct a full research cycle within a restricted amount of time.
Content	<p>The course starts with a brief introduction to the Internship describing the aim, format and requirements of the Master's thesis and the thesis presentation, recapitulation of setting up a research proposal, behaviour at the place of internship and initiatives to be taken by the student.</p> <p>The Master's thesis Internship is a research project in which the student will learn to conduct independent research, applying new or existing methods to a problem as indicated at the place of internship and relevant to water science and management.</p> <p>The student will work under the guidance of a supervisor at the place of internship, and will have regular meetings with the university supervisor to discuss updates of achieved progress in the form of written concept-versions of the Master's thesis.</p> <p>The student is expected to show ample initiative to realise the goals of the defined research. This includes collecting and analysing relevant scientific and other literature, approaching specialists or other relevant persons for additional information or assistance on research related methods and skills, making timely and regular appointments with the internship supervisor and university supervisor, etc. Learning-by-doing is part of the project. The student is</p>

	<p>encouraged to attend meetings or conferences etc. that are relevant to the research work.</p> <p>Students needs to motivate their choice for either a 30 EC or 45 EC Master's thesis Internship based on the problem description and time estimation at the place of internship, data collection and analyses needed, etc.</p>
Modes of instruction	<p>Introductory lectures.</p> <p>Individual guidance at place of internship and by university supervisor.</p>
Assessment	<p>Assessment is based on the quality of the written Master's thesis (70%), the quality of the internship process (20%) and the oral presentation (10%) of the thesis.</p>
Literature	<p>B. Malmfors et al., <i>Writing and Presenting Scientific Papers</i>. Nottingham: UP, 2004 (2nd edition).</p>

Course title	WSM - Tailor-made course
Code	GEO4-6005
Programme	WSM
Level	M
Status	Elective
Credits	15 EC
Period (slot)	2 or 4
Coordinator	Dr. P.P. Schot (Environmental Sciences); Prof. M.F.P. Bierkens (Earth Sciences)
E-mail	P.P.Schot@uu.nl ; M.F.P.Bierkens@uu.nl
Phone	030 253 2318; 030 253 2777
Language	English
Open to other students	No
Entrance requirements	Letter of acceptance MSc Water Science and Management. At least 60 EC passed within the programme.
Recommended pre-requisites	None

Objectives	Build on competences of the student in relation to the degree requirements of the master programme.
Content	<p>With a Master's thesis Internship of 30 EC, there is room for 15 EC extra master's activities. These activities may, in principle, be any activity that aids to the competences of the student in relation to the degree requirements of the master's programme. Examples are research projects, workshops, summer schools, extra courses, etc.</p> <p>The student takes the initiative to formulate a proposal for a Tailor-made course, and must find a staff member willing to provide guidance and grading during the course. The proposal should contain a description for a number of predefined elements (see Study Guide), and must be approved by the Board of Examiners.</p>
Modes of instruction	Dependent on the content of the proposed Tailor-made course.
Assessment	Dependent on the identified ways of assessment in the proposed Tailor-made course.
Literature	Dependent on the content of the proposed Tailor-made course.
Academic skills	Dependent on the content of the proposed Tailor-made course.

