

## Study Guide

Academic Programme 2017-2019



*(fieldwork France with HERBD, HWR, and GroundwatCH student groups, 2016)*

Programme Information: Water Science and Engineering MSc Programme

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## **Introduction**

The Water Science & Engineering Programme focuses on the understanding, management and development of water resources and water flows and quality in the natural and human-influenced environment, while addressing the multidisciplinary character of human activities dealing with water.

The specializations within this programme explore natural and anthropogenic influences on the water cycle, from the perspectives of civil engineering, technology and earth system sciences. They are of direct relevance to sustainable development because they prepare graduates to improve the sustainable management of human impacts on water resources, design simulation models for various phases of the water cycle, and contribute to the development of integrated solutions for reducing the impact of water-related natural hazards and other water issues.

The programme aims to deepen the knowledge, insights and skills for Hydraulic Engineering (part of Civil Engineering and covering the disciplines River Basin Development, Land and Water Development for Food Security and Coastal Engineering and Port Development), Hydroinformatics (a technology oriented discipline) and Hydrology (an earth system science). These different fields are complementary and ensure exposure of the student to a large variety of water issues from different perspectives, and the ability to develop sustainable solutions for complex water problems.

Graduates are able to work in professional water sector environments that require academic skills.

Graduates who obtain very good study results are eligible to undertake a PhD in an appropriate water science or engineering field.

In particular, this programme provides the education to:

- improve the management of water resources through assessing and monitoring their condition and vulnerability to hazards;
- sustain economic development by better flood and drought protection, risk management and hazard reduction, in an era of global climate change;
- improve environmental and public health through pollution prevention;
- sustain and improve water supply, power generation and agriculture through integrated water resources management;
- improve food production by developing, operating, maintaining and optimising water-related infrastructure;
- sustain economic growth through the development of coastal and riparian zones; and
- manage and control water systems in an integrated and sustainable way, with stakeholders, through the development of technologies to simulate such systems.

The programme focuses mainly on emerging and least developed countries and is especially suitable for midcareer professionals.

## **Domain specific framework**

### **The concept of Water Science & Engineering**

The concept of Water Science & Engineering is born out of the recognition that the technical and scientific problems related to water are increasingly multidisciplinary and graduates can no longer rely on spending their future working within only one of the traditional disciplines; rather, dealing with even the more technical aspects of water problems requires a mix of disciplines that:

- deal with water fluxes and quality in the natural and human-influenced environment;
- are concerned with different aspects of water resources management and development ;
- explore the natural and anthropogenic influences on the water cycle at various spatial and temporal scales;

- investigate the management and optimization of the human impact on water resources through structural and non-structural measures;
- develop and apply various simulation and predictive models for different phases of the water cycle;
- consider physical and logistical aspects of transport over water; and
- are concerned with protection against water-related natural hazards.

### **The academic field of Water Science & Engineering**

Water Science & Engineering includes a range of science and engineering disciplines related to the aquatic environment. Each discipline represents an established and well-defined academic field for which the objectives are readily obtained from international consensus. Hydrology for example is defined by the International Association of Hydrological Sciences (IAHS); and the fields of Hydraulic Engineering and Hydroinformatics by the International Association of Hydro-environment Engineering and Research (IAHR) and the International Water Association (IWA).

In short, the disciplines comprise:

- Hydrology: an earth system science that deals with the occurrence, circulation and distribution of water and the chemical and physical properties of water in the environment. In addition, it is the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the earth, and various phases of the hydrological cycle;
- Hydroinformatics: a discipline which deals with applications of information and communication technologies, advanced risk-based modelling and forecasting tools, system analysis and optimization to all areas of integrated water management and especially to river basins, aquifers, urban water systems, estuaries, and coastal waters; and
- Hydraulic Engineering: a part of Civil Engineering that deals with the application of engineering principles and methods to the control, conservation and utilization of water. This discipline is further divided into Land and Water Development for Food Security, River Basin Development and Coastal Engineering and Port Development.

### **Objectives of the Water Science & Engineering Programme and intended learning outcomes**

The overall objective of the Water Science & Engineering Masters Programme is as follows:

*"By the end of the course, students will be able to work in a complex environment, and, by using interdisciplinary approaches, will be able to improve the management of human impacts on water resources, to develop simulation models for various phases of the water cycle, and to develop methods to reduce the impacts of water-related natural hazards".*

To be able to work in this complex environment of water resources and to explore natural and anthropogenic influences on the water cycle as well as to develop solutions, scientific knowledge and academic skills are needed from the perspective of civil engineering (Hydraulic Engineering), technology (Hydroinformatics) and earth sciences (Hydrology). Therefore, these fields form the foundation for the Water Science & Engineering Masters Programme. In line with this overall objective, the Water Science & Engineering Masters Programme has the following intended learning outcomes.

Upon successful completion of the Water Science & Engineering Programme, graduates will be able to:

#### **Knowledge and understanding**

- A. demonstrate knowledge and understanding of hydrological, hydraulic, morphological and environmental processes and phenomena and their inter-relationships;
- B. identify and characterize the causes and impacts of water-related problems on society, the economy and the environment;

C. explain the need for integration of monitoring, modelling and information systems to support safe and reliable decision making;

D. demonstrate critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design;

### **Applying knowledge and understanding**

E. apply modelling and data management related to hydrological, hydraulic, morphological and environmental processes;

F. conduct research, independently or in a multidisciplinary team, including the formulation of research questions and hypotheses, the selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations

G. support planning, design, implementation, operation and maintenance, and management of engineered measures, of both a constructive and an operational character, aimed at the solution of problems arising from the multiple uses of water;

### **Making judgements**

H. co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills;

I. critically judge and evaluate their own work and results, as well as prior research carried out by others;

### **Communication**

J. communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences, making use of appropriate information and communication technologies;

### **Learning skills**



K. demonstrate academic attitude and learning skills (including thinking in multidisciplinary dimensions) to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner; and

L. integrate ethical issues encountered in engineering practice and in relation to working in emerging and least developed countries and countries in transition.

The table below shows how the various programme components contribute to the relation between the programme level learning objectives.

*Table 1: Relation between programme level learning objectives and programme components*

	A	B	C	D	E	F	G	H	I	J	K	L
1. Introduction to water science and engineering												
2. Hydraulics and hydrology												
3.-7. Specialization modules												
8. Programme-wide electives												
9. Fieldtrip/fieldwork												
10. Programme-wide electives												
11. Institute-wide electives												
12. Summer courses												
13. Groupwork												
14. MSc proposal preparation												
15. MSc research												

Key:  - objectives of primary focus;  - objectives of secondary focus

### Skills development

Skills development is an integral part of the programme's core learning objectives and activities. The academic and research skills are nurtured throughout the programme. These include, but are not limited to oral expression, reading comprehension, written expression, critical thinking, self monitoring, coordinating with others, scientific ethics, research skills and information literacy. These activities are well embedded within the core contents of the entire program (Tables 2 and 3), which helps to maintain a strong link between skills and knowledge (theory and application).

Table 2: Relation between skills development and programme components

	Oral expression	Reading comprehension	Written expression	Critical thinking	Monitoring self	Coordinating with others	Scientific ethics	Research skills	Information literacy
1. Introduction to Water Science and Engineering									
2. Hydraulics and Hydrology									
3.-7. Specialization modules									
8. Programme-wide electives									
9. Fieldtrip/fieldwork									
10. Programme-wide electives									
11. Institute-wide electives									
12. Summer courses									
13. Groupwork									
14. MSc proposal preparation									
15. MSc research									




Key:  covered well;  covered somehow;  not covered

Table 3: Explanation and definition of skills used in Table 2

<b>Oral expression</b>	Giving presentations, involvement in discussions, explaining concepts in own words
<b>Reading comprehension</b>	Carrying out exercises, assignments, reading lecture notes, reports, theses, articles
<b>Written expression</b>	Carrying out exercises, assignments, drafting reports, notes, thesis
<b>Critical thinking</b>	Being able to evaluate your work and that of others, making judgments about the value of information and drawing conclusions from data;
<b>Monitoring self</b>	Being able to change behavior to fit a situation;
<b>Coordinating with others</b>	Capacity to follow up tasks, follow through on undertakings, capacity to maintain, balance or restore workflow;
<b>Scientific ethics</b>	<ul style="list-style-type: none"> <li>- Exercising honest research practices;</li> <li>- Responsible for the activities, subject matter and method of his or her research, as well as for the quality of the results;</li> <li>- Respect the contributions of other researchers and follow standards for authorship and cooperation;</li> <li>- Follow national and international regulations on ethics and safety;</li> </ul>
<b>Research skills</b>	<p>Independence – being able to work without close supervision, managing your own time and projects</p> <p>Critical thinking – being able to evaluate your work and that of others, making judgments about the value of information and drawing conclusions from data.</p> <p>Problem solving – working without “a right answer” and devising strategies to work towards a solution</p> <p>Contributing as a professional – presenting work to your peers, managing discussions and defending your position, having the confidence to put forwards ideas to senior staff</p> <p>Initiative – having the confidence to make decisions and act on them, not waiting for approval to do basic tasks, but reporting back responsibly at appropriate times</p>
<b>Information literacy</b>	<p>How to use scholarly information effectively and responsibly? More in particular, an information literate person:</p> <ul style="list-style-type: none"> <li>- Determines the nature and extent of information needed;</li> <li>- Accesses the needed information effectively and efficiently;</li> <li>- Evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system;</li> <li>- Uses information effectively to accomplish a specific purpose;</li> <li>- Understands many of the economic, legal, and social issues surrounding the use of information, and accesses and uses information ethically and legally;</li> </ul>

## **Curriculum and structure of the Water Science & Engineering Programme**

The overall emphasis of the programme is on water sciences, engineering and technology placed in the contemporary context of society, economy and environment. The specializations are structured in a sequential build-up of educational components (incremental learning approach), which allow some interchange of topics and other educational activities among groups of students following one chosen specialization. The programme provides an excellent opportunity for students – although mainly devoted to their selected specialization – to interact with colleagues of other specializations and to share information and learning activities in a multidisciplinary context. Time constraints have required careful choice of compulsory subjects that form the main skeleton of each specialization programme and common subjects and electives to promote interspecialization thinking and development. The Water Science & Engineering Masters Programme incorporates seven specializations:

- Hydrology and Water Resources (HWR);
- Hydraulic Engineering and River Basin Development (HERBD);
- Hydraulic Engineering – Coastal Engineering and Port Development (HECEPD);
- Land and Water Development for Food Security (LWDFS);
- Hydroinformatics: Modelling and Information Systems for Water Management (HI);
- Erasmus Mundus Programme on Flood Risk Management (FRM); and
- Erasmus+ Programme on Groundwater and Global Change (GroundwatCH).

Several tracks of these specializations have been developed as part of educational programmes that lead to a double degree (from IHE DELFT and partner organisation). The figure below gives an overview of the different specializations and double degree programmes. The specializations GroundwatCH and FRM are offered as Erasmus Mundus and Erasmus+ programmes. The LWDFS specialization is, in addition to the track offered in Delft, also organised as a double degree programme with three other partners, i.e. AIT in Thailand, UNL in the USA, and Sriwijaya in Indonesia. HECEPD, HWR and HI offer the possibility to start in China by following the first three modules at Hohai University. In addition HI offers the possibility to start at Universidad del Valle in Colombia. In all these cases, the modules offered abroad are the same as the ones offered at IHE DELFT, using largely the same course materials.



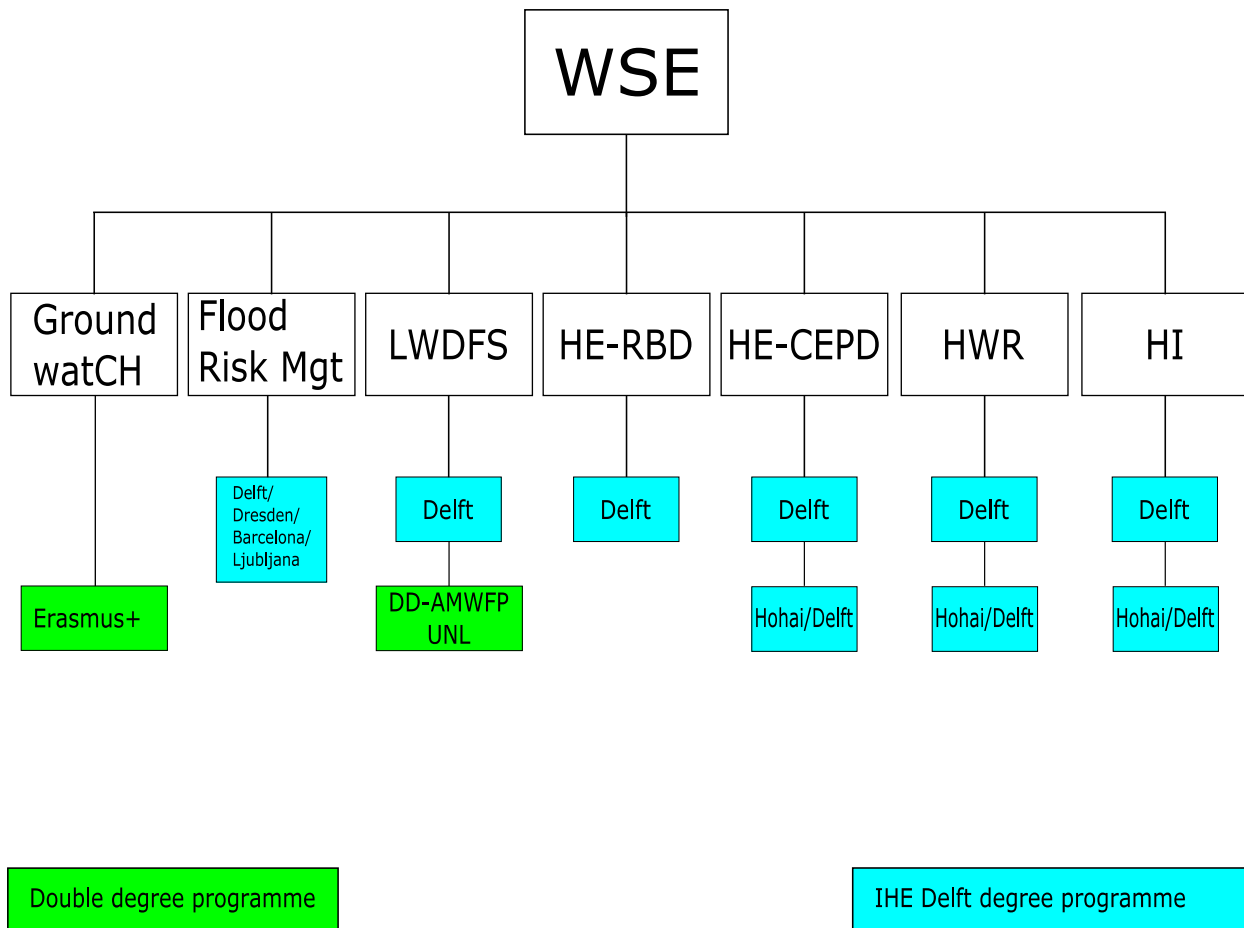


Figure 1: Water Science & Engineering Masters Programme: specializations and double degree programmes

The five Delft-based specializations have four distinct phases:

- a *foundation phase* – in which the foundation to build on is laid, fundamental principles and system understanding as well as key methodologies are introduced, students learn to understand their field of study (Water Science & Engineering) and neighbouring disciplines in a broader context;
- a *deepening phase* – when each student deepens his or her advanced knowledge and skills in their chosen specialization through an incremental learning approach;
- a *broadening phase* – when the student further learns to appreciate the inter-relationship between his or her specialization and the other specializations and programmes through (a) choosing electives offered by the other specializations and programmes, and (b) working collaboratively with his or her fellow students from those specializations and programmes on joint problems; and
- a *research phase* – when the student experiences doing his or her own independent research on a topic that may involve supervision from staff in more than one specialization. This is based on research experiences gained in the earlier parts of the curriculum (modules 1-13). Preparation for this phase begins early in the programme.

The programme has a modular structure with teaching organised into three-week blocks; sometimes two modules are scheduled in parallel for six weeks for didactical and logistical reasons. After a period of two blocks there is a week for examinations. This structure is generally reflected in the Academic Calendar.

### **Didactical concept**

Generally, IHE DELFT follows the T-shape model as a generic competency profile guiding the design of its curricula (see Uhlenbrook and de Jong, 2012, for further details). This model differentiates between cognitive competencies in a certain specialization of Water Science & Engineering (e.g. hydrology; vertical leg of the T) and other cognitive/knowledge competencies in neighbouring fields (e.g. hydraulics, aquatic ecology, land use management etc.) and functional, personal and values competencies and meta-competencies (horizontal bar of the T). It is based on the holistic model of professional competencies by Cheetham and Chivers (1996) and related studies (Oskam, 2009), and proved effective in the water sector (Kaspersma et al., 2012). For the effectiveness of graduates from the Water Science & Engineering Masters Programme as professionals, a variable mix of competencies is required that are developed throughout the curriculum and facilitated by the applied variety of didactical approaches and assessment methods (section 3.2).

The Water Science & Engineering Programme is particularly designed to stimulate active learning within a framework of incremental learning. Each module therefore comprises a balance of formal lectures, supervised and unsupervised workshops, case studies, field trips, field work, individual studies, etc. and self study by the student. That establishes a foundation for addressing scientific and practical problems in the later stages of the programme. The knowledge and abilities of students are thereby gradually developed, so that both disciplinary knowledge and insights in problem analysis and problem solving, and general academic skills can be deployed to good effect in subsequent groupwork and research thesis studies. The MSc research provides a vehicle through which integration of the programme material is achieved. The MSc thesis part is the culmination of the study, the part where independent thinking and problem-solving is further developed. Students typically take one of the following types of topics:

- a research topic from their own home environment, often in a sandwich programme, where field research and/or data collection is carried out for 2-3 months out of the six months period. Almost by definition these are quite development relevant contributions, and quality is ensured by supervision throughout the project;
- a research topic related to a (larger) research project at IHE DELFT and/or partner organisation (usually in cooperation with PhD or post-doctoral research studies). This allows a close link with the latest research in a certain field; or
- a topic as part of ongoing research or development project at a knowledge institute like Deltares, or at a consultancy or a company, where the student works in a team and gets a unique experience of working in a professional research and/or consultancy environment. Sufficient academic orientation is ensured through co-supervision of IHE DELFT supervisor/mentor throughout the project.

### **Hydrology and Water Resources**

Hydrology is the science dealing with the occurrence, transport, and properties of water on the earth, in which the principal attention is directed to continental fresh water resources. Hydrologists are involved in solving numerous problems arising in society and generally work as specialised scientists and professionals within a multidisciplinary setting. Given the broad scope of the subject matter, hydrologists often focus on specific fields but need to have a good foundation in the overall aspects of the discipline itself, as well as a basic overview of concepts and principles of related disciplines. Typical issues and themes that are therefore dealt within the hydrology programme are:

- water cycle and water balances
- hydrological and hydrogeological systems, physical and chemical processes
- relationships with vegetation, landforms, geology, land use and infrastructure
- runoff formation and anthropogenic influences

- water resources assessment, planning and development
- environmental impact assessment
- water quality assessment
- water resources management
- hydro- and geo-informatics
- modelling and simulation of rivers, catchments and groundwater systems
- effects of landuse, urbanisation
- flood risk, drought, groundwater over-exploitation analysis
- pollution vulnerability and remediation
- statistical methods for rainfall, runoff and groundwater characterisation
- methods and techniques for measurements and data collection, processing and analysis
- reporting and presentation
- independent research, literature study

#### Short outline of the curriculum

Modules 1 and 2 are combined for all specializations in the WSE programme. The initial specialization modules 3 and 4 introduce the major concepts and principles of hydrology and hydrogeology while moving towards an advanced level of understanding. The important relations and underlying concepts of earth sciences used in hydrology, and the relation of hydrology with the atmosphere and climate are also outlined. Modules 5 and onward deal with specialist issues, including methodologies relating to water quality, data collection, processing and analysis methods, modelling tools and multidisciplinary application aspects in water resources management. Students can, according to their preference, focus on either surface water hydrology (module 7A), or groundwater hydrology (module 7B). During the summer, the fieldwork provides the opportunity for real-terrain experience. The fieldtrips expose students to a wide range of applications and problems involving hydrology. The group work is aimed at making a comprehensive hydrological assessment using a variety of data from real situations within a team framework. With permission of the professors involved, students can also choose the corresponding module 8, 10 or 11 from other WSE specializations. Module 14 deals with research methodology and approach, and offers the students to choose a selected topic on contemporary issues in current research related to hydrology, which are to be reviewed in an in-depth study. Finally, students will prepare a thesis proposal and carry out their thesis research under the guidance of an individual supervisor.

#### **Hydroinformatics – Modelling and Information Systems**

Hydroinformatics uses simulation modelling and information and communication technology to help in solving problems of hydraulics, hydrology and environmental engineering for better management of water-based systems. It provides the computer-based decision-support systems that now enter increasingly into the offices of engineers, water authorities and government agencies. The Hydroinformatics course aims at enriching traditional engineering practice by introducing innovative approaches in order to open up for the participants much broader perspectives.

To achieve these objectives the Hydroinformatics specialization provides:

- Academic education in fundamental Hydroinformatics. The basic hydraulic, hydrologic, water quality and environmental processes and the fundamentals of computer sciences and software engineering. The ways of combining both fields for design and development of software tools.
- Education for understanding the two modelling paradigms of 'physically-based (process) modelling' and 'data-driven modelling'. Training in analysis and modelling techniques from both paradigms, including their complementary applications.

- Education for understanding systems analysis, and training in use of optimisation and decision support tools and techniques.
- Hands-on training in using software tools in several application areas: river and flood management, urban water systems, coastal systems, environmental systems, groundwater and catchments hydrology and water quality.
- Education for understanding the integrative nature of Hydroinformatics and its broader role in society.

Overview of the study programme

The study programme is structured in such a way that several different and interrelated themes are being covered through the introduction, and the extensive use of various modelling, information technology, and decision support tools. (Figure 1):

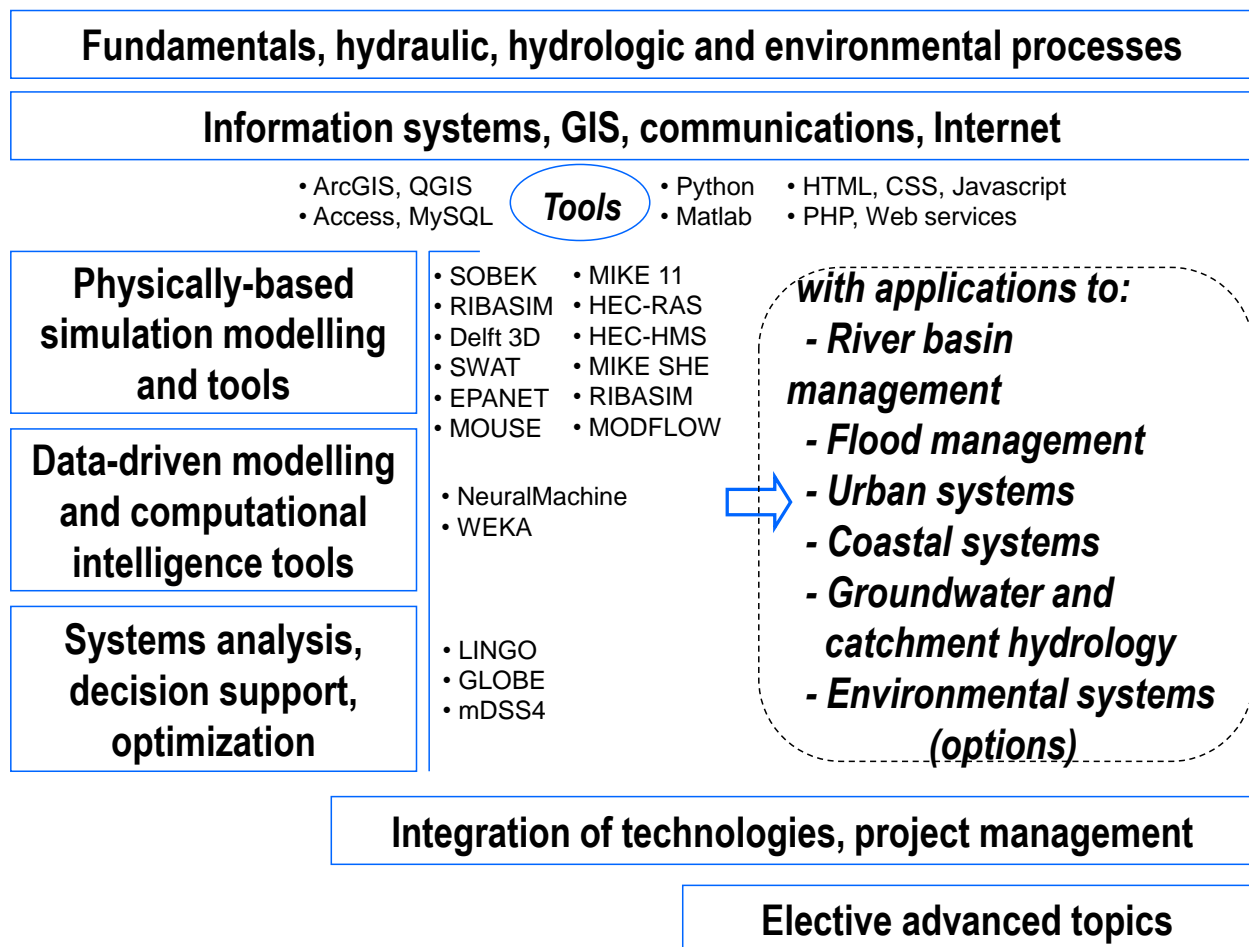


Figure 2: The general thematic structure of the Hydroinformatics specialization

The *Fundamentals, hydraulic, hydrologic and environmental processes* theme groups all the subjects that should be mastered in order to be able to fully assimilate and benefit from the subjects given in the other blocks. A strong emphasis is put on the basic notions of hydraulic and hydrologic processes, water quality and environmental processes, as well as appropriate mathematical techniques and computer manipulation.

The *Information systems, GIS, communications and Internet* theme groups the fundamentals of computer science and software engineering. It includes database and data analysis systems, Geographical Information Systems (such as GIS), and technologies for Internet based communications.

The *Physically-based simulation modelling* theme comprises subjects concerned with the modelling approaches that are based on the description of the various physical water-related processes. It also includes a reasonable understanding of the numerical techniques used in most commercially available models, and the precautions that should be taken in order to ensure good quality modelling solutions.

The *Data-driven modelling and computational intelligence* theme groups all the subjects related to modelling techniques that do not rely on a physical description of the processes involved in the system under study. This includes in particular artificial neural networks, genetic algorithms as well as more classical statistical techniques.

The *Systems analysis, decision support and optimisation* theme combines subjects in basic optimisation techniques, with those on understanding the nature and role of systems analysis in water resources. The concepts of control- and decision support systems are introduced with applications to different kinds of problems in water resources planning and management.

The *Applications* theme includes subjects in which different modelling techniques, and Information and Communication Technologies (ICT) are being applied in a variety of water related areas such as: river basin and flood management, coastal systems, urban systems, groundwater and catchment hydrology and applications dealing with water quality and the aquatic environment. Most of the subjects from this theme are common to all participants.

The participants need to choose however between specialization modules:

- **River flood modelling and risk management**
- **Hydroinformatics for urban systems**
- **Hydroinformatics for environmental applications**

The *Integration subjects* theme includes subjects where the participants are expected to combine and synthesise the notions acquired in all the other themes. This includes in particular the groupwork that plays a very important role in the Hydroinformatics programme.

The programme also includes several elective subjects on *special topics*, which can be chosen by the participants depending on their particular interest.

### **Hydraulic Engineering and River Basin Development**

The Hydraulic Engineering and River Basin Development specialization educates engineers involved in design and implementation of projects for sustainable use of river systems and their resources (fresh water, floodplain space and sediments) and further develops the scientific and engineering knowledge in this field of interest through independent research. Nowadays, fresh water resources and floodplain space are limited and therefore of significant value. The pressing need for food, energy, flood protection and domestic and industrial water supply require an efficient use and management of water resources. Traditional river engineering has had serious consequences for riverine ecosystems and land-use, causing damage to flora and fauna and sometimes exacerbating floods and droughts. Based on the sound understanding of physical aspects of river behaviour, planning, design, construction, operation and maintenance, water resources are critically assessed for implementing sustainable water-related infrastructure, tools and management strategies in river basins.

### **Aims and learning objectives**

The aim of the programme is to convey knowledge, concepts, insights and skills that are required for students to function as independent professionals within the field of hydraulic engineering and river basin development and to prepare candidates for further study as part of a research career. This aim has been

developed into a set of objectives, which have been transformed to final qualifications that are formulated within a more generic context for the entire Water Sciences and Engineering programme.

The development and management of water resources in a river basin requires a broad approach in which full integration takes place over the entire spectrum of socio-economic and environmental interests. The challenge for water users, planners, policy and decision-makers and engineers is to contribute effectively to meet social and economic goals, maintaining and managing water resources on a sustainable basis and avoiding the physical and social degradation of the environment.

The success of these activities depends on the ability to design river structures for different purposes and on the correct understanding of dynamic river processes. Emphasis will be laid on different scales of water projects (catchments, river stretch and floodplains), river defence works and river management and their environmental compatibility and sustainability. The student has to acquire sufficient knowledge to integrate different relevant interest in hydraulic engineering projects as well as to optimise their multiple uses, operation and maintenance.

The focus of the specialization is on the following main fields of interest:

- *River Dynamics* , this encompasses the study of the way in which water flows in rivers and the consequent transport of sediment and morphological change. The impact of measures to enhance the environment and mitigate damage is considered throughout. In an engineering context the role and design of river intakes and river training works are considered.
- *River Structures* , which is mainly directed to the design of hydraulic structures, by defining sites and designs of reservoirs, dams, intakes, hydropower plants, conveyance systems, etc. Emphasis is given not only to technical aspects but also, in a broader context to managerial, social and environmental questions associated with these engineering works.
- *Flood Risk Management* , which is mainly concerned with the engineering issues, planning, policies and structural/non-structural measures and approaches to cope with floods and mitigate their impacts and consequences.
- *Modelling*, all the above make use of conceptual models which are often computer-based. Modelling is taught both throughout the course and in specific modules. The aim is to allow students to develop as intelligent and discerning users of models in river basin management.

### **Hydraulic Engineering – Coastal Engineering and Port Development**

The management of resources in coastal areas of the world and the hydraulic engineering works required for their development, operation and maintenance have gained an increasing importance and complexity with time. They often require -in addition to well-proven experiences and technologies adapted to local conditions- innovative solutions. Based on considerable experience accumulated in The Netherlands and under inclusion of modern approaches, IHE DELFT offers a well-balanced and updated curriculum in the areas of Hydraulic Engineering - Coastal Engineering and Port Development.

### **Background**

Several large hydraulic engineering projects have made the Netherlands famous all over the world. Examples are the enclosing and partially reclaiming of the former Zuyder Zee (1927- 1968), the large multi-purpose project for damming the delta of the rivers Rhine and Meuse, known as the Delta Plan (1958-1986) with the construction of the storm surge barrier in the Eastern Scheldt estuary; a masterpiece of today's hydraulic engineering both servicing the protection against flooding and the environment. The port of Rotterdam is one of the largest ports in the world and is still expanding today. Europort, the outer port of Rotterdam, has been built on newly reclaimed land from the sea, while a new extension by reclamation is under construction. A storm flood barrier in the New Waterway, the entrance to Rotterdam, protects the banks of the tidal branches of the Rhine River. Coastal Zone management and the conservation of the natural sea defences in The Netherlands are political foci and demand much

attention. All of these hydraulic engineering works, as well as a wealth of overseas experience by various Dutch firms well known for their expertise in hydraulic engineering, have created a concentration of know-how in The Netherlands. The main objective of this course is to transfer this knowledge available in The Netherlands and to demonstrate the applicability of the Dutch experience to solve the hydraulic engineering problems of, in particular, developing countries.

### **Organisation**

In the modules of the specialization Coastal Engineering and Port Development attention is paid to basic topics such as the design of coastal and port structures (dikes, closure dams, breakwaters, mooring facilities). The physical phenomena of the sea and the coast, in particular coastal morphology, are emphasised. The study of coastal defence works forms an important element of the study package. Major exercises are conducted on coastline management and coastal zone management. The design of a coastal structure is worked out in detail.

The Port Development modules concentrate on the planning, design and construction of ports and harbours. A seminar on port management forms part of the programme. Also special attention is paid to foundations of port structures. The design of the layout of a new port is a core element of the programme. Furthermore the execution of coastal and port works and environmental aspects are discussed.

### **Aim**

The overall aim of the Coastal Engineering and Port Development programme is to train engineers such that after the programme they are able to solve practical technical problems in coastal and port engineering. These problems are of relevance for the *future* needs of their countries. Given the need for practical professionals (like designers at a high academic level), this programme is practically oriented.

### **Approach**

In general there are three levels of problems:

- I: those that have to be solved by the engineer (or his staff) fully independently;
- II: those for which the help of an outside advice (like a consulting engineer) is required;
- III: those for which the help of a specialist is required.

Type I problems are the every-day problems of the engineer, for which problems tools are available (like handbooks and simple PC programs). The engineer should be able to define the problem, analyse the problem, solve the problem, completely without any help from other departments, consultants, etc.

Type II problems are the problems at a larger scale, or for which special designs have to be made. These designs or studies are usually made by outside consultants. For these type of problems, the engineer should be able to define the problem, define the terms of reference for a consultant, supervise the study and assess the final report.

Type III problems are the very unusual problems, which cannot be solved by an average consultant. Only a few specialised organisations in the world can do the job. The engineer should know that these advanced techniques exist, which specialised organisations can solve the problem, and how to set-up a supervising structure to supervise this work by a more specialised expert.

Alumni of IHE DELFT master's course are engineers, who can address these three types of problems as outlined above. It should be mentioned that the course is *practically oriented*.

## **Land and Water Development for Food Security**

### **Academic domain and normative activities**

Central to the educational and research domain of the Land and Water Development for Food Security (LWDFS) specialisation of the Master Programme in Water Science and Engineering (WSE) is the

conceptual and practical understanding for sustainable development and management of irrigation and drainage systems and protection of flood prone areas. Developing a multidisciplinary and comprehensive perspective including various institutional, socio-economic, infrastructural and environmental issues is key to addressing the current and foreseen issues in the field of land and water development and management. In line with the above premise, the LWDFS specialisation has defined two major normative domains:

- *Irrigation, drainage and flood protection*: measures to improve water management, to enhance crop production and water use efficiency;
- *Interaction land use, water management and flood protection in flood prone areas: optimization of* measures related to man induced changes in land use and climate changes.

### **Aim**

In keeping with the academic domain and normative activities, the overall aim of the LWDFS Programme is to generate new and advance current knowledge and skills with regard to development, management and adaptation of land and water resources for different types of use, with a focus on land use for agriculture. The guiding principle is the development of irrigation, drainage and flood protection infrastructure to meet an agreed level of service for an optimal balance between costs and benefits.

### **Approach**

Given the importance of both technical and non-technical aspects in land and water development and management, the LWDFS Programme courses and research works integrate:

- technology and management capacity;
- technology and society, economy and environment;
- agricultural and civil engineering aspects of development and management.

### **Content and description**

The LWDFS Specialisation consists of a total of 15 modules - most modules have a duration of three weeks. These are categorized as:

- three common WSE modules (modules 1, 2 and 13);
- five specialisation specific modules (modules 3 to 7);
- three elective WSE modules (modules 8, 10 and 11);
- three Institute-wide modules (modules 12, 14 and 15).

Module 9 consists of two weeks of international field trip, and this might be undertaken together with one or more of the other WSE specialisations; and a one-week field work, which is specialisation specific.

### **Specialisation modules**

The specialisation modules - modules 3 to 7 - deal with the following subjects:

**Module 3** *Introduction to Land and Water Development*: conceptualizes and analyses the demand and supply of land and water resources on a global and regional scale to meet the present and future food requirements; discusses basic functions, elements and needs of and for irrigation and drainage systems and illustrates layout and design of primary and secondary irrigation and drainage networks, including canals, drains, roads and farms.

**Module 4** *Design Aspects of Irrigation and Drainage*: introduces applied hydraulics of irrigation and drainage systems, soil-water-crop yield relationships, agronomy, and water and drainage requirements, leading to the design of an irrigation and drainage network at a tertiary unit (on-farm) level.

**Module 5** *Tertiary Unit Design and Hydraulics*: gives participants a comprehensive understanding of applied hydraulics in irrigation and drainage systems, water-crop yield relationships, and the ability to



select appropriate irrigation and drainage methods and to estimate crop water requirements and devise complex irrigation schedules matching water demand and supply.

**Module 6** *Socio-economic and Environmental Aspects of LWD*: covers economic, financial, and sociological aspects of irrigation and drainage, assessment of environmental impacts of land and water development projects, and drainage management for salt control.

**Module 7** *Conveyance and Irrigation Structures*: Includes unsteady flow equations, hydrodynamic models, DUFLOW, wave propagation, and the characteristics and hydraulic design of irrigation and flow control structures.

**Module 9** *Field work part (1 week)*: this practical course focuses on various types of flow measuring equipment, methods and techniques, pumps and pipes, field canals, irrigation methods and soil characteristics. *International field trip part (2 weeks)*: familiarises the participants with various layout, design and management of irrigation, drainage and other hydraulic systems in different parts of Europe or the USA.

These specialisation modules are preceded with two WSE common modules that acquaint the participants with broad practices and principles for managing and developing land and water resources. These common modules also introduce some important land and water analysis techniques such as GIS and remote sensing.

### **Elective WSE modules**

To give an added depth and breadth to certain specific technical, management and socioeconomic aspects of land and water development and management, three elective modules are offered:

**Module 8** *Management of Irrigation and Drainage Systems*: demonstrates how to formulate objectives for irrigation and drainage, define water delivery systems, apply (inter)national water law, and develop an irrigation management plan considering conflictive water uses, water rights frameworks, cost recovery, and monitoring and evaluation for performance assessment.

**Module 10** *Innovative Water Systems for Agriculture*: covers groundwater flows and use for agriculture, Darcy equations, precision irrigation such as drips and sprinklers, solar-powered irrigation, management of floods for productive use, and pumps and lifting devices.

**Module 11** *Remote Sensing, GIS, and Modelling for Agricultural Water Use*: deals with irrigation and remote sensing, water system modelling and GIS, lowlands and flood prone areas including polder systems, land subsidence, and sediment in canals.

In module 13 (common WSE), the participants engage in the group work and identify alternative solutions to various land and water development related issues in an integrated manner from the systems perspective in close collaboration with the other WSE specialisation participants.

### **Institute-wide modules**

In Module 12 the participant can choose a summer course from different specialisations (institute-wide). After successful completion of the above common, specialisation specific and elective modules, the participants undertake individual MSc thesis research for 6 months during modules 14 (preparation and proposal) and 15 (field work and analysis).

The MSc thesis research (modules 14 and 15) is driven by the following two key objectives:

- To advance the horizon of science and current knowledge and expertise in various technical, socio-economical, environmental and institutional aspects of land and water development and management;
- To investigate pragmatic solutions to challenges related to water scarcity, food insecurity, flood risks and fragility of the environment, particularly in the least developed and emerging countries.

Prior to embarking on their field work (module 15), the participants follow Module 14 in which they become acquainted with the main drivers and incumbent research priorities as identified, but not limited to, by the WSE Master Programme in general and the LWDFS specialisation in particular. They also acquire valuable skills in problem description, formulating scientific research questions, articulating related research methodologies, literature review, data collection and analyses using pertinent techniques including modelling and presentation of the research findings.