Course title	Sustainable Entrepreneurship
Code	ECMSE
Programme	SD/IS/SBI/ES/WSM
Level	M
Status	SBI: obligatory, SD/ES/IS/WSM: elective Required for the university wide Sustainable Entrepreneurship & Innovation track.
Credits	7,5 EC
Period (slot)	2 (B)
Coordinator	Prof. Dr. E. Stam
E-mail	E.Stam@uu.nl
Phone	030-253 7894
Language	English
Open to other students	Letter of acceptance MSc Energy Science or MSc Science and Innovation Management or MSc Innovation Sciences or MSc Sustainable Business and Innovation or MSc Sustainable Development or MSc Water Science and Management or MSc International Economics and Business or MSc Science and Business Management.
Entrance requirements	Letter of acceptance MSc Energy Science or MSc Science and Innovation Management or MSc Innovation Sciences or MSc Sustainable Business and Innovation or MSc Sustainable Development or MSc Water Science and Management or MSc International Economics and Business or MSc Science and Business Management.
Recommended pre-requisites	International Business Ventures (ECMIBV)
Objectives	<p>This course is designed to provide academic knowledge on the development, market introduction and management of new sustainable business. The major course objectives include:</p> <ul style="list-style-type: none"> • to provide understanding of (sustainable) entrepreneurship (what entrepreneurship is, cognitive foundations of entrepreneurship, and entrepreneurial opportunities, distinctive characteristics of entrepreneurs), • to provide understanding and skills about the processes of starting a new sustainable business (business planning, resource acquisition, capability development for launching a new sustainable business), and • to provide understanding and skills about running and managing a new sustainable business (marketing strategies, operational strategies, growth strategies, and exit strategies). <p>This necessitates that students understand the concepts of sustainability and sustainable entrepreneurship, and that students learn about the economic, environmental and social problems facing local and global communities and recognize the opportunities that arise from this. Finally, students should be able to evaluate the risks and rewards of undertaking sustainable entrepreneurship, which involves finding ways to measure the economic as well as social and</p>

	environmental risks and rewards of a new venture.
Content	<p>Entrepreneurship focuses on identifying new opportunities for creating value for customers or users and commercially developing those opportunities to establish a profitable business. Sustainable entrepreneurship combines the traditional focus of entrepreneurship with an emphasis on opportunities to alleviate social or environmental conditions. Sustainable entrepreneurship is about entrepreneurs striving simultaneously for profit and for improving local and global environmental and social conditions. This course is addressed to students interested in exploring the challenges of sustainable entrepreneurship, both in SMEs and in larger organizations. The course will provide academic insights into the entrepreneurial process and in particular:</p> <ul style="list-style-type: none"> • The challenges of launching and sustaining a new business; • The challenges of keeping the entrepreneurial spirit in large organizations. • The challenges of aligning profits with social and environmental value. • The course is based on lectures, case discussions and seminars with guest speakers. <p>The overall objective of this course is to make the students aware of the opportunities offered by an entrepreneurial career, the skills needed for and academic knowledge about entrepreneurial processes, in the context of sustainability. The course emphasizes the business & management perspectives to entrepreneurship, while the economics perspective is emphasized in the course "Economics of Entrepreneurship and Innovation" (ECMEEI).</p>
Modes of instruction	This course is an interactive and participatory course that teaches students the key concepts in the class by developing a new business plan, a business case, or by doing applied research related to sustainable entrepreneurship. Students are expected to attend and participate in all classes and take part in all group discussions.
Assessment	<ul style="list-style-type: none"> • <u>Project / Business Planning</u>: Students are required to develop or evaluate a business plan for a new sustainable business, to develop a case for an existing business, or to conduct applied research related to sustainable entrepreneurship. This is a group assignment and guidelines will be given to students during the course. • <u>Final Exams</u>: The exams consist of open-ended questions. The questions are based on the key course concepts that are taught and discussed during the course. • Case discussions and (evaluation of) project / business planning 40% • Written exam 60%
Literature	<p>Recommended: Dean, Sustainable Venturing: Entrepreneurial Opportunity in the Transition to a Sustainable Economy, 1st ed. Syllabus and course manual</p>