The MSc thesis topics and contents are aligned with the following main research lines under the LWDFS Specialisation:

- **Hydraulic structures and hydraulic systems:**

- o *Hydraulic performance evaluation and modernization of irrigation and drainage systems:* Research focused on various technical approaches and methods for analysing the performance of irrigation and drainage systems and optimising crop, land and water productivities as well as the development of improvised approaches and techniques for modernising irrigation and drainage systems.

- o *Sediment transport in irrigation canals.* Research focused on the analysis of sediment movement in irrigation canals under different conditions and operation rules.

- o *Lessons to learn from historical approach:* As the importance of projects aiming at rehabilitation and/or transformation of existing water infrastructure is increasing, knowing, understanding and learning lessons from the history of such systems and their management are prerequisites for quality design and planning.

- **Environmental impacts of hydraulic works:**

- o *Water saving in irrigation.* Research is focused on improvements in water use in irrigation in light of prevention of environmental degradation.

- o *Interaction between irrigation, drainage and sustainable development.* Research on sustainable exploitation of water resources (surface water and groundwater).

- **Institutional and socio-economic aspects of system management:**

- o *Performance analysis and accountability mechanisms.* Research on institutional and socio-economic aspects of irrigation and drainage system management.

- o *Global future irrigation and drainage needs.* Research on the needs for and potentials of irrigation and drainage in light of food production, sustainable rural development and the development of flood prone areas under the influence of various drivers for global change.

- **Integrated lowland development and management:**

- o *Interaction between land use and flood management.* Research on interaction between land use and flood management in flood prone areas. Economic optimisation in the design, operation and maintenance of water management and flood protection schemes.

- o *Land and water management in tidal lowlands.* Long-lasting research cooperation with various Dutch and Indonesian institutions with a focus on integrated development of tidal lowlands in Indonesia.

### **Joint International Masters with Specializations (JIMS) in WSE: programme description and organisation**

The specializations of Hydroinformatics, Hydraulic Engineering – Coastal engineering and port development, and Hydrology and water resources, are also offered jointly by two core partners: IHE-Delft and Hohai University (HU) in Nanjing, China. This variant of these specializations has the following description:

- JIMS has the same number of ECTS as the regular Delft-based specializations (106 ECTS).

- JIMS has the same study curriculum and module descriptions as the regular Delft-based specializations.
- The framework of the programme, the organisation of the programme and the examination procedures, as described in the General part of this Handbook, also apply to JIMS.
- In the JIMS variant the taught part of the specializations is divided in two blocks:  
Block 1, consisting of the first two modules: Introduction Water Science and Engineering, Hydrology and Hydraulics It consists of 10 ECTS. This block is implemented and delivered by Hohai University in Nanjing, China.  
Block 2, consisting of all remaining taught modules of the respective specializations (modules 3-14, consisting of 60 ECTS). This block is implemented at IHE-Delft and is identical to the regular Delft-based specializations.

*In the academic year 2017-2019, due to organisational matters, Block 1 of JIMS will also be delivered at IHE-Delft.*

### **Erasmus Mundus + Programme GroundwatCH ([www.groundwatermaster.eu](http://www.groundwatermaster.eu))**

The GroundwatCH programme is organized around the following thematic areas:

- General Hydrogeology;
- Groundwater Data Collection, Interpretation and Modelling;
- Climate Processes and Modelling;
- Integrated River Basin and Water Resource Management;
- Groundwater and Environmental Impacts;
- Groundwater, Society and Policies; and
- Groundwater, Climate and Global Change Impacts and Adaptation.

The students will start the academic year in September at Instituto Superior Técnico in Lisbon, where during the first semester they receive courses addressing core competences in Thematic Areas 1-6, totalling 30 ECTS.

In March of the following year, the students will move to IHE Delft, where they acquire 30 ECTS in the second semester, taking advanced courses within Thematic Areas 2 and 4-7.

Following conclusion of the second semester and the summer break, the students then move to the Technical University of Dresden, where they study during the third semester, obtaining advanced training (30 ECTS) in Thematic Areas 3 and 7, through compulsory teaching modules in climate modelling and groundwater-soil-land-climate feedback mechanisms, as well as a study project. Here the students will also have a number of optional modules from which they can choose two, specialising in a certain direction, depending on their thesis subject.

In March of the second academic year the students will start their thesis study (30 ECTS). Students can conduct dissertation research at any private or public institution, under promotorship of a lecturer of a consortium partner institution. Lecturers of both the consortium and associated partner institutions can act as co-promoters.

Balance for MSc dissertation projects amongst partner institutions will be achieved by means of promoting the establishment of joint projects between different members of the consortium.

### **Flood Risk Management ([www.floodriskmaster.org](http://www.floodriskmaster.org))**

#### Semester 1

TU Dresden, Germany

The programme starts with the first semester at TUD, where students take either non-engineering or engineering subjects to complement their background and build a solid foundation for everyone. A fieldtrip to flood-prone areas is organised.

#### Semester 2

IHE Delft, Netherlands

At IHE Delft the students join IHE's Hydroinformatics programme, focussing on different types of modelling. On real case studies students learn how to apply and integrate various types of modelling and decision support systems. An international fieldtrip is offered as well.

#### Semester 3

UPC, Spain and University of Ljubljana, Slovenia

During the third semester the students take more specialised modules, such as Debris Flow and Coastal Flooding (including fieldtrips). The last part of the third semester is conducted at University of Ljubljana where the students study spatial planning and socio-economic and institutional frameworks for flood risk management.

#### Semester 4

Research thesis

During the thesis phase the students, while remaining associated with one partner, may occasionally carry out the research together with an industrial partner (which may be an Associated Member or not).

### **DD-AMWFP (Double Degree Programme on Advanced on Advanced Water Management for Food Production)**

The first 9 modules of the programme are identical to the LWDFS programme. Then, until the end of year 1, the student follows coursework at University of Nebraska-Lincoln (UNL), aimed to deepen knowledge on plant-water relations, remote sensing, and advanced irrigation and drainage systems followed by a final exam week and Christmas Holidays. From then on the student will write a thesis, and, at the same time, will do more coursework on the human dimensions of Global Water and Food.

## Study Guide

# General information

Academic programme 2017 - 2019

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# 1. IHE Delft

## 1.1 Introduction

IHE Delft continues the work that was started in 1957 when IHE first offered a postgraduate diploma course in hydraulic engineering to practicing professionals from developing countries. Over the years, IHE has developed into an international education institute providing a host of postgraduate courses and tailor-made training programmes in the fields of water, environment and infrastructure; conducting applied research, implementing institutional capacity building and human resources development programmes, participating in policy development, and offering advisory services worldwide.

The Institute has gradually expanded its academic base to include disciplines such as sociology, economics, and environmental and management sciences. The range of activities has broadened accordingly, from identifying solutions to engineering problems to designing holistic and integrated approaches in the development and management of water and environmental resources, and urban infrastructure systems. The services of the Institute now also include integrated water resources management, effective service delivery and institutional reform, all of which aim to enhance full stakeholder involvement, equity, accountability and efficiency in water sector development and management.

The mission of the Institute is to contribute to the education and training of professionals and to build the capacity of sector organisations, knowledge centres and other institutions active in the fields of water, the environment and infrastructure, in developing countries and countries in transition.

IHE is located in Delft, an internationally renowned centre of excellence in civil engineering and in water related sciences. The Delft University of Technology, the laboratories of Deltares, and The Netherlands Organisation for Applied Scientific Research are situated nearby. IHE Delft maintains intensive relations with national and international institutions to ensure a continuous exchange of knowledge and experience.

## 1.2 MSc Degree Programmes

The backbone of the Institute are the postgraduate programmes in the fields of:

- Environmental Science
- Urban Water and Sanitation
- Water Management and Governance
- Water Science and Engineering

Each year, these programmes are attended by hundreds of engineers, chemists, biologists, earth scientists, and other professionals from all over the world. The graduates are awarded a Master of Science degree. The programmes are subject to accreditation under Dutch law.

## 1.3 Research and PhD Programmes

IHE Delft carries out scientific research, often in co-operation with universities and research institutes in developing countries. A number of positions are available for PhD research.

The PhD programme has a nominal duration of 4 years and can be carried out either in Delft or in a sandwich construction. The PhD degrees are awarded by IHE Delft together with a Dutch university. Candidates should preferably hold an IHE Delft MSc degree, but an equivalent degree from another reputed university may also be acceptable.

## 1.4 Organisation

The Rectorate of the Institute consists of a Rector, a vice rector Academic Affairs and a Business Director.

There are three academic departments:

- Water Science and Engineering
- Environmental Engineering and Water Technology
- Integrated Water Systems and Governance

These departments have one or more chair groups in major fields, led by a professor, who is assisted by academic staff and research fellows.

Process management support units and an education bureau provide administrative support.

Besides the academic staff of IHE Delft, education is provided by selected guest lecturers, who are experts employed by universities, research institutes, government agencies, consulting firms, international organisations, etc. in the Netherlands and abroad.



## 2 Programme framework

### 2.1 Introduction

The Institute offers the following Master of Science degree programmes:

- the master programme in Environmental Science;
- the master programme in Urban Water and Sanitation;
- the master programme in Water Management and Governance; and
- the master programme in Water Science and Engineering.

Each programme has several distinct specialisations, in which students follow a curriculum best suited to their preference. Some specialisations are offered jointly with one or more partner institutes in the world. Details of each programme and its (joint) specialisations are given in the programme descriptions of the study guide.

### 2.2 Academic Regulations

The *Examination Regulations* describe the precise details of how examinations are assessed and marked, the procedures and rules for re-examinations, procedures for appeal, and which results are required for awarding the Master of Science degree.

Special examination regulations are drafted for the joint specialisations.

Students are strongly advised to familiarise themselves with these procedures at an early stage during their study.

### 2.3 Structure of the Programmes

All Delft based curricula follow a modular structure.

The Delft-based curricula of the MSc Programmes have a duration of 18 months, and consist of 106 ECTS credit points divided between a Taught Part (61 ECTS credit points) and a Thesis Research Part (45 ECTS credit points).

The Taught Part consists of 13 modules.

A module consists of a teaching period (usually 3 weeks) and an exam period (within the exam week following each two consecutive modules). Modules may be shared between or among specializations and/or programmes.

The Thesis Research Part consists of two modules on research methodology and MSc proposal drafting and defence, followed by a period of six months of individual research and writing of the thesis. The MSc thesis is defended publicly at the end.

The curricula of the joint specialisations consist of modules offered at IHE Delft and courses at the partner institutes.

### 2.4 Final Qualifications

Each programme specialisation has a set of final qualifications that state the knowledge, insight and skills achieved by students who successfully complete the programme. A distinction is made between discipline-specific qualifications, which are required by the field of study, and general academic skills, which are expected from university education graduates.

Similarly, each module of the curriculum has a set of learning objectives, which detail the specific outcomes if the student completes that part of the programme. The individual topics in the modules usually aim to achieve a further detailed subset of the module learning objectives.

## 2.5 Curriculum Information

All components of the curriculum are described in the module plans of the study guide providing the following information:

- the name and code of the module;
- the learning objectives;
- the pre-requisite knowledge or skills;
- the study load hours and credit points;
- the lecture, exercise and examination contact hours;
- the nature and weights of the examination parts;
- the responsible lecturers/examiners;
- a concise description of the contents and working methods; and
- the required and recommended literature, and other materials.

## 2.6 Teaching Methods

All education activities are conducted using a combination of lectures, exercises, assignments and assessments.

Lectures serve one or more of the following functions:

- to impart information;
- to introduce and explore a topic;
- to build-up complex structures step-by-step;
- to clarify and illustrate concepts and ideas detailed in the literature or lecture notes; and
- to provide a framework for further independent study and reading.

An exercise takes one of the following forms:

- a design or practical exercise;
- a computer or other workshop;
- a laboratory session;
- a fieldwork or fieldtrip; and
- a group work discussion.

Assignments are carried out independently by the students and consist of all required activity to:

- study or practice the lecture material;
- prepare a report, thesis or presentation;
- work out the results of an exercise;
- conduct an experiment or test;
- prepare for an examination; and
- conduct a research or other study.

## 2.7 Assessments

Assessments serve to test if and how far students have achieved the learning objectives of a module, and ultimately those of the programme itself. The assessment for a module may consist of multiple parts. For example, a combination of a written or oral test and one or more assignments to be handed in separately. Examination work can also be produced by (small) groups of students working together on an assignment, e.g. the group work report.

Assessment of examination material is carried out by appropriate examiners, which are usually the involved lecturers. Students who successfully complete a module will be granted the credit points for that module. Fieldtrips may require active participation instead of an examination in order to receive the credit points.

For each assessment, students are informed about the results via e-mail. When all assessments have been passed, the student has successfully completed the so-called programme examination and will be awarded the degree.

## 2.8 Study Load

All scheduled education activity taking place in the presence of a lecturer or an assistant is designated as contact time. All other time spent by students in relation to the study programme is designated as independent study time. The study load for (a part of) a programme is the cumulative contact time and independent study time that is nominally required to successfully complete that (part of the) programme. Study load is expressed in whole ECTS credit points, where one ECTS credit point is equivalent to 28 working hours.

The study load credits for a curricular activity indicate the notional time spent by an average learner to achieve the required outcomes for that activity, as specified by the learning objectives. The nominal time expenditure for a 5 ECTS credit points module is therefore 140 hours.

Where study load involves scheduled class-based activity, one lecture period is taken equal to two hours of contact time.

## 2.9 Planning and Scheduling

Education activities taking place inside the Institute are, in principle, scheduled into 'periods' of two hours each, for which the following times are available:

Period 1 08:45 – 09:30 and 09:45 – 10:30

Period 2 10:45 – 11:30 and 11:45 – 12:30

Period 3 13:45 – 14:30 and 14:45 – 15:30

Period 4 15:45 – 16:30 and 16:45 – 17:30

Throughout the academic year, the student will receive the following information and materials:

- schedules of the education activities;
- required lecture notes, textbooks and other course-related material;
- announcements of assessment planning details; and
- statements on assessment results and study progress.

## 2.10 Participation in coursework and lunch seminars

Active participation and attendance by students is required for all curricular activities on the schedule. Special attention is required for lunch seminars. During the academic programme lunch seminars are organised focussing on a specific topic. Participants are required to attend these seminars as well. Students have to inform their programme coordinator as early as possible when they are not able to attend a scheduled programme activity.

## 2.11 Evaluation of the Programme by Students

As part of the quality assurance procedures of the Institute the programmes are routinely evaluated in order to obtain feedback from the students regarding the quality of the content and the performance of the lecturers. The evaluations are based on a module questionnaire, which the students complete in separate class sessions. The questionnaire asks the students to provide a rating for achievement of the learning objectives, the study load feasibility, the contents of the subject matter, the balance between the various working and examination methods, the quality of the lecture materials, and the presentation by the lecturers. Furthermore, additional written comments and an overall rating for the module may be provided.

The module evaluations are carried after the examination, but before the results have been announced. Students can also request to address specific programme related issues in a group or individual discussion with the involved coordinator or lecturers.

Feedback on the programmes from the students is much appreciated. The Institute uses the results of the evaluations to improve the academic programmes where necessary, in order to maintain high standards of education.

## 3 Regulations

### 3.1 Examination regulations

See for the Examination regulations the separate part of the study guide.

### 3.2 Library regulations

Fair use of on-line information resources at the IHE Delft Library.

The IHE Delft Library Services provides access to a large number of on-line information resources and databases. Access to these resources is provided to all computer users within the premises at Westvest and through remote authentication via the IHE Delft portal. By using these on-line resources you agree with the following conditions:

- 1) Systematic downloading of electronic journals articles using manual means is permitted only within reasonable amounts; no more than 50 downloads per user within 24 hours.
  - 2) Programmatic downloading / 'web crawling' is not allowed. In addition to systematic downloading of files manually, the use of a spider (web crawler), the intention of which is to programmatically download data within a specific website, is prohibited.
  - 3) Copyright/reproduction. It is prohibited to reproduce entire or parts of publications in your own publication without the consent of the publisher. You are obliged to provide a correct source reference of all of the material at all times.
  - 4) Selling and providing material to third parties is strictly forbidden. The re-sale of material purchased subject to license to third parties is prohibited; this applies both within and outside of the Institute for which the materials have been purchased.
  - 5) Permanent archiving. Large-scale archiving is not permitted on the local servers or your hostel personal computer nor is the continued use of these servers as an archive, in collaboration with third parties or otherwise. The temporary storage of archive material for personal use is permitted for a period not longer than 120 days.
  - 6) Making changes to an original work. Infringing upon an original work by merging various original texts into a document or by amending original texts is prohibited. Processing materials in such a way is an infringement upon the copyright that is held by the publisher or the author him/herself.
- Infringement of one or all of the above mentioned stipulations will be considered as academic misconduct and will result in disciplinary measures, which will be proportionate to the seriousness of the infraction. The Rector will decide upon the disciplinary measures which will be taken. These measures may include temporary or permanent suspension from attending class.

### 3.3 Code of conduct

#### THE RECTORATE OF IHE Delft

- In consideration of the need for rules and regulations concerning the safety and the proper use of the buildings, grounds and facilities of IHE Delft by students and visitors;
- In accordance with article 7.57h and article 9.2, first paragraph, of the Higher Education and Scientific Research Act of the Netherlands;
- Having heard the Student Association Board;

RESOLVES to establish the following Regulations:

#### Article 1 Definitions

1.1 WHW	Higher Education and Scientific Research Act of the Netherlands (Staatsblad Bulletin of Acts and Decrees 1992, 593);
1.2 the Rector:	the rector of IHE Delft
1.3 the Rectorate:	the rector, the deputy rector Academic affairs and the business director
1.4 Central services department	the central services department of IHE Delft
1.5 Facilities	the institute buildings, the interior and equipment as well as rented office and accommodation facilities
1.6 Buildings	the buildings of IHE Delft, located at Westvest, Delft
1.7 Student	anyone who is enrolled at IHE Delft for the purpose of education provided by IHE Delft and who uses the educational and examination facilities of IHE Delft for this purpose;
1.8 Visitor	anyone who is not a student nor is employed by IHE-Delft as referred to in article 1.1 of the Collective Labour Agreement (CAO) for Dutch Universities.

#### Article 2 Compliance requirement for rules, guidelines and instructions

2.1 Any student or visitor making use of the grounds, buildings or facilities of IHE Delft is required to comply with all rules, instructions and/or directions issued by the Rectorate and delegated staff with regard to maintaining order and proper social conventions of the host country within the buildings and on the grounds. According to the in the institutes code of undesirable behaviour the following is considered to be undesirable behaviour: sexual harassment, aggression, or violence, both verbal and non-verbal towards course participants, staff, visitors or contracted staff. Furthermore all participants, staff, visitors and contracted staff are to observe and comply with the rules and regulations with regard to appropriate and legitimate use of the facilities of IHE Delft scrupulously and without delay, and is required to deport him or herself such that:

- a. he or she does not cause direct or indirect damage to IHE Delft or to other persons who are present on the grounds or in the buildings of IHE Delft or who make use of the facilities of IHE Delft, nor that he or she causes nuisance or annoyance;
- b. he or she does not infringe on the rights of IHE Delft or of other persons who are present on the grounds or in the buildings of IHE Delft or who make use of the facilities of IHE Delft;
- c. he or she does not act contrary to statutory obligations;
- d. he or she does not act contrary to appropriate and proper social conventions with regard to people or property.

2.2 It is prohibited to wear clothing that covers the face or to wear other clothing and/or accessories that severely interfere with communication between teaching staff and students or between students themselves or between members of the teaching staff. When sitting an examination it is prohibited to wear clothing that covers the face or to wear other clothing and/or accessories that severely limit the ability to establish the identity of the person in question.

2.3 The Head of the Central Services department may, on behalf of the Rectorate, issue instructions and directions for the purpose of ensuring the smooth and proper use and functioning of buildings and grounds of IHE Delft entrusted to him/her.

#### Article 3 Disciplinary Measures

The Rectorate may take the following measures against any student or visitor who fails to comply with the contents of these Regulations, with due observance of the procedure described in these Regulations:

- a. excluding the student or visitor from the buildings and grounds of IHE Delft or from one or more parts of IHE Delft, with the provision that a student may only be excluded from buildings or grounds in whole or in part for a period not to exceed one year;
- b. excluding the student or visitor from the use of the facilities of IHE Delft;
- c. fining the student if such fine has been agreed on or follows from the statute;
- d. issuing a written reprimand;
- e. retribution for damages to properties and or facilities.

#### Article 4 Exclusion Order by the Rectorate

4.1 The Rectorate may immediately issue an exclusion order for the buildings or grounds, or for parts of those buildings or grounds, to a student or visitor who commits an infringement on these Regulations or the rules referred to in article 2, or it may issue an exclusion order for the institute facilities.

4.2 Anyone who is subjected to measures as referred to in the first paragraph will be given the opportunity for a subsequent hearing as soon as possible by or on behalf of the Rectorate if this was not previously possible due to the urgent nature of the matter at hand.

4.3 The exclusion order will contain at least the following:

- a. an indication of the buildings and/or grounds or the parts of the buildings and/or grounds of IHE Delft and/or the facilities or use of the facilities of IHE Delft to which the exclusion order applies;
- b. the duration of the exclusion order;
- c. the reasons for the exclusion order;
- d. any conditions which will result in the effectuation of the exclusion order in case of noncompliance.

#### Article 5 Termination of the exclusion order

5.1 The Rectorate may, of its own accord or in response to a request by a person who is subject to a disciplinary measure in the form of an exclusion order as referred to in these Regulations, choose to terminate the exclusion order or alter its scope before it has elapsed if there is sound reason to do so according to the judgement of the Rectorate.

5.2 The Rectorate may attach special conditions to the termination or alteration of the exclusion order.

5.3 If in the judgment of the Rectorate the person subject to the exclusion order, and on behalf of whom a proposal to terminate said order has been forwarded, has not met the special conditions set by the Rectorate, then the original exclusion order will once again be put into force; the period of time that has passed since the termination or alteration of the exclusion order will not be deducted from the originally specified period in this case.

#### Article 6 Entry into force

These Regulations enter into force on October 1st 2007

#### Article 7 Method of Citation

These Regulations may be cited as "Regulations for the use of buildings, grounds and facilities by students and visitors of IHE Delft". Approved in the rectorate meeting of September 25th 2007

### 3.4 Plagiarism

NOTE: FAILURE TO COMPLY WITH THE TERMS OF THIS SECTION COULD JEOPARDISE YOUR DEGREE. PLEASE READ AND DIGEST CAREFULLY.

It is very important that all students understand IHE Delft rules about plagiarism.

Students sometimes break these rules unintentionally because they do not realise that some of the ways in which they have incorporated other people's work into their own, before they came to IHE Delft, may be against the rules here.

At the beginning of the programme, and before submitting any assessments, you will be required to agree to an 'own work declaration'. You will also be invited to give consent for the scanning of your work by plagiarism detection software. Work cannot be submitted unless these conditions are agreed to.

What is plagiarism?

Plagiarism is the practice of taking someone else's work or ideas and passing them off as one's own. This act is considered as academic fraud. When there is a strong presumption of plagiarism, whether occurring during the course of the study or after the completion of the study, cases will be investigated by the Examination Board. The Examination Board shall examine the cases of alleged plagiarism on their individual merits. After examining all the evidence, the Examination Board shall establish whether plagiarism and implicitly fraud has been committed. When fraud has been established the offender will be given the mark of 1.0 for the examination work.

Plagiarism detection

IHE Delft uses a computer program called Turnitin<sup>®</sup> to assist with the detection of plagiarism. The plagiarism detection service is an online service that enables IHE Delft and its staff to carry out electronic comparison of students' work against electronic sources including other students' work. Turnitin<sup>®</sup> works by executing searches of the World Wide Web, and extensive databases of reference material, as well as content previously submitted by other IHE Delft students.

Each new submission is compared with all the existing information. The software makes no decisions as to whether a student has plagiarised, it simply highlights sections of text that are duplicated in other sources. All work will continue to be reviewed by the course coordinator.

Once work has been submitted to the system it becomes part of the ever growing database of material against which subsequent submissions are checked.

The software is used as a tool to highlight any instance where there is a possible case of plagiarism. Passages copied directly or very closely from existing sources will be identified by the software and both the original and the potential copy will be displayed for the examiner to view. Where any direct quotations are relevant and appropriately referenced, the examiner will be able to see this and will continue to consider the next highlighted case.

Citing references

The key to avoiding plagiarism is to make sure that you give correct references for anything that you have taken from other sources to include in your academic work. This might include, for example, any ideas, theories, findings, images, diagrams or direct quotations that you have used. At IHE Delft the house style for references is based on the Hydrogeology Journal output. If you take any material word for word from another source, it is essential that you make it clear to your reader that this is what you have done.

If you take material from another source, change a few words and then include the reference you may still have committed a plagiarism offence because you have not made it clear to your reader that you have essentially reproduced part of the original source. You should either express the ideas fully in your own words and give the reference or else use clearly labelled direct quotes. Bear in mind that if you include too many direct quotes in your work this may reduce your grade, as the marker will find



it difficult to see evidence of your own understanding of the topic. You must also include a bibliography and references section at the end of your work that provides the full details of all of the sources cited within the text. You should be aware that, for work done in other subject areas, you might be expected to use a different referencing system.

The process of referencing may seem rather complicated and arbitrary, if it is new to you, but it should begin to make more sense as you progress through your studies. In order to assess your work and to give you useful feedback your marker needs to have a clear sense of what ideas you have developed for yourself and what comes from elsewhere. To be fair to all of the students on the course it is important that each student is given grades that accurately reflect their own efforts. As you learn to produce work at a Master standard, you are developing the skills that will allow you to participate within wider communities of scholars. In these communities new knowledge and understanding is often developed by building on the work of others. By properly acknowledging earlier work you give credit where it is due and help to maintain the integrity and credibility of academic research in this area. Clear referencing also allows readers to learn about the wider literature through your work. It is often the case that understanding the ways in which particular scholars have contributed to the development of the literature makes it much easier to make sense of the current state of play.

#### Team work, accidental and self-plagiarism plagiarism

Students sometimes wonder where to draw the line between discussing their ideas with their peers (which can be an excellent learning experience) and unacceptable collusion. The time to be particularly careful is when you are preparing work for assessment. You need to be certain that the work you submit represents your own process of engagement with the task set. You may get into difficulty if, for example, reading another student's plan for their work influences you, or if you show them your plan. Assisting another student to plagiarise is a cheating offence.

In addition to giving references for all of the materials that you have actually included within your assignments, it is important to appropriately acknowledge other sources of guidance you have used when preparing your work.

Accidental plagiarism is sometimes a result of a student not yet having fully come to terms with how to study effectively at university. For example, the ways in which students take their notes sometimes makes it difficult for them to later distinguish between verbatim quotes, paraphrased material and their own ideas. A student may also plagiarise unintentionally because they have been feeling daunted by a piece of work and so have put it off for so long that they have had to rush to meet the deadline. If you think these kinds of wider issues may be relevant to you then you should contact your module coordinator.

#### Plagiarism guide's references

The following sources were used in the development of the plagiarism guide:

Blum, S. D. (2009). *My word! : plagiarism and college culture*. Ithaca: Cornell University Press.

Carroll, J. and Appleton, J. (2001). *Plagiarism: A Good Practice Guide*. Oxford: Oxford Brookes University and Joint Information Systems Committee

Eisner, C., & Vicinus, M. (2008). *Originality, imitation, and plagiarism : teaching writing in the digital age*. Ann Arbor: University of Michigan Press.

Sutherland-Smith, W. (2008). *Plagiarism, the Internet and student learning : improving academic integrity*. New York: Routledge.

Harvard University Guide to Plagiarism

<http://isites.harvard.edu/icb/icb.do?keyword=k70847&pageid=icb.page355322>

Purdue University Writing Lab

<http://owl.english.purdue.edu/>

University of Princeton Academic Integrity

Site <http://www.princeton.edu/pr/pub/integrity/pages/plagiarism/>

University of Teesside Plagiarism Guidance <http://dissc.tees.ac.uk/Plagiarism/Plag-4.htm>

## 4 Facilities

### 4.1 Location

The IHE Delft buildings and facilities are located on a single compound at the Westvest 7 in the centre of Delft. The buildings provide an efficient atmosphere for optimal learning and creativity, direct communication with lecturers and other staff, as well as meeting with fellow students. The building is open during the following times:

Monday to Friday 07:30 – 20:00

Saturday 08:00 – 12:30

### 4.2 Student Affairs (office)

The Student Affairs office provides non-academic support to students. The SA office takes care of student applications and student registration. The new students are also assisted with formalities such as applications for residence permits, insurance, bank accounts, and fellowship issues. Housing arrangements in one of the hostels are being made immediately upon arrival.

Throughout their study period, students can contact the staff during office hours for information or questions related to health, religion or other issues related to the student's wellbeing. Personal matters can be discussed with the student counsellor and will be dealt with strictly confidential.

During the entire academic year, SA organizes a number of social and cultural activities including the weekly movie night, social evenings and the annual Christmas dinner. Other activities include cultural excursions to interesting cities and places in the Netherlands and other countries in Europe. Furthermore, the students are given opportunity to actively practice sports on a regular basis. From October to May, the Institute arranges accommodation in Delft for such sports as soccer, volleyball, basketball and badminton. The SA office organizes sports events and tournaments, in which the teams can compete internally, but also against players from other international institutes.

### 4.3 Student Association Board

The Student Association Board (SAB) is composed of representatives who are elected by the students in annual elections that take place several weeks after the opening of the academic year.

The SAB provides a forum through which students can share their experiences, problems and general issues on study-related matters. If necessary, the SAB will bring these matters forward in discussions with the executive levels of the Institute. The board can be contacted directly via its members or the general e-mail address [sab@unesco-ihe.org](mailto:sab@unesco-ihe.org). The SAB closely co-operates with the Student Affairs office in organizing social and sporting events.

### 4.4 ICT services

IHE Delft provides modern computing (IT) facilities for education and research. A local wired- and wireless network is available in the building. Through the network all computers have access to a fast Internet connection. Besides that, participants have unlimited access to Internet in all hostels provided by IHE Delft.

All desktop and laptop PCs are Intel based with Microsoft Windows operating system. The laptop PC will be provided in order to get access to the IT facilities.

The laptop is on loan for use during studying at IHE Delft. At the end of the study, the institute offers the possibility to buy the laptop. The contract given clearly states the terms and conditions for borrowing the laptop. Bringing one's own laptop is allowed; however, laptops other than the IHE Delft laptop might not give access to all the required IT-facilities and might not be supported by IT-service desk.

A wide range of software packages is available, ranging from standard PC-software, like Microsoft Office (Word, Excel, etc.) to special modelling software used for the education programmes. Upon registration you will receive an IHE Delft e-mail account which enables you to make use of all relevant

computing facilities at the Institute.. A web-based E-learning and collaborative system is accessible for all participants to exchange learning information and documents.

For specific applications during the thesis study, it may be possible to use specialist software packages on the laptop PCs. This is, however, dependent on the particular type of licence agreement that the Institute has with the supplier. Enquiries for specific software should be made at the computer helpdesk.

#### 4.5 General Facilities in the Building

In the reception area of the building, students have their own locker for the distribution of schedules, lecture notes and other study-related papers, and private mail. Two monitor screens opposite the reception desk are regularly updated with news or information on events taking place at IHE Delft.

The restaurant provides a wide variety of reasonable-priced multicultural meals and beverages during lunchtime. The meals can be paid using the bank-card or cash. Coffee, tea and soft drinks can be obtained from machines throughout the day.

The building houses a number of fully-equipped lecture rooms and theatres, which can accommodate groups of all sizes from 15 to 300 persons. Rooms for facilitating computer classes and workshops are present and can be used freely by students outside class hours.

Furthermore, the Institute has its own printing and reproduction facilities and also contains an in-house distance learning and video conferencing centre. Photocopy services are available to students. In the building also a meditation room is available, which is located on the third floor.

#### 4.6 IHE Delft Library and Information Services

IHE Delft's Library provides access to over 35,000 printed titles, among which the complete collection of IHE Delft Master thesis and PHD dissertations. Furthermore the collection contains over 8.000 online journals. The online journals collection is accessible on the network at the Westvest premises or through remote authentication through the portal. For more information please visit the Library's Internet page <http://www.unesco-ihe.org/library>

The library is open to all IHE Delft participants and staff, and to visitors by appointment.

The services provided by the library include lending out books, requesting articles and other materials through the inter-library loan system and providing assistance in searching the electronic catalogue.

##### Membership

Upon registration participants receive a registration card which can also be used to borrow items from the library collection.

##### The catalogue

The library collection is accessible through an electronic catalogue, which is searchable by author, title (word) and subject, as well as by Boolean operators. Please visit <http://www.unesco-ihe.org/library> for more information.

##### Borrowing library items

A maximum of ten items may be borrowed from the library at any one time. The maximum loan period is 21 days, renewable up to a maximum of 42 days. Renewals can be made online, <http://www.unesco-ihe.org/library> by using the borrower information function within the catalogue or by email ([library@unesco-ihe.org](mailto:library@unesco-ihe.org)). Please note that the loan period can be extended only if the items have not already been reserved by another person.

Reference works, MSc theses, bound and non-bound periodicals and materials bearing a green sticker may not be borrowed. By using their library card to borrow items from the library, borrowers agree to be responsible for those items, including the cost of replacing lost or damaged items.

#### Opening Hours

Monday 09:00–18.30

Tuesday-Friday 09:00–19.00

Saturday 09:30–12:30

Please note that the Library opening hours are subject to change. Visit the Library webpage for regular updates. For further information please contact the library reference desk.

Email: [library@unesco-ihe.org](mailto:library@unesco-ihe.org)

Tel: +31 (0)15 215 1714

Fax: +31 (0)15 212 2921

#### 4.7 Laboratories

Modern educational and research laboratories are available in the fields of chemistry, process technology, microbiology, aquatic ecology and soil science. A wide range of standard analytical tests can be performed for chemical, physical and microbiological water, air and soil quality analyses.

Elemental analyses, various kinds of microscopy and analytical techniques such as spectrophotometry, gas- and ion chromatography, and atomic absorption can be carried out. A wide range of laboratory and bench-scale reactors, temperature and light controlled growth chambers, and various constant temperature rooms are available for research in one of the departmental research programs, including waste water management using aquatic macrophytes and wetlands, the adsorption and/or (an-)aerobic degradation of micropollutants, self-purification in drains and filtration. Through close co-operation with the Delft University of Technology and other educational and research institutions, research possibilities are quite extensive.

In addition to the in-house facilities, the laboratory has a range of instrumentation and equipment available for field instruction and for conducting hydrological or environmental field experiments and measurements.

#### 4.8 Study Materials

Study materials such as textbooks, lecture notes and hand-outs are provided by the Institute.

Students receive the lecture notes either on paper in their personal locker or via the electronic repository 'eCampusXL', before the start of the involved lecture series. Additional material (on paper or electronically) can be provided by the lecturers in the form of hand-outs. Also other materials, such as for example PowerPoint presentations or exercise materials used by the lecturers, can be accessed or downloaded from the electronic repository. Reference works are available from the Institute library or the library of the Delft University of Technology (see above).

Students can login to the electronic repository from any location via the Internet web page located at <http://ecampusxl.unesco-ihe.org>

Students are expected to bring in other materials, such as electronic calculators and language dictionaries on their own account.

#### 4.9 English support courses

##### Introduction

A variety of academic writing courses are offered to students during the first 12 months of study. Students are allocated a place on these courses according to their language level, not their specialization. Writing courses are available from 'lower-intermediate' to 'advanced' level, consisting of about 20 hours contact time. These courses run parallel to scheduled lectures, and are not limited to one programme specialization or module.

##### Placement Test for everyone

Every student must take the English Placement Test. Based on the result, the student may be required to follow an academic writing course. Placement tests are held in October and January. Participants

with weakest English skills are strongly advised to take the test in October, as they will receive support courses first. All remaining participants will be tested in January. Places on writing courses are allocated according to the student's placement test score. A student cannot join a writing course unless s/he has taken the placement test.

Students whose test score is at A1, A2 or B1 level CEFR (The Council of Europe's *Common European Framework* of Reference for Languages is a basis for recognising language qualifications. A1-A2 = Basic; B1-B2 = Intermediate; C1-C2 = Advanced), are obliged to attend a support course: attendance is required. Students whose test score is B2 are strongly recommended to attend a course. If students who score B2 choose to take a support course, regular attendance is required. Those with score levels C1 and C2 are exempt from academic writing courses.

#### Scheduling and attendance

Academic Writing courses are given throughout the year, with the first courses starting in October and the last courses ending in August/September. Students are assigned a course based on their Placement Test performance.

English support courses usually consist of about 20 hours contact time, approximately 13 or 14 lectures. English support courses are always scheduled at the following times:

Tuesdays 3.45pm-5.30pm

Thursdays 8.45am-10.30am

Occasionally classes are given on Saturday mornings. In special cases, evening classes may be necessary.

A Certificate of Attendance will be provided on completion of an academic writing course, provided attendance requirements have been met. If a student does not turn up for the allocated course without giving notification of absence, s/he forfeits their place on the course. An alternative course is not provided.

#### Summary descriptions of writing courses:

##### *1. First Steps in Academic Writing: lower intermediate*

Based on textbook '*First Steps in Academic Writing*', Longman

This course provides low-intermediate students with essential tools to master basic academic writing. It focuses on paragraph organization, sentence structure, and grammar. Students are guided through the writing process to produce well-organized, clearly developed paragraphs.

Simple explanations are supported by clear examples to help students through typical rough spots, and numerous practices help students assimilate each skill.

##### *2. New Headway Academic Skills: intermediate*

Based on textbook '*New Headway Academic Skills*', Oxford University Press

This course combines reading, writing, and study skills, and is suited to those who have reasonable English but have not studied for a while. It aims to refresh and consolidate existing language through practice, as well as to learn new language. There is guided writing practice and relevant grammatical structures are explained. In addition, skills and strategies which develop good vocabulary learning and recording are included.

##### *3. Academic Writing: upper intermediate*

Based on textbook '*Focus on Academic Skills for IELTS*', Pearson-Longman

- Focuses on academic writing skills
- Includes vocabulary building and reading techniques relevant to research.
- Specific writing skills include: collocations; useful phrases and language of research; the language of change (increase, decrease, etc); interpreting and comparing information from diagrams; presenting arguments and opinions; justifying solutions (modal verbs, conditionals) and much more to improve academic writing.

· Life-long learning. This textbook offers systematic preparation for the IELTS exam, hence it can help any student who wishes to gain this internationally-recognised certificate, or improve their existing score.

#### *4. Advanced Academic Writing: advanced*

Based on textbook '*Academic Writing, A Handbook for International Students*' Routledge

Specifically aimed at improving key academic writing skills, this is a very practical and thorough course.