Appendices

Appendix I Rules for choosing optional courses

1. Students in the Master's programme choose optional courses from another or their own Master's programme. Courses that are obligatory in the examprogramme cannot be used as optional courses.
2. The student must subject in advance his optional courses to the approval of the Board of Examiners. The coordinator of the student's track will advise the Board in this matter.
3. The Board tests the proposed optional course on the following criteria:
 - a. They must be thematically linked to the Master's programme;
 - b. The track coordinator supports the proposition;
 - c. It concerns a course at a master level (M);
 - d. Courses that were taken as a necessary component of the student's admission programme will never be approved as an optional in the Master's programme.
4. Within these bounds students are **free to propose any course** (even in Dutch) from any other programme in the Faculty of Geosciences, the UU or another recognized University in the Netherlands (see www.vsnu.nl > universiteiten) or abroad. Useful sources to find electives are the Osiris webpage (www.uu.nl/osirisstudent) and the USI website (www.usi-urban.nl).
5. If the student wishes to choose an optional course, he must do so by a written request (form) to the Board of Examiners and he must attach written information on the contents, the level, and the study load of the course, preferably by means of a copy of the course's description from the course catalogue. The 'Application Form Optional courses IMEW' can be downloaded at www.studiepunt.geo.uu.nl.
6. The student can either ask the track coordinator to sign the application form or forwards an email containing the **track coordinator's approval** to the Board of Examiners. The form (and email if applicable) and the course description can be sent to the Board's secretary, Examcommissie.geo@uu.nl. If in hard copy, for Environmental Sciences: mrs.drs. Erika Dijkma (room 10.23, or pigeon-hole on the 10th floor of the Van Unnik building, Heidelberglaan 8). For Earth Sciences: Mrs. Ingrid Beekman (room Z121, Earth Sciences Building, Budapestlaan 4).
7. Recommended optional courses do not need to be approved by the track coordinator but must still be approved *before starting* by the Board of Examiners.
8. Actual participation is only possible if the student satisfies the course's entrance conditions; in case of doubt he should contact the course coordinator first.
9. In the programme's course schedule, room has been reserved for taking electives. However, the student is free to deviate from this planning, e.g. because he wishes to take an interesting optional course in another period. If this causes delay in his study planning, the responsibility is for account of the student! Students are therefore advised to take their electives in the reserved periods and timeslots, or use a part of the time planned for their internship and/or Master's thesis.

Appendix II Teaching periods teaching institutes Innovation, Environmental & Energy Sciences and Earth Sciences, 2014-2015. Always check course manuals for exact start and end dates of each course!!

36	37	38	39	40	41	42	43	44	45
1	2	3	4	5	6	7	8	9	10
1/9 GEO Intro					BBX-UAV				break

46	47	48	49	50	51	52	1	2	3	4	5
1	2	3	4	5	6	Xmas break	Study week	7	8	9	10
	21/11 BA Information day		2/12 rep. 1	9/12 rep. 1	AGU			rep. 1			break

6	7	8	9	10	11	12	13	14	15	16
1	2	3	4	5	6	7	8	9	10	11
2/2 GEO Intro			24/2 rep. 2	3/3 rep. 2				3/4 Good Friday	6/4 Easter	break
5/2 UU Careerday				rep. 2					Fri 10/4 no classes	EGU
Company presentations										

17	18	19	20	21	22	23	24	25	26	27	28	29
1	2	3	4	5	6	7	8	9	10	11	Break	Break
	27/4 King's Day	5/5 Liberation day	12/5 rep. 3	19/5 rep. 3	25/5 Whitsun					Break	6-9/7 rep. 4	
			14/5 Ascension Day								rep. 3+4	
			15/5 break									
						IMEW	GEOwide	Earth Sciences				

Appendix III UU-time table 2014-2015

Teaching periods

Semester I:

Period 1: Monday 1 September – Friday 7 November

Period 2: Monday 10 November – Friday 30 January

Semester II:

Period 3: Monday 2 February – Friday 17 April

Period 4: Monday 20 April – Friday 10 July

Timeslots

- A Monday morning and/or Wednesday morning
- B Tuesday morning and/or Thursday afternoon
- C Monday afternoon and/or Thursday morning
- D Wednesday afternoon, Friday morning and/or Friday afternoon
- E Monday evening, Tuesday evening, Wednesday evening, Thursday evening and/or Friday evening

Course registration (only via Osiris Student: www.uu.nl/osirisstudent)

- For period 1: 2 June 2014 up to and including 29 June 2014
 - late registration 18 and 19 August 2014
- For period 2: 15 September 2014 up to and including 28 September 2014
 - late registration 27 and 28 October 2014
- For period 3: 3 November 2014 up to and including 30 November 2014
 - late registration 19 and 20 January 2015
- For period 4: 26 January 2015 up to and including 22 February 2015
 - late registration 7 and 8 April 2015