Three main areas are covered:

The Writing Process – from making an outline to proofreading;

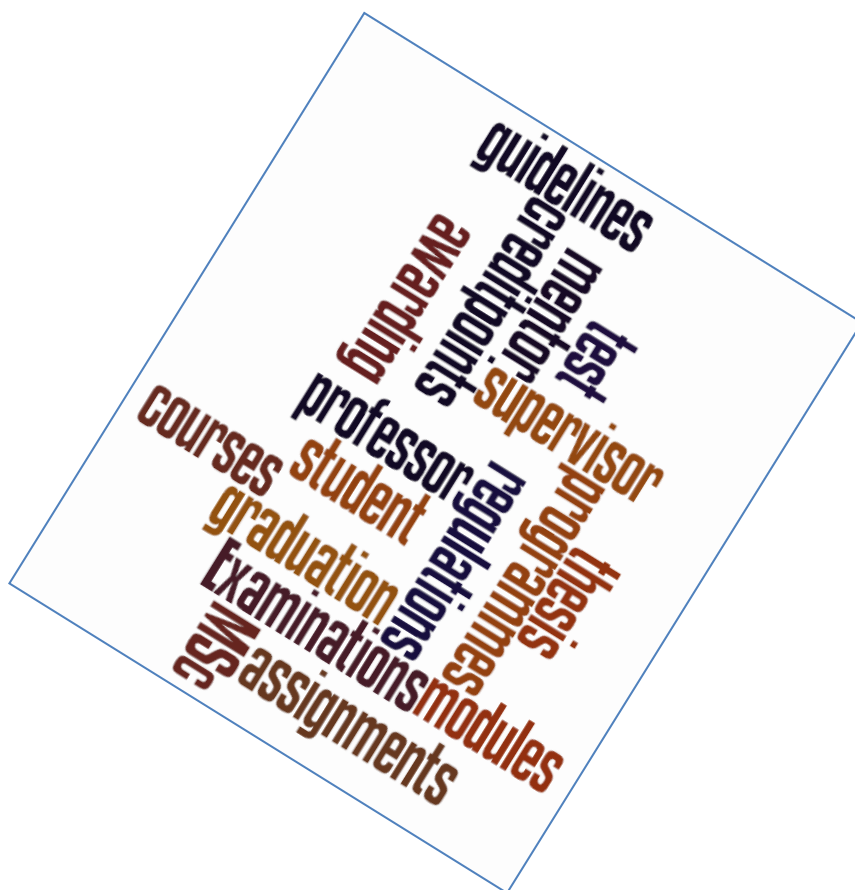
Elements of Writing – writing skills such as making comparisons, describing results and paraphrasing;

Accuracy in Writing – to improve common problems, e.g. articles, passives, prepositions.

The above courses follow a workshop approach and are designed to provide maximum hands-on practice. There is a strong emphasis on collaborative writing activities for students, with the lecturer adopting the role of facilitator.

#### *5. MSc Thesis Writing: for all participants. A reader is provided.*

In August/September a series of lectures is given, open to all MSc participants, on thesis writing. The lectures aim to make participants aware of the conventions and structures used to write a proposal, literature review and thesis, and how to present their judgements in a persuasive and reasoned argument. Topics will include proposal writing, literature review, thesis chapters, argument structure, paragraph writing, editing skills, etc.



## Education and Examination Regulations 2017– 2019

For:

- the Master Programmes in
  - a. Urban Water and Sanitation
  - b. Environmental Science
  - c. Water Management
  - d. Water Science and Engineering
- short and online courses which are part of these programmes (starting between 1 Sep 2017 and 31 Aug 2018)
- Graduate professional diploma programmes





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## Chapter 1. Definition of terms

The following terms are defined in the context of these regulations:

<b>Act:</b>	the Higher Education and Scientific Research Act ( <i>Wet op Hoger Onderwijs en Wetenschappelijk Onderzoek</i> );
<b>Assessment:</b>	is the evaluation of a student's achievement on a course or topic. Assessments can have different formats, such as (written and oral) examinations, assignments, presentations etc.
<b>Blind marking:</b>	the student information is hidden from the examiner while they are marking the examination;
<b>Co- mentor:</b>	a staff member from an external institute or different chair group within IHE Delft involved in the daily direction of a student during the MSc thesis research phase;
<b>Degree:</b>	a degree as stipulated in article 7.10a. of the Act;
<b>Double (multiple) degree programme:</b>	a master programme offered by multiple institutes of higher education leading to multiple degrees;
<b>Diploma:</b>	a written proof of evidence as stipulated in art 7.11 of the Act that a student has passed all programme requirements;
<b>Diploma supplement:</b>	a written document as stipulated in art 7.11/4 giving information about nature and content of the programme and the results obtained by the student for each component of the programme;
<b>ECTS:</b>	the European Credit Transfer and Accumulation System: a standard for comparing the study attainment and performance of students of higher education across the European Union and other collaborating European countries;
<b>Examination:</b>	an assessment for a part of the module as stipulated in art 7.10/1 of the Act;
<b>Examination Board:</b>	the committee as stipulated in article 7.12 of the Act;
<b>Academic Appeals Board:</b>	the committee as stipulated in article 7.60 of the Act;
<b>(External) Examiner:</b>	a person who sets and marks examinations to test students knowledge or proficiency
<b>Fraud:</b>	a deception deliberately practiced in order to secure unfair or unlawful gain;
<b>Joint programme:</b>	a master programme offered by two or more institutes of higher education leading to a joint or multiple degree(s);
<b>Mentor:</b>	staff member involved in the daily direction of a student during the MSc thesis research phase;
<b>Module:</b>	a self-contained programme unit with specified learning objectives, as stipulated in article 7.3 of the Act; can also be offered as a short- or online course.
<b>Module plan:</b>	a document describing a.o. the learning objectives, content, didactic methods and assessments. Modules plans are part of the study guide;
<b>Observer:</b>	a person who is present at an oral examination in order to monitor and listen to what happens;
<b>Online short course:</b>	a module offered as an online certificate course;
<b>Peer review:</b>	is the evaluation of work by one or more people of similar competence to the producers of the work (peers);
<b>Plagiarism:</b>	the practice of taking someone else's work and passing them off as one's own;
<b>Practical:</b>	a practical educational activity as stipulated in article 7.13, paragraph 2, clause d of the Act, taking one of the following forms:

	<ul style="list-style-type: none"> <li>• the writing of a report or thesis;</li> <li>• producing a report, study assignment or design;</li> <li>• conducting a test or experiment;</li> <li>• performing an oral presentation;</li> <li>• participating in groupwork, fieldwork or a fieldtrip;</li> <li>• conducting a research assignment; or</li> <li>• participation in other educational activities that aim to develop specific skills;</li> </ul>
<b>Programme evaluation:</b>	the formal evaluation of the student performance before graduation (in the Act: <i>examen</i> );
<b>Study Guide:</b>	a reference document for a specific programme containing generic and programme specific information, which students need to know throughout their programme;
<b>Short course:</b>	a module offered as a face-to face certificate course;
<b>Student:</b>	a person who is registered in a study programme and sits for assessments;
<b>Supervisor:</b>	professor responsible for the work of student during the MSc thesis research phase.
<b>Taught part:</b>	part of the study programme consisting of taught modules and courses;
<b>Transfer of credit points:</b>	the procedure of granting credits to a student for studies completed at another institute;
<b>Research part:</b>	part of the study programme consisting of an individual research work by the student leading to a MSc thesis, based on an approved research proposal.

## Chapter 2. General Information

### Article 1 Scope of the regulations

- 1.1 The present regulations apply to the education offerings and examinations within:
- I. the Master programmes in:
    - i. Urban Water and Sanitation
    - ii. Environmental Science
    - iii. Water Management and Governance
    - iv. Water Science and Engineering
  - II. Short and online courses which are part of these master programmes
  - III. Graduate Professional Diploma Programmes (GPDP)

referred to hereafter as ‘the programmes’.

The programmes are executed by the IHE Delft Institute for Water Education, Delft, the Netherlands, referred to hereafter as ‘the Institute’ and several partner institutes in various countries.

- 1.2 For the following 3 specialisations separate examination regulations apply as they lead to a joint MSc degree:
- Urban Water Engineering and Management (UWEM);
  - Limnology and Wetland Management (LWM);
  - Environmental Technology for Sustainable Development (ETSuD).
- 1.3 In case a joint specialisation (see art. 1.4) leads to a double or multiple degrees, the rules and regulations of the partner institute will be applicable for those parts of the programme organised and implemented by the partner.
- 1.4 The following Master of Science programmes and specialisations are offered:

#### 1. Urban Water and Sanitation programme:

Specialisation	Offered by	Type of degree
1. Water Supply Engineering	IHE Delft	IHE Delft degree
2. Sanitary Engineering	IHE Delft	IHE Delft degree
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Universidad de Valle, Cali, Colombia</li> </ul>	Double degree
3. Urban Water Engineering and Management	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology, Thailand</li> </ul>	Joint degree

#### 2. Environmental Science programme:

Specialisation	Offered by	Type of degree
1. Environmental Science and Technology	IHE Delft	IHE Delft degree
2. Environmental Planning and Management	IHE Delft	IHE Delft degree
3. Water Quality Management	IHE Delft	IHE Delft degree
4. Limnology and Wetland Management	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• BOKU - University of Natural Resources and Life Sciences, Vienna, Austria</li> <li>• Egerton University, Egerton, Kenya</li> </ul>	Joint degree
5. Environmental Technology for Sustainable Development	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology, Thailand</li> </ul>	Joint degree

### 3. Water Management and Governance programme:

Specialisation	Offered by	Type of degree
1. Water Management and Governance	IHE Delft	IHE Delft degree
2. Water Resources Management	IHE Delft	IHE Delft degree
3. Water Services Management	IHE Delft	IHE Delft degree
4. Water Quality Management	IHE Delft	IHE Delft degree
5. Water Conflict Management	IHE Delft	IHE Delft degree
6. Water Cooperation and Diplomacy	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Oregon State University, USA</li> <li>• UPEACE, Costa Rica</li> </ul>	Triple degree

### 4. Water Science and Engineering programme:

Specialisation	Offered by	Type of degree
1. Hydrology and Water Resources	IHE Delft	IHE Delft degree
2. Hydraulic Engineering - River Basin Development	IHE Delft	IHE Delft degree
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• University of Kuala Lumpur</li> </ul>	Double degree
3. Coastal Engineering and Port Development	IHE Delft	IHE Delft degree
4. Land and Water development	IHE Delft	IHE Delft degree
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology Thailand</li> </ul>	Double degree
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• University of Nebraska -Lincoln, USA</li> </ul>	Double degree
5. Hydroinformatics- Modelling and information systems for water management	IHE Delft	IHE Delft degree
6. Flood Risk Management (Erasmus Mundus programme).	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Technische Universität Dresden, Germany</li> <li>• Universitat Politècnica de Catalunya, Spain</li> <li>• University of Ljubljana, Slovenia</li> </ul>	Multiple degree
7. Groundwater and Global Change - Impacts and Adaptation (Erasmus Mundus programme).	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• TU Dresden, Germany</li> <li>• University of Lisbon, Portugal</li> </ul>	Multiple degree

### 5. Graduate professional diploma programmes:

Name	Offered by	
Sanitation and Sanitary Engineering	• IHE Delft	Diploma

## **Article 2 Aim of the programmes and courses**

- 2.1 The aim of the master programmes is for students to acquire knowledge, insight and skills that are required for them to function as independent professionals within their field of study and to be appropriate candidates for further study towards a research career.
- 2.2 The final qualifications of the master programme graduates are listed in Appendix A.
- 2.3 The aim of a short course or an online course is for students to acquire knowledge, insight and skills of a particular field of study.
- 2.4 The aim of the GPDP is to convey to the students the knowledge, insight and skills of a particular field of study and consists of a number of online modules, regular master modules or a combination of both.

## **Article 3 Full-time/part-time**

- 3.1 The master programmes and short courses are offered on a full-time basis.
- 3.2 Online courses are offered on a part-time basis.
- 3.3 The GPDP is executed on a part-time basis.

## Chapter 3. Content of the Programme

### **Article 4 Constitution of the specializations and joint specializations**

- 4.1 The constitution of each programme specialization and diploma programme is described in the study guides of IHE Delft and the partner institutes (in case of joint or double / multiple degree programmes)
- 4.2 The learning objectives of all modules (face to face and online), the content and assessment methods are described in the module plans.

### **Article 5 Participation**

- 5.1 The attendance and active participation of students is required for all scheduled curricular activities, examinations and the practicals of the programme in which they are registered.

## Chapter 4. Assessments

### Article 6 Timing, formats and duration of assessments

- 6.1 Assessments tests whether a student has met the learning objectives.
- 6.2 A module is assessed through (a combination of) written and/or oral examinations, assignments and presentations as described in the module plans of the study guide.
- 6.3 The sequence of the modules and its assessments will take place according to the order described in the study guide.
- 6.4 Students cannot sit for a module assessment more than twice per academic year.
- 6.5 The date and time of the written and oral assessments are announced in the programme schedules. Written and oral assessments take place during the examination periods indicated in the academic calendar.
- 6.6 Written and oral assessments for short and online course participants are held within two weeks after the end of the module. Dates are determined in consultation between the module/course coordinator and the students
- 6.7 The format for the final assessment of a short course can deviate from the assessment format for the corresponding module.
- 6.8 Students of short courses or online courses (including GPDP) are eligible to sit for the assessment and one (1) re-assessment of the course they are registered for provided that the fee to sit for these assessments has been paid.
- 6.9 The duration of a written examination may not exceed three hours and is scheduled to take place in a morning or afternoon session. In case the examination consists of two or more different parts, a break of 15 minutes is allowed, provided that all examination work of the first part(s) is collected by the invigilators before the break.
- 6.10 In the case of a combination of an oral and written assessments of a module during the examination week, the maximum total duration of the combined examination shall not exceed three hours.

### Article 7 Re- assessments

- 7.1 Re-assessment consists of re-taking one or more failed assessments as described in the assessment part of the module plan, as is required to achieve a successful module result.

Taking part in re-assessments is required if:

- one of the assessments is  $\leq 4.9$  or marked as a 'fail';
- the module mark is a fail ( $\leq 5.9$ ). In this case one or more assessments for which a mark  $< 6.0$  has been obtained can be re-taken.

Taking part in re-assessments is not allowed if:

- the module mark is a pass ( $\geq 6.0$ ) and all assessments are  $\geq 5.0$

- 7.2 The first written and oral re- assessments take place in the examination period immediately following the examination period of the first attempt, except for the re-examinations of modules 10 and 11 which take place on the first Friday of module 14.



Dates and times of written re-examinations are announced in the programme schedules.

- 7.3 The dates and times of further written and oral re- assessments during the thesis period are set by the module coordinator in collaboration with the programme coordinator and the Education Bureau.
- 7.4 Students are not allowed to sit for further assessments during the programme period they are registered for, if they failed three separate modules (after re-assessments) of the taught part of the programme ('modules' does not include the MSc proposal defence).
- 7.5 The format of a re- assessment may deviate from that of the first assessments for the same module.
- 7.6 The latest moment to sit for a re- assessment is one month before the submission date of the MSc thesis.

#### **Article 8 The organisation of the assessments**

- 8.1 Assessments are carried out according to the Examination Procedures as described in annex B of these regulations.
- 8.2 In the case of an oral or written assessments for an online course, the student has to provide proof of identity (e.g. passport) to the examiner.
- 8.3 Students are expected to be in the examination room 10 minutes before the scheduled start of the exam. They will not be allowed to enter the examination room after the scheduled start of the examination.
- 8.4 Misreading the date, time or room allocation are not accepted as legitimate reasons for absence from an examination or for arriving too late.
- 8.5 Students who suffer from a physical or sensory impairment are offered the opportunity to take examinations such that, as much as possible, account is taken of their disability. If required, an expert will be consulted for advice.

#### **Article 9 Oral assessments**

- 9.1 Oral assessments are taken individually (only one student at a time). During oral assessments, a second staff member is present as an observer. In case of absence of a second staff member, the oral assessment is recorded for reference purposes and kept on file for 12 weeks.
- 9.2 During oral assessments for online courses a second staff member as observer is not required. The oral assessment has to be digitally recorded and kept on file for 12 weeks.
- 9.3 Oral assessments are non-public, unless stated otherwise in the module plan or current regulations.

#### **Article 10 MSc proposal defence**

- 10.1 The MSc thesis proposal examination is an oral examination during the examination period indicated in the academic calendar. The examination consists of a presentation of the proposal, and a discussion with the examining committee. The examining

committee consists of the supervisor and the mentor of the student. The examination is open to public attendance and discussion.

- 10.2 To be allowed to sit for the MSc proposal defence, students must have successfully completed all but with a maximum of 2 failed modules.
- 10.3 The MSc thesis proposal defence is assessed as a pass or a fail. In the case of a fail, the student may defend his/her thesis proposal one more time within one month after the first attempt before the same examining committee as stipulated in article 10.1. In the case of an unsuccessful second attempt the student is not allowed to embark on their MSc thesis work.

#### **Article 11 Replacement of modules and transfer of credit points**

- 11.1 Replacement of a module by a course followed elsewhere and transfer of credit points is generally not granted. In exceptional cases, the Examination Board may evaluate a request and conclude to grant a transfer of credit points, after receiving a favourable recommendation from the programme committee.
- 11.2 For joint specializations credits obtained at the partner institute are accepted on the basis of the credit transfer agreements made in the cooperation documents.

#### **Article 12 Absence from examinations and late submission of assignments**

- 12.1 Absence from an examination or late submission of an assignment must be reported by the student to the programme coordinator as early as possible. Absence is only allowed if the student missed a substantial part of the education relevant for the examination and/or the examination itself due to:
  - a. medical reasons, to be confirmed by student counsellor or a statement by a doctor;
  - b. serious personal circumstances beyond control of the student which should be supported by written evidence as far as possible.
- 12.2 For cases in which the programme coordinator, in agreement with the module coordinator, decides that the absence from an examination or the late submission of the assignment is justified, the student shall sit the examination or submit the assignments as soon as is reasonably possible.
- 12.3 For cases in which the programme coordinator, in agreement with the module coordinator, decides that the absence from an examination or the late submission of the assignment is not justified, a mark of 1.0 will be recorded.

#### **Article 13 Fraud**

- 13.1 If a student is caught in an attempt to take unfair advantage during an examination, the invigilators or examiners will inform the Academic Registrar who will submit a written report to the Examination Board after investigation of the incident, and after having had a discussion with the student.
- 13.2 Plagiarism is an act of fraud.
- 13.3 An examiner who observes or suspects fraud during the marking of examination work is required to submit a substantiating report to the Examination Board via the module coordinator.

- 13.4 If the Examination Board, after investigation of the incident as described in articles 13.1-13.3, concludes that there has been a case of fraud, the offender will be given a mark of 1.0 for the examination work.
- 13.5 If a student commits severe or repeated fraud, the Examination Board may decide to withdraw the student the right to sit for one or more examinations for a determined period with a maximum period of one year.
- 13.6 In case of severe or repeated fraud the rectorate, upon advice of the Examination Board, may also decide to permanently terminate the registration of the student concerned.

## Chapter 5. Results of Assessments

### Article 14 Assessment and notice of assessment results

- 14.1 Assessment results (including the thesis examination) are represented on a scale of 1.0 to 10.0, with one decimal of accuracy. Marks 6.0 and higher indicate a pass. The following grading scale is used:
- |               |            |
|---------------|------------|
| 9.0 - 10.0    | Excellent  |
| 8.0 - 8.9     | Very good  |
| 7.0 - 7.9     | Good       |
| 6.0 - 6.9     | Sufficient |
| 5.9 and below | Fail       |
- 14.2 Assessment results (including the thesis examination) obtained at partner institutes are represented according to the descriptions in annex C of these regulations.
- 14.3 The mark for a module is determined by the weighted average of the results of the various assessments. The weights for each assessment are stated in the module plan. The minimum mark that should be obtained for each assessment is 5.0. Marks between 5.0 and 5.9 can be compensated by higher marks of other assessments in the same module.
- 14.4 After a successful re-sit of an assessment, the mark for the module is recalculated according to the weighted average of the assessment results. The highest mark obtained (first assessment or re-sit) for an assessment will be used. However, the maximum module mark which can be awarded when there has been a re-assessment is 7.0.
- 14.5 Students will be informed on the outcome of their module mark and assessments as soon as possible, but at least three weeks before the planned re-assessments.
- 14.6 Students will be informed on the outcome of their module mark and re-assessments as soon as possible, but maximum three weeks after the re-assessments.
- 14.7 The examination committee for the thesis examination shall determine the result immediately after the defence. The mark shall be formally communicated to the student before the diploma awarding by the Education Bureau.

### Article 15 Period of validity

- 15.1 The result of a module, if successful, is valid for an unlimited period of time.
- 15.2 Notwithstanding paragraph 1 of this article, the period of validity for which the Examination Board takes module results into account for the programme evaluation is four years.

### Article 16 Right to inspection of assessments

- 16.1 Students may, upon their own request, peruse their assessment work within ten working days after they were notified of the result.
- 16.2 Where a practical is part of a module, the work for that part may be returned to the students when all assessments of the module are fully completed.
- 16.3 Written examination work is archived for a minimum of 7 years.

**Article 17 Study progress and study advice**

- 17.1 All study results that are required for evaluating the performance of the students, are recorded by the Education Bureau on behalf of the Examination Board.
- 17.2 Upon request, students will be provided with a written summary of the study results obtained in the programme to date.

## Chapter 6. Thesis Examination

### Article 18 The organisation of the thesis examination

- 18.1 Students can sit the thesis examination only if all other modules required to obtain the degree have been successfully completed one month before the thesis examination.
- 18.2 All students have to submit the examination version of the thesis report on or before the date as annually announced by the Examination Board, and defend their thesis in the designated period.
- 18.3 The thesis will be assessed by a thesis examination committee, consisting of three members: a professor as the chairperson, the mentor and maximum one external independent examiner.

In special circumstances the committee may consist of more than three members:

- a) If the IHE Delft mentor is a PhD fellow, an additional staff member is to be appointed in the committee.
- b) If the research work is carried out outside IHE Delft a co-mentor from that institute may be appointed.
- c) If the research work is co-mentored by a staff member from another chair group at IHE Delft;
- d) In the case of a double degree or joint degree programme, where the MSc research work is carried out under co-supervision of staff members of the partnering institutes.

External examiners:

- to avoid conflict of interest, external examiners are not involved in the preparation of the thesis work and have to be able to give an independent judgment.
- are from outside the institute or are in exceptional cases from a chair group within the institute, but not involved in the supervision of the research work.
- have to possess at least a Master degree.

- 18.4 After submission, the thesis will be assessed by the members of the examination committee, including a check on plagiarism. If the examination committee concludes that the thesis is unfit to be successfully defended, they may propose to the student to accept a fail without the thesis defence. The student is given the opportunity to re-sit as per Article 18.5. The student can also decline the offer and ask for the thesis defence to be organised anyhow.
- 18.5 If the outcome of the thesis examination, including the defence, is a fail, the examination can be repeated once. The examination committee will detail the reasons for the failure in writing and clarify what is required to pass the exam. The student has to finalize the work without further supervision without financial support. The thesis shall be re-submitted and the defence shall be done within three months after the date of the first defence session and will, in principle, be done in front of the same MSc Examination Committee as for the first attempt. The examination can take place via videoconference.

- 18.6 The maximum recorded mark for a re-sit of the thesis examination is 6.0.
- 18.7 The MSc thesis work shall be assessed according to the MSc thesis assessment criteria as outlined in appendix E.
- 18.8 The mark for the thesis examination is based on the following components: written MSc thesis report, oral presentation, and examination. The latter includes the ability of the student to satisfactorily answer questions from the examination committee. The oral presentation of the thesis research has a maximum duration of 30 minutes and is followed by a maximum 30 minutes examination discussion with the examining committee. The oral presentation is open to public attendance and discussion.
- 18.9 The decision on a final mark for the thesis examination in principle will be based on a consensus of the examining committee. In the case of insurmountable disagreements the chair of the examining committee takes a decision.
- 18.10 The maximum duration of the MSc research phase is six months for full-time study. In the case of a *force majeure*, as supported by substantiating documents, extension of this period may be granted by the Examination Board on request by the student through his/her mentor.

## Chapter 7. Criteria, degrees and certificates

### Article 19 Evaluation of the programme

19.1 The student has fulfilled the requirements for the programme evaluation if s/he has met the following criteria:

#### 1. Urban Water and Sanitation programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Water Supply Engineering	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Sanitary Engineering	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Universidad de Valle, Cali, Colombia</li> </ul>	Double degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 113.36 ECTS.	GPA of 3.5 or higher for the course work done at Univalle	Achieved a mark '6' or higher for the thesis examination
3. Urban Water Engineering and Management	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology, Thailand</li> </ul>	Joint degree	Successfully completed all modules at IHE Delft	48 AIT credits or 120 ECTS	minimum CGPA of 2,75 for courses at AIT	Has obtained a grade 'fair' or higher for the Master thesis at AIT



## 2. Environmental Science programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Environmental Science and Technology	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Environmental Planning and Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
3. Water Quality Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
4. Limnology and Wetland Management	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• BOKU - University of Natural Resources and Life Sciences, Vienna, Austria</li> <li>• Egerton University, Egerton, Kenya</li> </ul>	Joint degree	Successfully completed all modules at IHE Delft, BOKU, and Egerton	Obtained a minimum of 120 ECTS		
5. Environmental Technology for Sustainable Development	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology, Thailand</li> </ul>	Joint degree	Successfully completed all modules at IHE Delft	48 AIT credits or 120 ECTS	minimum CGPA of 2,75 for courses at AIT	Has obtained a grade 'fair' or higher for the Master thesis at AIT

### 3. Water Management and Governance programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Water Management and Governance	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Water Resources Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
3. Water Services Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
4. Water Quality Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
5. Water Conflict Management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
7. Water Cooperation and Diplomacy	IHE Delft Oregon State University U-Peace	Triple degree	Successfully completed all modules at IHE Delft, at OSU and U-Peace	Obtained a minimum of: Option 2a: 113.9 ECTS Option 2b: 116.1 ECTS Option 2c: 119.3 ECTS		

### 4. Water Science and Engineering programme:

Specialisation	Offered by	Type of degree	Criteria for diploma awarding			
1. Hydrology and Water Resources	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
2. Hydraulic Engineering - River Basin Development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• University of Kuala Lumpur</li> </ul>	Double degree	Successfully completed all modules of the programme	Obtained a minimum of 108.7 ECTS		
3. Coastal Engineering and Port Development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		

4. Land and Water development	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Asian Institute of Technology Thailand</li> </ul>	Double degree	Successfully completed all modules at IHE Delft	48 AIT credits or 120 ECTS	minimum CGPA of 2,75 for courses at AIT	Has obtained a grade 'fair' or higher for the Master thesis at AIT
	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• University of Nebraska -Lincoln, USA</li> </ul>	Double degree	Successfully completed all modules at IHE Delft and at Nebraska	Obtained a minimum of 112 ECTS		
5. Hydroinformatics-Modelling and information systems for water management	IHE Delft	IHE Delft degree	Successfully completed all modules at IHE Delft	Obtained a minimum of 106 ECTS		
6. Flood Risk Management (Erasmus Mundus programme).	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• Technische Universität Dresden, Germany</li> <li>• Universitat Politècnica de Catalunya, Spain</li> <li>• University of Ljubljana, Slovenia</li> </ul>	Multiple degree	Successfully completed all modules of the programme, according to the grading rules of TU-Dresden, University of Ljubljana, TU-Catalonia and IHE Delft	Obtained a minimum of 120 ECTS		
7. Groundwater and Global Change - Impacts and Adaptation (Erasmus Mundus programme).	<ul style="list-style-type: none"> <li>• IHE Delft</li> <li>• TU Dresden, Germany</li> <li>• University of Lisbon, Portugal</li> </ul>	Multiple degree	Successfully completed all modules of the programme, according to the grading rules of the University of Lisbon, Technical University Dresden, and IHE Delft	Obtained a minimum of 120 ECTS		

**5. Graduate professional diploma programmes:**

Name	Offered by		Criteria for diploma awarding			
Sanitation and Sanitary Engineering	• IHE Delft	Diploma	Successfully completed all modules at IHE Delft	Obtained a minimum of 20 ECTS for the programme		

19.2 The student has fulfilled the requirements for the short or online course if s/he successfully completed all assessments of the course.

19.3 The student has successfully completed the programme evaluation or short / online course evaluation if the Examination Board takes a decision to that effect.

## **Article 20 Awarding of degrees and certificates**

- 20.1 Master of Science degree.  
Students who have successfully completed the programme evaluation requirements will be awarded the Master of Science degree. The degree is signed by the Chair of the Examination Board, the Rector of the Institute and the Academic Registrar. In addition to the degree certificate, the graduate receives a degree supplement stating the results achieved and credit points for each component of the programme.
- 20.2 Certificate of Graduate Study.  
Students who fail to meet the master programme evaluation requirements and have accumulated a minimum of 45 credits will be awarded a certificate of graduate study in the programme for which they are registered. Registration as student will be terminated.
- 20.3 Certificate of attendance.  
Students who fail to meet the master programme evaluation requirements, or who suspend or terminate their registration, will be issued a certificate stating the result achieved and credit points for each successfully completed component of the programme, and the period of registration. The Certificate of Attendance is signed by the Course coordinator and the Academic Registrar.
- 20.4 If a student re-registers within 4 years after termination and meets (after assessment(s)) the requirements of an MSc degree, s/he is obliged to return the certificate as mentioned under art 20.2 and art 20.3.
- 20.5 With reference to art 20.4, if a student re-registers within 4 years with the aim to obtain an MSc degree, s/he has to re-take in full all failed and missed modules. Re-registration is only possible for a subsequent academic period.
- 20.6 Certificate for short or online course.  
Students who have successfully completed a credited short or online course including all its assessments, will be awarded a certificate. The certificate is signed by the Course coordinator and the Academic Registrar. In addition to this certificate, the graduate receives an academic transcript stating the result achieved and credit points awarded.
- 20.7 Certificate of Attendance.  
Students who have successfully completed the short or online course without assessments, and who have demonstrated an active participation in the course throughout the whole study period, will be awarded a Certificate of Attendance. The Certificate of Attendance is signed by the Course coordinator and the Academic Registrar.
- 20.8 GPDP diploma  
Students who have successfully collected a minimum of 20 ECTS for the programme will be awarded a Postgraduate Professional Diploma in Sanitation and Sanitary Engineering.  
The diploma is signed by the Rector of the Institute, the Chair of the Examination Board and the Academic Registrar. In addition to this diploma the graduate receives a diploma supplement stating the learning objectives, the composition of the programme, the results achieved and the associated credit points.
- 20.9 Students who fail to meet the requirements for the awarding of the GPDP diploma will receive a Certificate (art 20.4) for those courses which were successfully completed.

## **Article 21 Criteria for MSc degree with distinction**

21.1 The chair of the examination committee may consider to make a recommendation to the Examination Board for an MSc degree with distinction if the following conditions are met:

For single degree programmes:

- the candidate obtained a mark of 8.5 or higher for the thesis examination, and
- an arithmetic average mark at IHE Delft of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1,
- there were no re-assessments during the taught part, and
- a recommendation is made by the chair of the examination committee.

For double / multiple degree programmes where student sits for the thesis examination at IHE Delft:

- the candidate obtained a mark of 8.5 or higher for the thesis examination, and
- an arithmetic average mark at IHE Delft of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1.
- a recommendation is made by the chair of the examination committee.

The recommendation should also be based on the results for the courses obtained at the partner institute(s).

For double / multiple degree programmes where student sits for the thesis examination at a partner institute:

- the candidate obtained an arithmetic average mark at IHE Delft of 8.0 or higher for all modules that are assessed on a numerical scale, conform article 14.1.
- a recommendation is made by the professor responsible for the specialization concerned.

The recommendation should also be based on the results for the courses and thesis obtained at the partner institute(s).

21.2 The student will be awarded an MSc degree with distinction if the Examination Board takes a decision to that effect.

## Chapter 8. Appeals

### Article 22 Grounds for appeal

- 22.1 Students have the right to appeal against an assessment result, if
- a. the performance of the student suffered through illness or other factors;
  - b. a material administrative error in the conduct of an assessment occurred;
  - c. the assessment or evaluation was not conducted in accordance with the regulations;
  - d. some other material irregularity occurred;
  - e. there is a serious unsolved conflict with the supervisor or the mentor.

### Article 23 Procedure for appeal

- 23.1 A student shall first attempt to resolve the problem with the body or person that has taken the disputed decision.
- 23.2 If the appeal concerns a decision taken by an Examiner or an MSc Examination Committee, the appeal shall be submitted to the Examination Board within 3 weeks following the date on which the decision was made known. It should be submitted by the student in writing, stating the grounds for appeal and enclosing appropriate documentation, including an account of the attempt to resolve the case amicably.
- 23.3 If the appeal concerns a decision taken by the Examination Board - not being an appeal as referred to in Article 23.2 - or a decision taken by the Academic Registrar, the appeal shall be submitted to the Academic Appeals Board within 3 weeks following the date on which the decision was made known. It should be submitted by the student in writing, stating the grounds for appeal and enclosing appropriate documentation, including an account of the attempt to resolve the case amicably.
- 23.4 Pending the outcome of the appeal procedure, the initial (contested as per appeal) decision will remain in force and will be implemented
- 23.5 Reference is made to Appendix F for a detailed description of the appeal procedure.

## Chapter 9. Final Articles

### Article 24 Amendments

- 24.1 Amendments to these regulations are made by separate decision of the Rectorate.
- 24.2 No amendments shall be made in relation to the ongoing academic year, unless there is reasonable expectation that the amendment will not disadvantage the students.

### Article 25 Unforeseen situations

- 25.1 Situations which are not foreseen by the present regulations will be decided on by the Examination Board, where necessary after consultation with the programme committee concerned.

### Article 26 Publication

- 26.1 The Rectorate is responsible for the timely publication of these Examination Regulations, and any amendments thereof.

### Article 27 Period of application

- 27.1 These regulations take effect for the cohort 2017 – 2019. Approved by the Rectorate of IHE Delft on 11 July 2017





## Appendix A Qualifications of Graduates

### 1. Urban Water and Sanitation Programme

#### 1.1 Water Supply Engineering

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"><li>1. understand the structure of drinking water supply systems, including water transport, treatment and distribution;</li><li>2. understand water quality criteria and standards, and their relation to public health, environment and urban water cycle;</li><li>3. understand in-depth occurring physical, chemical and biological phenomena and their mutual relationships, within water supply systems;</li><li>4. understand water quality concepts and their effect on treatment process selection;</li><li>5. understand the interaction of water quality and materials applied;</li><li>6. understand hydraulic concepts and their relationship to water transport in treatment plants, pipelines and distribution networks;</li><li>7. understand the importance and methods for operation and maintenance of water supply systems;</li><li>8. understand options for centralised and urban systems versus decentralized and rural systems;</li><li>9. understand water supply engineering within a watershed context.</li></ol>
Applying knowledge and understanding	<ol style="list-style-type: none"><li>1. design and to rehabilitate raw water abstraction, transport, treatment and distribution processes and systems;</li><li>2. use statistical and modelling tools for simulating, prediction of performance and operation of water supply system components;</li><li>3. conduct independent research, including formulation of hypotheses, selection and application of research methodologies, and the formulation of conclusions and recommendations</li></ol>
Making judgements	<ol style="list-style-type: none"><li>1. define and evaluate project alternatives on basis of chosen selection criteria.</li></ol>
Communication	<ol style="list-style-type: none"><li>1. communicate effectively in oral and written presentations to technical and non-technical audiences.</li></ol>
Lifelong learning skills	<ol style="list-style-type: none"><li>2. posses the learning skills to acquire continual knowledge in an independent manner.</li></ol>

## 1.2 Sanitary Engineering

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. understand and explain the role of sanitation in urban water cycle and its relation to public health and environment;</li> <li>2. develop rational approaches towards sustainable waste(water) management via pollution prevention, appropriate treatment, resources recovery and re-use on both centralized and decentralized level;</li> <li>3. understand in-depth relevant physical, chemical and biological processes, and their mutual relationships within various sanitation components.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. apply gained knowledge and skills in practice;</li> <li>2. prepare conceptual engineering and process design of sanitation components;</li> <li>3. apply modern tools for technology selection and carry out modelling of sanitation components;</li> <li>4. identify, develop and conduct independent research including formulation of hypotheses selection and application of research methodologies, and the formulation of conclusions and recommendations;</li> <li>5. carry out desk studies, field work, and laboratory based research;</li> <li>6. contribute to the development of innovative approaches to the provision of adequate and sustainable sanitation services in developing countries and countries in transition.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. define and critically analyse, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge and solid waste treatment process technologies;</li> <li>2. analyse, synthesise, integrate, interpret, and discuss both scientific and practical information in the context of various research and engineering projects including preparation of Master plans, feasibility studies and preliminary designs;.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. clearly communicate concerning both oral and written skills.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. continuously acquire knowledge and assimilate and implement innovative learning methods and skills in an independent manner;</li> <li>2. operate both autonomously and in a multidisciplinary and multinational environment.</li> </ol>

### 1.3 Urban Water Engineering and Management

After successful completion of the programme graduates will be able to:

<p>Knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. understand the urban water cycle and its water system components, their characteristics and functioning within greater urban infrastructure systems;</li> <li>2. understand urban water management problems including ability to: identify water systems' demand; deal with climatic and hydrologic uncertainties and/or extremes; institutional limitations; and work within a data-constrained environment;</li> <li>3. understand water infrastructure/asset planning, financing and management, and utility management;</li> <li>4. familiarise with the concept of integrated water resources management (IWRM) and its application to a variety of water management problems at the urban catchment scale.</li> </ol>
<p>Applying knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. make appropriate and critical use of methods, techniques and tools necessary to monitor, analyze and design urban water systems including: water supply infrastructure; drinking water treatment and distribution; wastewater collection, treatment, transport and disposal systems; drainage systems;</li> <li>2. identify, articulate, analyse and solve problems of the urban water cycle and systems, integrating theory and applications;</li> <li>3. collect, summarise, analyse and interpret technical data/materials in a structured form to gain knowledge on urban water system design and operation and maintenance;</li> <li>4. work with a range of information technology tools available for solving urban water management problems and for effectively communicating with fellow water managers, researchers, scientists, planners, and policy-makers.</li> </ol>
<p>Making judgements</p>	<ol style="list-style-type: none"> <li>1. critically recognize and assess the need for continued-education and research on planning, design, maintenance and management of urban water systems.</li> </ol>
<p>Communication</p>	<ol style="list-style-type: none"> <li>2. reporting and give presentation.</li> </ol>
<p>Lifelong learning skills</p>	<ol style="list-style-type: none"> <li>1. learn independently;</li> <li>2. demonstrate having improved IT skills;</li> <li>3. work independently and / or as part of a team;</li> <li>4. manage time effectively.</li> </ol>

## 2. Environmental Science Programme

### 2.1 Environmental Science & Technology

After successful completion of the programme, graduates will be able to:

<p>Knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources;</li> <li>2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;</li> <li>3. identify the impacts of human activities on the environment, under different levels of environmental stress and in different socio-economic contexts;</li> <li>4. name and explain concepts, instruments and technologies for pollution prevention and remedial actions in a national and international context.</li> </ol>
<p>Applying knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;</li> <li>2. apply general methods (including statistics and modelling) in scientific and technological approaches, concepts and interventions;</li> <li>3. contribute as a flexible and creative member in interdisciplinary teams in developing solutions for prevention or remediation of environmental problems, by linking scientific knowledge to engineering interventions and to management decisions in different cultural and socio-economic contexts, and using different levels of available knowledge and information.</li> </ol>
<p>Making judgements</p>	<ol style="list-style-type: none"> <li>1. critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;</li> <li>2. conduct research, independently or in a multidisciplinary team, including the formulation of research questions and hypotheses, the selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations.</li> </ol>
<p>Communication</p>	<ol style="list-style-type: none"> <li>1. communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.</li> </ol>
<p>Lifelong learning skills</p>	<ol style="list-style-type: none"> <li>1. demonstrate academic attitude and learning skills (including thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

## 2.2 Environmental Planning & Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources;</li> <li>2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;</li> <li>3. understand the environmental policy cycle and planning process and to analyse and prepare environmental policy strategies, taking into account the impact that society has on water and environmental resources;</li> <li>4. name and explain principles, concepts and instruments of major national and international water and environmental legislation and common and desired institutional and management arrangements.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;</li> <li>2. apply general scientific methods (including statistics and environmental modelling) to processes of water and environmental resources allocation and use at different scales in order to gain an understanding of problems, trends, causes and effects;</li> <li>3. apply environmental scientific methods (including environmental impact assessment, policy analysis, resource valuation, environmental economics) and models for institutional development with emphasis on policy development, functional decentralisation and good governance;</li> <li>4. design and facilitate consultation- and decision-making processes between stakeholders, users and their representatives, water managers, politicians and other decision-makers.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;</li> <li>2. identify and critically assess the different ecological and socio-economic functions and values of the environmental system and the, often competing, interests of the various stakeholders;</li> <li>3. conduct research, independently or in a multidisciplinary team, including the formulation of research questions and hypotheses, the selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations;</li> <li>4. design comprehensive environmental resources policies and strategies that aim to enhance the sustainable use of the environment especially focusing on water, and that include a suitable combination of technical, legal, administrative and financial measures.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences;</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. demonstrate academic attitude and learning skills (including thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner;</li> </ol>

## 2.3 Water Quality Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources;</li> <li>2. describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;</li> <li>3. identify the impacts of human activities on aquatic ecosystems;</li> <li>4. name and explain principles, concepts and instruments of main national and international water and environmental legislation and common and desired institutional and management arrangements.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;</li> <li>2. interpret, design and optimise water quality monitoring and assessment schemes in the watershed;</li> <li>3. apply experimental, statistical and modelling tools for interpreting and designing water quality management programmes;</li> <li>4. conduct research, independently or in a multidisciplinary team, including the formulation of research questions and hypotheses, the selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;</li> <li>2. contribute as a flexible and creative member in interdisciplinary teams in developing solutions for water quality management problems in different cultural and socio-economic contexts, and using different levels of available knowledge and information;</li> <li>3. critically analyse and evaluate alternative water quality management programmes in the watershed under different socio-economic and legal contexts, often in data-poor conditions.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. demonstrate academic attitude and learning skills (including thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

## 2.4 MSc programme in Environmental Science with specialisation Limnology and Wetland Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. to demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex interrelationship between protection and wise use of environmental resources;</li> <li>2. to describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;</li> <li>3. to identify the impacts of human activities on freshwater ecosystems in different socio-economic contexts;</li> <li>4. to demonstrate knowledge and understanding of the international water quality guidelines;</li> <li>5. to name and explain concepts, instruments and technologies for protection and remedial actions of freshwater ecosystems.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. to design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;</li> <li>2. to design, optimise and interpret environmental monitoring and assessment schemes for freshwater ecosystems;</li> <li>3. to apply general scientific methods (including statistics and environmental modelling) for the development and application of scientific and technological approaches, concepts and interventions to address problems of freshwater ecosystems;</li> <li>4. to conduct research, independently/in multidisciplinary teams, incl. formulation of research questions and hypotheses, selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;</li> <li>2. to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of problems related with freshwater ecosystems, under different socio-economic and legal contexts, and under often data-poor conditions;</li> <li>3. to contribute in interdisciplinary teams in developing solutions for prevention/remediation of aquatic ecosystem problems by linking scientific knowledge to engineering interventions and management decisions in different cultural/socio-economic contexts.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. to communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. to demonstrate academic attitude and learning skills (incl. thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in an independent manner.</li> </ol>



## 2.5 Joint MSc programme in Environmental Science with specialisation Environmental Technology for Sustainable Development with AIT, Bangkok

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. to demonstrate understanding of natural environmental processes, the socio-economic concepts underlying functioning and exploitation of environmental systems, and of the complex interrelationship between protection and wise use of environmental resources;</li> <li>2. to describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;</li> <li>3. to identify the impacts of human activities on the environment, under different levels of environmental stress and in different socio-economic contexts;</li> <li>4. to name and explain concepts, instruments and technologies for pollution prevention and remedial actions in a national and international context.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. to design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;</li> <li>2. to apply general methods (including statistics and modelling) in scientific and technological approaches, concepts and interventions;</li> <li>3. to contribute in interdisciplinary teams in developing solutions for prevention/remediation of environmental problems by linking scientific knowledge to engineering interventions and to management decisions in different cultural/socio-economic contexts;</li> <li>4. to conduct research, independently/in multidisciplinary teams, incl. formulation of research questions and hypotheses, selection and application of research methodologies and techniques and the formulation of well-founded conclusions and recommendations.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. to communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. to demonstrate creativity and critical, multidisciplinary thinking for problem-solving and decision-making;</li> <li>2. to demonstrate responsibility and own initiative;</li> <li>3. to demonstrate capacity to work in an international, multi-cultural team;</li> <li>4. to demonstrate academic attitude and learning skills (incl. thinking in multidisciplinary dimensions and distinguishing main issues from minor ones), to enhance and keep up-to-date the acquired knowledge and application skills in an independent manner.</li> </ol>

### 3. Water Management and Governance Programme

#### 3.1 Water Management and Governance

After successful completion of the programme, graduates will be able to:

<p>Knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and ecological processes and how these processes are dynamically linked with human activities, including land and water use.</li> <li>2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water, including policies, laws and institutions, and by adopting a historical perspective.</li> <li>3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches.</li> <li>4. comprehend the broader scientific, engineering, socio-economic and environmental context in which water management and governance issues are manifested and addressed.</li> </ol>
<p>Applying knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. formulate and apply water management and governance frameworks / tools / methods to water related issues in a given context in a social inclusive and environmental sustainable manner.</li> <li>2. apply different concepts and methods in a coherent way and through a process of triangulation synthesize results and draw well reason conclusions and recommendations.</li> <li>3. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.</li> </ol>
<p>Making judgements</p>	<ol style="list-style-type: none"> <li>1. compare and contrast different ideas and approaches to make sound judgement based on available information, and assess the potential for application, integration and further development.</li> <li>2. apply suitable techniques, tools and procedures for a given context in order to evaluate the consequences of different development and intervention scenarios.</li> <li>3. reflect critically on ho how different activities impact on the sustainable use of water in a given context.</li> <li>4. reflect on own professional and educational background relate to this knowledge and skills needed to build a solid career in the water sector, and on this basis identify a coherent personal learning trajectory.</li> </ol>
<p>Communication</p>	<ol style="list-style-type: none"> <li>1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.</li> </ol>
<p>Lifelong learning skills</p>	<ol style="list-style-type: none"> <li>1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.</li> <li>2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> <li>3. Have the ability to reflect on own performance and advance own career within the water sector.</li> </ol>

### 3.2 Water Resources Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and ecological processes and how these processes are dynamically linked with human activities, including land and water use.</li> <li>2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water, including policies, laws and institutions, and by adopting a historical perspective.</li> <li>3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches.</li> <li>4. characterize and explain water resource issues using economic concepts and theory for addressing water issues and describe how economic concepts and tools including valuation support integrated water resources management.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. model processes of the water system (rainfall-runoff, flooding, water allocation, water accounting), validate models, critically interpret model outcomes in order to derive insight in trends, causes and effects, and define and explain model limitations.</li> <li>2. formulate and critically evaluate governance frameworks related to water resources management and apply tools for policy analysis with the emphasis on social inclusion and sustainability.</li> <li>3. Apply and develop integrated tools / methods to support water resources assessment / planning / management at different scales and accounting for aspects relating to quality and quantity and upstream / downstream linkages.</li> <li>4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. analyse a given water resources system in order to quantify the water flows over space and time, accounting for and describing the interdependencies between many (competing) water users.</li> <li>2. critically evaluate technical and/or institutional water resources interventions (policy actions / agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.</li> <li>2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

### 3.3 Water Services Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. describe for a given water resources system the interplay between the main biophysical processes and social dynamics, in analyzing service delivery modalities.</li> <li>2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements concerning water supply and sanitation services, including policies, laws and institutions, and by adopting a historical perspective.</li> <li>3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water services management and describe challenges of providing water supply and sanitation services at different levels (from global to local).</li> <li>4. summarize the current debates relevant for water supply and sanitation services, using institutional and management theories from different academic disciplines (e.g. economics, public administration, sociology, political science, law).</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. design and apply analytical tools to research issues of water services management and describe, modify and apply management tools (e.g. with the benchmarking, cost benefit analysis, management information systems) with the aim of improving water supply and sanitation provision.</li> <li>2. formulate and critically evaluate governance frameworks related to water services management and apply tools for policy analysis with the emphasis on social inclusion and sustainability.</li> <li>3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.</li> <li>4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. analyze and evaluate governance processes and utility management arrangements in the water services sector, integrating technical, legal administrative, social and financial components.</li> <li>2. critically evaluate technical and/or institutional interventions (e.g. policies actions, agreements) through analysis of implications for water supply and sanitation services, its users and their interrelations at various spatial and temporal scales.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.</li> <li>2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

### 3.4 Water Quality Management

After successful completion of the programme, graduates will be able to:

<p>Knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. describe and predict for a given water resources system the main hydrological, hydraulic, chemical and biological processes and how these processes are dynamically linked with aquatic ecosystems as well as with human activities such as land and water use and pollution.</li> <li>2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements for water quality management, including policies, laws and institutions, and by adopting a historical perspective.</li> <li>3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of aquatic ecosystems and describe the challenges of such approaches.</li> <li>4. describe concepts to determine the value of water for various uses and users in (amongst others) economic and ecological terms and explain how these concepts can be used in water resources planning at various spatial and temporal scales.</li> </ol>
<p>Applying knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. interpret, design and optimize water quality assessment and monitoring programmes by applying experimental, statistical and modelling tools.</li> <li>2. formulate and critically evaluate governance frameworks related to water quality management and apply tools for policy analysis with the emphasis on social inclusion and sustainability.</li> <li>3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.</li> <li>4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions.</li> </ol>
<p>Making judgements</p>	<ol style="list-style-type: none"> <li>1. define a given water resources system, and compose the water and pollution flows across time and space, including the various water uses, and describe the interdependencies these create between the various water users.</li> <li>2. critically evaluate technical and/or institutional interventions focused on water quality (projects/ programmes/ policies/ agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.</li> </ol>
<p>Communication</p>	<ol style="list-style-type: none"> <li>1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.</li> </ol>
<p>Lifelong learning skills</p>	<ol style="list-style-type: none"> <li>1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.</li> <li>2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

### 3.5 Water Conflict Management

After successful completion of the programme, graduates will be able to:

<p>Knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. describe for a given water resources system the interplay between the main biophysical processes and social dynamics, in analyzing, anticipating, preventing and managing conflicts.</li> <li>2. describe and explain the main concepts and instruments for analysing and influencing formal and informal arrangements over water for collaboration, including policies, laws and institutions, and by adopting a historical perspective.</li> <li>3. explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches at sector, intersectoral and transboundary levels.</li> <li>4. name and critically discuss theories, concepts and tools of conflict management and cooperation building techniques in the context of natural resources and water in particular.</li> </ol>
<p>Applying knowledge and understanding</p>	<ol style="list-style-type: none"> <li>1. design and facilitate inclusive consultation and conflict management processes, such as consensus building, public participation, negotiation and mediation between actors at different levels.</li> <li>2. formulate and critically evaluate governance frameworks related to water conflict management and apply tools for policy analysis with the emphasis on social inclusion and sustainability.</li> <li>3. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.</li> <li>4. conduct, independently or in a multidisciplinary team, research including the formulation of research questions and hypotheses, the selection and application of adequate research methodologies and techniques and the formulation of well-founded conclusions, recommendations and limitations.</li> </ol>
<p>Making judgements</p>	<ol style="list-style-type: none"> <li>1. appraise the different functions of the water resources system, and the associated competing interests of water using sectors and actors, describe the inter-dependencies between these, and finally assess the possibilities and limitations of cooperation.</li> <li>2. critically evaluate technical and/or institutional interventions focused on conflict management (projects/ programmes/ policies/ agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.</li> </ol>
<p>Communication</p>	<ol style="list-style-type: none"> <li>1. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.</li> <li>2.</li> </ol>
<p>Lifelong learning skills</p>	<ol style="list-style-type: none"> <li>1. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.</li> <li>2. have the academic attitude and learning skills to enhance and keep up-to-date the acquired knowledge and application skills in a largely independent manner.</li> </ol>

### 3.6 Water Cooperation and Diplomacy

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"><li>1. Articulate the complexities of socio-natural processes</li><li>2. Discuss and compare theories and dimensions of conflict and its avoidance, management and resolution</li></ol>
Applying knowledge and understanding	<ol style="list-style-type: none"><li>1. Use an interdisciplinary approach to critically assess and evaluate conflict management tools and techniques available to deal with water-related disputes</li><li>2. Apply conflict management tools and design conflict resolution processes with the aim of mitigating water management disputes</li></ol>
Making judgements	<ol style="list-style-type: none"><li>1. Critically analyse water disputes (including actors, policies, institutions, historical, social and bio-physical processes)</li><li>2. Identify and analyse issues, challenges and potential conflicts of water allocation and access to water resources at different scales</li></ol>
Communication	
Lifelong learning skills	<ol style="list-style-type: none"><li>1. Research the selection and application of adequate methodologies and techniques of water conflict management tools and formulate well-founded conclusions and recommendations</li></ol>

## 4. Water Science and Engineering Programme

### 4.1 Hydrology and Water Resources

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"><li>1. have in-depth understanding of the current theories and concepts in both surface and subsurface hydrology, the relevant physical, chemical and biological process interactions between the hydrosphere, the lithosphere, the biosphere and the atmosphere, and have a thorough awareness of the natural and human-induced variability in space and time of hydrological systems;</li><li>2. master the major hydrological methodologies and applications with regard to both water quantity and water quality, including techniques for data collection, processing and analysis, and the application of catchment hydrological modelling and aquifer modelling techniques;</li><li>3. have a good knowledge of the relevant literature and the contemporary research questions in the field of hydrology.</li></ol>
Applying knowledge and understanding	<ol style="list-style-type: none"><li>1. apply and integrate the relevant physical, chemical, applied mathematical, computational and earth-scientific principles and concepts, and to use information and communication technology within a hydrological context;</li><li>2. design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework.</li></ol>
Making judgements	<ol style="list-style-type: none"><li>1. evaluate and analyse hydrological systems and processes at a wide range of scales in both space and time for the purpose of water resources assessment, natural hazards assessment and mitigation, and environmental planning and management;</li><li>2. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others.</li></ol>
Communication	<ol style="list-style-type: none"><li>1. adequately communicate methodologies, results, evaluations, conclusions and recommendations in oral, written and graphical form to a wide variety of audience.</li></ol>
Lifelong learning skills	<ol style="list-style-type: none"><li>1. be aware of the importance of hydrology to society, the relationship of hydrology with related disciplines such as ecology, meteorology and climatology, and be able to co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills; and</li><li>2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.</li></ol>



## 4.2 Hydraulic Engineering and River Basin Development

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. have in-depth understanding of physical processes and natural phenomena in river basin systems, development of river basins by human interference, such as designing river structures and training works, and the management of floods and droughts;</li> <li>2. master the major hydraulic methodologies and applications for river structures and river modelling techniques with regard to techniques for data collection, processing and analysis;</li> <li>3. have knowledge of contemporary research (questions) and relevant literature in the field of hydraulic engineering and river basin development;</li> <li>4. have acquired sufficient skills in using information and communication technology for conducting studies and analyses, in addition to presentation and communication.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. evaluate and analyse river basin systems and processes at a wide range of scales for the purpose of water resources, including morphological assessments, impact analysis of hydraulic structures and natural hazards assessment and mitigation taking into account relevant aspects of environmental, economical and social planning and management;</li> <li>2. design and conduct hydraulic research, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework; by intelligent use of engineering and scientific principles, develop and undertake critical evaluations of strategies for the implementation of river engineering works;</li> <li>3. have the skills to apply and integrate relevant concepts and methodologies in the area of hydraulic, hydrological and geotechnical engineering and research as well as applying computational principles within the context of hydraulic engineering.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. critically judge and evaluate their own work and results, as well as the information of prior research or investigations.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. adequately communicate methodologies, results, evaluations, conclusions and recommendations in written, oral and graphical form to a wide variety of audience.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. be aware of the importance of hydraulic engineering to society and be able to co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills;</li> <li>2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and applications in an independent manner.</li> </ol>

### 4.3 Coastal Engineering and Port Development

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. have advanced level of understanding of the hydraulics, coastal processes and nautical and logistic aspects and their interactions with the nearshore and offshore structure;</li> <li>2. develop strategies to cope effectively with problems related to natural hazards (e.g. coastal floods) and shoreline erosion problems and understand the conflict between coastal developments and natural coastal processes;</li> <li>3. develop an understanding of the application of modern analysis and design techniques to coastal problems and gain the expertise necessary to make effective engineering interventions in the coastal environment;</li> <li>4. be equipped with various analytical and computational expertise necessary to solve problems in coastal and port engineering.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. apply sophisticated design techniques using theoretical concepts of coastal hydraulics and various principles and approaches of coastal engineering design to advance the needs of society for shelter, infrastructure and a safe environment and be able to evaluate and implement the solutions in a multidisciplinary and interdisciplinary environment;</li> <li>2. apply hydraulic and nautical, logistic and economic theories in the planning and design of coastal and ports layout and port logistics;</li> <li>3. have the skills to undertake academic research that contributes to the better understanding of coastal and/or port engineering;</li> <li>4. have developed the talents and skills for problem formulation and solutions synthesizing different fields of knowledge to formulate solutions to relevant technical problems using modern engineering tools.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. place a coastal engineering and/or port project in its environment (social, ecological and physical environment), be able to quantify and understand the interactions between the project and the environment, and is able to communicate the interactions with experts of a different background.</li> </ol>
Communication	
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. have developed the skills to undertake independent creative academic activities and research and the ability to extend them leading to new knowledge that addresses problems of national and international importance;</li> <li>2. have experienced different aspects of learning which are integrated through different teaching methods and through independent study experiences;</li> <li>3. possess critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design;</li> <li>4. have acquired sufficient skills in using information and communication technology for conducting research, studies and analyses, in addition to presentation and communication;</li> <li>5. develop a sense of professionalism and an appreciation for the obligations of a professional engineer;</li> <li>6. be aware of the professional and ethical issues encountered in engineering practice</li> </ol>

#### 4.4 Land and Water Development

After successful completion of the programme graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. Describe the latest concepts and theories of irrigation and drainage design, modernisation and management, flood protection and land reclamation for sustainable development and food security;</li> <li>2. Explain the cross-sectoral linkages related to land and water development comprehending wider aspects of society, economy, human health and environment and its contributions to food security;</li> <li>3. Acquire knowledge and understanding of contemporary research issues in the field of land and water development for food security.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. Apply the latest hydraulic engineering and hydrological methods in planning, design and implementation of irrigation and drainage schemes, independently or in a multidisciplinary team;</li> <li>2. Apply innovative tools like Remote Sensing and GIS in planning and performance management of land and water development schemes for enhanced food security.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. Identify options for participatory land and water development, and critically assess their technical, socio-economic and environmental performance;</li> <li>2. Evaluate aspects of planning, design, modernization, operation &amp; maintenance and financing of irrigation and drainage schemes.</li> <li>3. Identify, develop and conduct independent research including formulation of hypotheses, selection and application of research methodologies, planning and executing of data gathering and analysis, and formulation of conclusions and recommendations.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. Clearly and systematically communicate, argue and defend research proposal and findings orally and written to a wide variety of audience.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. Independently acquire knowledge, critically assess data, and acquire critical reading and writing skills whereby distinguishing between minor and major issues.</li> <li>2. Contribute to the development of innovative approaches for adequate and sustainable land and water development for food security.</li> </ol>

#### 4.5 Learning objectives Agricultural Water Management for Enhanced Land and Water Productivity (joint specialisation with AIT)

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. have in-depth understanding and specific knowledge of the latest concepts and theories of irrigation, drainage, flood management, land reclamation and consolidation technologies for increased returns from land and water resources in a sustainable manner;</li> <li>2. have in-depth understanding and specific knowledge of the cross-sectoral linkages between land and water development and wider aspects of society, economy and the environment</li> <li>3. acquire knowledge and understanding of contemporary research issues in the fields of land and water development and agricultural water management.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. use latest hydraulic engineering and hydrological methods to apply in planning, design, implementation and management of irrigation, drainage and flood protection schemes, independently or in a multidisciplinary team;</li> <li>2. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their technical, economical, institutional and environmental feasibility;</li> <li>3. engage in or advise the developers, system managers and water users on the participatory development, management and modernisation, including planning, design, implementation, operation and maintenance, as well as on modernisation of the irrigation, drainage and flood management schemes;</li> <li>4. formulate and conduct hydraulic and agronomic research, plan development and designs in the field of enhanced land and water productivity, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework.</li> </ol>
Making judgements	
Communication	<ol style="list-style-type: none"> <li>1. formulate research questions, articulate research methodologies, develop study plans, and adequately communicate research results and conclusions in written and oral forms to a wide variety of audience.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. develop the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.</li> </ol>

#### 4.6 Learning objectives of the Advanced Water Management for Food Production Program specialization, (joint specialisation with Nebraska)

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. understand in-depth the latest concepts and theories of irrigation, drainage, flood protection, land reclamation and consolidation technologies for food production;</li> <li>2. describe the cross-sectoral linkages comprehending wider aspects of society, economy and the environment;</li> <li>3. understand and formulate water management methodologies to enhance crop production with limited water supplies;</li> <li>4. acquire knowledge and understanding of contemporary research issues in the field of land and water development and water for food.</li> <li>5. identify and develop available water resources for food production;</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. use latest hydraulic engineering and hydrological methods to apply in planning, design and implementation of irrigation, drainage and flood protection schemes, independently or in a multidisciplinary team;</li> <li>2. enhance the of on-farm irrigation systems through better design and management;</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their feasibility; technologically, economically, and environmentally;</li> <li>2.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. engage in or advise developers, system managers and water users on the participatory development and management, including operation and maintenance of the irrigation, drainage and flood protection schemes;</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. formulate research questions, articulate research methodologies, develop study plans, and adequately communicate research results and conclusions in written and oral forms to a wide variety of audience.</li> </ol>

## 4.7 Hydroinformatics– Modelling and Information Systems for Water Management

After successful completion of the programme, graduates will be able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. have in-depth understanding of the information cycle in relation to the management of water based systems, and have a thorough awareness of the flow of information from data acquisition to modelling, to support for decision making;</li> <li>2. have a critical understanding of the theories and concepts of physical, chemical and biological processes relating to the flow of water in the natural environment, including river basins, coastal waters and urban water systems, as necessary to generate safe and reliable models for water based systems;</li> <li>3. have an understanding of advanced and appropriate information and communication technologies and their application to manage information relating to water management;</li> <li>4. have a good knowledge of the relevant literature and the contemporary research questions in the field of Hydroinformatics.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. master the theory and practice of different modelling paradigms, and, in particular, physically based and data driven modelling, and be able to integrate them in hydroinformatics systems applied to a wide variety of hydraulic, hydrological and environmental situations;</li> <li>2. to select and apply software tools available on the market, and critically assess their advantages and disadvantages in application to water resources management, hazard risk assessment and forecasting, environmental planning and asset management;</li> <li>3. provide considered advice to managers and users of advanced Hydroinformatics tools;</li> <li>4. appreciate and discuss the ethics and nature of the postmodern society and the role of water within it as a "right" and an "asset".</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. make critical use of advanced theories and concepts in Hydroinformatics to research creative solutions for new problems and situations, either independently or within a team;</li> <li>2. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others.</li> </ol>
Communication	<ol style="list-style-type: none"> <li>1. develop a range of personal and communication skills, including the use of appropriate information and communication technologies, for oral and written presentation of methodologies, results, evaluations, conclusions and recommendations to a wide variety of audiences.</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. be aware of the importance of the relationship of Hydroinformatics with related disciplines such as hydraulics, hydrology, ecology and information science, and be able to co-operate within a multidisciplinary and interdisciplinary framework;</li> <li>2. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner;</li> <li>3. be aware of the professional and ethical issues encountered in Hydroinformatics practice directed towards issues facing developing countries and countries in transition.</li> </ol>

## 4.8 Flood Risk management

After successful completion of the programme, graduates will have:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. a broad and cross-boundary scientific knowledge on flood risk management;</li> <li>2. a comprehensive knowledge base and understanding of the current theory and practice relating to flooding and flood management;</li> <li>3. the fundamental knowledge leading to the understanding of socio-economic issue related to flooding;</li> <li>4. a broad scientific knowledge about conservation, restoration and management measures to overcome challenges imposed on water by humans and by climate change, and;</li> <li>5. an extended knowledge on a basin-wide approach to flood risk management.</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. analyse the reciprocal relationships between the physical system, the institutional framework and the socio-economic environment, identifying future social and climatic pressures and needs and the consequent trends in system management;</li> <li>2. apply specific practical skills, such as identifying the major physical processes in a given river basin or coastal zone and their interaction with the associated assets and receptors;</li> <li>3. identify the links between all issues related to flooding in order to apply an integrated approach using the best tools to support decision making for the sustainable management of floods;</li> <li>4. review scientific literature and carry out independent research (such as writing a state of the art paper based on research and practice literature);</li> <li>5. apply sophisticated hydroinformatics and modelling tools and best practices to address the problems of flood risk management.</li> </ol>
Making judgements	
Communication	<ol style="list-style-type: none"> <li>1. communicate his/her knowledge and research results to the scientific and non-scientific communities (such as presenting papers/posters to scientific congresses, general lectures to policy makers and interested non-specialists).</li> </ol>
Lifelong learning skills	<ol style="list-style-type: none"> <li>1. occupy an independent and responsible position as a flood risk professional;</li> <li>2. acquire independently further knowledge and techniques, and</li> <li>3. operate in a team.</li> </ol>

#### 4.9 Groundwater and Global Change - Impacts and Adaptation

At the end of the programme students are able to:

Knowledge and understanding	<ol style="list-style-type: none"><li>1. explain in detail how groundwater systems function;</li><li>2. describe the interactions between groundwater systems, climate, surface waters and land use.</li></ol>
Applying knowledge and understanding	<ol style="list-style-type: none"><li>1. use modelling tools for climate and groundwater systems;</li><li>2. plan groundwater-related adaptation solutions for global change.</li></ol>
Making judgements	<ol style="list-style-type: none"><li>1. identify the consequences of global and climate change impacts for groundwater management under uncertainty.</li></ol>
Communication	<ol style="list-style-type: none"><li>1. effectively transfer knowledge, through written and oral communication, using the English language, within the scientific discipline.</li></ol>
Lifelong learning skills	<ol style="list-style-type: none"><li>1. demonstrate creativity and critical, multidisciplinary thinking for problem-solving and decision-making;</li><li>2. take responsibility, show initiative and have the capacity to work in an international, multi-cultural team.</li></ol>



## 5. Graduate professional diploma programme

Upon completion of the programme participants will be qualified to:

- perform as a competent professional in the field of sanitation and/or sanitary engineering
- to contribute to the development of innovative approaches to the provision of sustainable sanitation services especially under challenging conditions usually prevailing in developing and countries in transition.

Students are able to:

Knowledge and understanding	<ol style="list-style-type: none"> <li>1. Understand and explain the role of sanitation in the urban water cycle and its relation to public health and environment;</li> <li>2. Understand the relevant physical, chemical and biological processes and their mutual relationships within various sanitation components;</li> </ol>
Applying knowledge and understanding	<ol style="list-style-type: none"> <li>1. Develop rational approaches towards sustainable wastewater management via pollution prevention, appropriate treatment, and resource recovery and re-use at both centralized and decentralized setting;</li> <li>2. Apply modern tools for technology selection and to model sanitation components.</li> </ol>
Making judgements	<ol style="list-style-type: none"> <li>1. Define and critically analyze, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge (including faecal sludge) and solid waste treatment process technologies;</li> <li>2. Analyze, synthesize, integrate, interpret, and discuss scientific and practical information in the context of preparing research and engineering projects including preparation of master plans, feasibility studies and preliminary designs.</li> </ol>
Communication	
Lifelong learning skills	

## Appendix B Examination Procedures

### GENERAL RULES

Students taking part in an examination are expected to have taken notice of these procedures and are expected to understand the implied meaning of these procedures.

### WRITTEN EXAMINATIONS

#### PROCESS:

1. the student brings his / her student card and displays it on the table;
2. the invigilator verifies the card and confirms attendance by the student by ticking the box of the student on the attendance list;
3. students hand in their exam papers at the end of the session; this is their own responsibility;
4. invigilators bring the exam papers to the Education Office (immediately after the exam);
5. Education Officers verify which exam papers have been received and record this on a list;
6. the list produced by the Education Officers serves as the evidence that the exam papers have been handed in;
  - a. if exam papers get lost and they have been recorded on the list of Education Office, IHE Delft has the responsibility to propose an adequate alternative assessment to the student.
  - b. if a student claims that an exam paper got lost and the exam paper is not recorded on the list of Education Office, then the Institute considers the exam paper not to have been handed in by the student. There will be no alternative assessment proposed.

**Invigilators:** The invigilators (examination supervisors) ensure proper conduct of the examination and maintain order in the examination room. They will announce the beginning and the duration of the examination, and will warn the students 10 minutes before the ending of the examination.

**Communication:** During the examination, students are not allowed to exchange materials or to communicate with other students. If something is unclear, students have to inform the invigilator, who will contact the programme coordinator, the examiner or education officer if necessary.

**Attendance list:** Students are considered to have taken part in an examination from the moment they receive the examination papers from the invigilators, whether or not they submit any answers.

**Bags:** Bags and carrying cases, including penholders, are to be placed along the side of the room before the start of the examination.

**Exam paper:** Answer and scratch paper will be provided to the students. Students provide the answers in clearly readable English, with proper indication of the question label. All answer papers must carry the student number and locker number of the student. Unreadable answers or unidentified answer papers may be discarded for assessment by the examiner.

**Pen:** Students are required to bring the necessary writing and drawing tools. The answer papers to be submitted must be written with a pen, a pencil is not allowed.

**Dictionary:** The use of a printed language dictionary without any additional written annotations is allowed (all languages are allowed). Invigilators are allowed to check the dictionaries for hand-written annotations during the exam (spot checks while they are walking around).

Electronic dictionaries are not allowed.

**Calculators:** Only self contained calculators with a single-line display or dual-line display are allowed, provided that these devices are battery operated, that any audio functions are switched off, and that these devices are exclusively built for calculation purposes only and do not have internet access.

**Cell phones:** Use of cell phones is not allowed and must be switched off

**Other materials:** The use of materials other than listed above, including blank paper, texts, laptops, computing and communication devices, personal audio and video devices, of any kind, is not allowed.

Examiners may nevertheless allow students to use specified text matter or other effects in a so-called 'open book' examination. These materials shall not include previous or example examinations and solutions.

**Toilet visit:** Only one student at a time will be allowed by the invigilator to leave the examination room for a short visit to the lavatory, except during the first 15 and the last 15 minutes of the examination. Examination materials and requirements may not be taken outside the examination room. Before leaving the examination room, students have to hand over their cell phone to the invigilator.

**Submission of exam papers:** Students who finish the examination at least 15 minutes after the start and at least 15 minutes before the ending of the examination are allowed to submit their work to the invigilator and quietly leave the examination room.

Students have to ensure that all required papers are submitted to the invigilator. Papers cannot be submitted after the student has left the examination room.

#### **ASSIGNMENT REPORTS AND INDIVIDUAL DISCUSSIONS**

For designated subjects students have to submit an assignment report, which will be assessed as part of the subject examination. The examiner may discuss the assignment report with the student as part of the assessment.

The examiner will set a deadline for submitting assignment reports. The deadline cannot be set at a date after the examination period for the subject, as indicated in the academic calendar. Students submit assignments to either the lecturer or the responsible coordinator.

## Appendix C GRADING SYSTEMS used by partner institutes

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### 1. Asian Institute of Technology

Grade	Grade Points	Description
A	4	Excellent
B+	3.5	
B	3	Good
C+	2.5	
C	2	Fair
D	1	Deficient
F	0	Fail
I		Incomplete

### 2. Universidad del Valle

Grade	Description
0.0	Given when absent from the exam without valid reason, when blank exam is submitted, or when caught cheating.
1.0 – 2.9	Non-pass, resit needed
3.0	Acceptable
4.0	Good
5.0	Excellent

Degree is awarded when

- GPA for the taught part is 3.5 or higher, and
- a pass is obtained for the thesis. (pass / non-pass)

### 3. Egerton University

Grade	Grade Points	Description
A	70% and above	Excellent
B	60-69%	Good
C	50-59%	Average
F	0-49%	Fail

Grading systems approved by the University Senate, with 50% as the pass mark.

### 4. BOKU

Austrian grade	ECTS Grade	Description
1	A/B	excellent/very good
2	C	good
3	D	satisfactory
4	E	pass

### 5. TU Dresden:

Grade	Grade Points	Description
A	1	very good
B	2	good
C	3	satisfactory
D	4	sufficient
E	5	insufficient

All courses have to be lower than 4 for a degree.

### 6. University of Ljubljana

Grade	Description
10	excellent: outstanding results with negligible mistakes
9	very good: high pass with minor mistakes
8	very good: sound knowledge
7	good: sound knowledge with major mistakes
6	satisfactory: adequate knowledge suiting minimum criteria
5 - 1	insufficient: failure, poor knowledge below minimum criteria

Candidates with grades satisfactory (6) or more, have passed the examinations successfully.

The student has two grades per subject: separately theory and lab exercise (seminar work). For thesis there are also two grade: written report and presentation, both should be more than 6. Finally we have one grade for thesis and common final grade of study (special formula).

### 7. TU-Catalonia

Grade	Description
9.0 - 10.0	excellent
7.0 - 8.9	very good
5.0 - 6.9	satisfactory
4.0 - 4.9	marginal fail
0.0 - 3.9	fail
NP	not examined
R	recognition

MH Honors (is given on exceptional cases)

### 8. University of Lisbon

Grade	Grade Points	Description
A	20-18	excellent
B	17-16	very good, with few errors
C	15-14	good, with some errors
D	13-12	satisfactory, with many errors
E	11-10	sufficient



## **Appendix D MSc modules: names, credits & assessment methods**

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The tables on the next pages give an overview of the module in each specialisation, including the ways these modules are assessed.

## 1. Urban Water and Sanitation programme

SANITARY ENGINEERING		C1349									
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
1	Introduction to UWS 1	M3188	Slokar	149	5	60		35		5	
2	Introduction to UWS 2	M3192	Salinas	76	5	75		25			
3	Introduction to UWS 3	M3189	vd Steen	167	5	85				15	
4	Urban drainage and sewerage	M3190	Vojnovic	142	5	60		40			
5	Conventional wastewater treatment	M1802	Lopez	148	5	80		20			
6	Resource oriented wastewater treatment and sanitation	M2384	Ronteltap	157	5	80		20			
7	Wastewater treatment plants design and engineering	M2373	Lopez	142	5	50	25	25			
8	Modelling of wastewater treatment processes and plants	M3054	Hooymans	132	5	60		40			
9	International fieldtrip and fieldwork	M1421	Slokar	150	5			100			
12	Summer course										
13	Groupwork Sint Maarten	M3114	Petrusevski	132	5			60	40		
14	MSc research proposal development	M3239	Slokar	40	9		100				
15	MSc research, thesis and defence	M2927	various	1008	36			100			
	Electives modules:										
10	Industrial effluents treatment and residuals management	M3102	Garcia	146	5	60		40			
10	Water treatment processes and plants	M2371	Sharma	140	5		60	40			
10	Urban water systems	M3006	Vojnovic	142	5	40		60			
11	Solid waste management	M3270	Hullebusch	140	5	60		4			
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50			
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30		
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20		
11	Urban water governance	M3261	Acevedo Guerre	139	5			100			
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40			
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15			
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10		
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100			
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25		
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60			
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40			
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60			



WATER SUPPLY ENGINEERING		C1352										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	
1	Introduction to UWS 1	M3188	Slokar	149	5	60		35		5		
2	Introduction to UWS 2	M3192	Salinas	76	5	75		25				
3	Introduction to UWS 3	M3189	vd Steen	167	5	85				15		
4	Surface water treatment I	M2550	Kennedy	140	5	60		20		20		
5	Surface water treatment II	M1577	Ferrero	150	5	70		10		20		
6	Groundwater resources and treatment	M3033	Petrusevski	141	5	70		15		15		
7	Water transport and distribution	M3245	Trifunovic	139	5	60		40				
8	Desalination and membrane technology	M3225	Salinas	123	5	70		20		10		
9	International fieldtrip and fieldwork	M1421	Slokar	150	5			100				
12	Summer course											
13	Groupwork Sint Maarten	M3114	Petrusevski	132	5			60	40			
14	MSc research proposal development	M3239	Slokar	40	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36			100				
	Electives modules:											
10	Industrial effluents treatment and residuals management	M3102	Garcia	146	5	60		40				
10	Water treatment processes and plants	M2371	Sharma	140	5		60	40				
10	Urban water systems	M3006	Voijnovic	142	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerra	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

URBAN WATER ENGINEERING AND MANAGEMENT			C1036											
Location	Module number	Module Name	Code	Module coordinator	Workload	AIT credits / ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)		
AIT		Watershed hydrology	CE74.11			3 (7.5)	x		x					
		Drinking water treatment	ED78.36			3 (7.5)	x							
		Wastewater treatment				3 (7.5)	x		x					
		Integrated water resources management	CE74.54			3 (7.5)	x		x					
U-IHE	4	Urban drainage and sewerage	M3190	Vojnovic	142	5	60		40					
	5	Asset management	M3047	Pathirana	150	2 (5.0)		50	50					
	6	Managing water organisations	M3170	Tutusaus Luque	96	2 (5.0)			100					
	7	Water transport and distribution	M3245	Trifunovic	139	2 (5.0)	60		40					
	8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	2 (5.0)	40		60					
	9	International fieldtrip and fieldwork	M1421	Slokar	150	2 (5.0)			100					
		Electives:												
	10	Industrial effluents treatment and residuals management	M3102	Garcia	146	5	60		40					
	10	Water treatment processes and plants	M2371	Sharma	140	5		60	40					
	10	Urban water systems	M3006	Vojnovic	142	5	40		60					
		Summer course				0.4 (1)								
		Total coursework					26 (65)							
						0			x	x				
AIT		MSc thesis work				22 (55)			x	x				
		Grand total (coursework + thesis)					48 (120)							

Joint MSc programme in Urban Water and Sanitation with specialisation Sanitary Engineering with Universidad del Valle, Colombia			C1033										
Location	Module number	Module Name	Code	Module coordinator	Workload	UVC /ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	
Univalle	C1	C1 Chemistry of Environmental Pollution	C1			3 /5.13	50		20		30		
	C2	C2 Environmental Pollution Microbiology	C2			3 /5.13	x		x	x	x		
	C3	C3 Fundamentals of Environmental Processes	C3			3 /5.13	60		20		20	20	
	C4	C4 Environmental and Development	C4			3 /5.13	35		30	35			
	C5	C5 Engineering Research Introduction	C5			2/3.42			100		20		
U-IHE	4	Urban drainage and sewerage	M3190	Vojnovic	142	5	60		40				
	5	Conventional wastewater treatment	M1802	Lopez	148	5	80		20				
	6	Resource oriented wastewater treatment and sanitation	M2384	Ronteltap	157	5	80		20				
	7	Wastewater treatment plants design and engineering	M2373	Lopez	142	5	50	25	25				
	8	Modelling of wastewater treatment processes and plants	M3054	Hooymans	132	5	60		40				
	9	International fieldtrip and fieldwork	M1421	Slokar	150	5			100				
	12	Summer course											
	13	Groupwork Sint Maarten	M3114	Petrusevski	132	5			60	40			
		Electives modules:											
	10	Industrial effluents treatment and residuals management	M3102	Garcia	146	5	60		40				
10	Water treatment processes and plants	M2371	Sharma	140	5		60	40					
10	Urban water systems	M3006	Voijnovic	142	5	40		60					
						5							
Univalle	C9	Engineering research I (4 UVC)	C9			4/6.84							
	C10	Engineering Research II (8 UVC)	C10			8/13.68							
		MSc thesis (14 UVC)				14/23.94							

## 2. Environmental Science programme

ENVIRONMENTAL SCIENCE AND TECHNOLOGY		C1140										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1	M3172	de Ruyter	140	5	100						
2	Introduction to environmental science 2	M3173	de Ruyter	140				100				
3	Introduction to environmental science 3	M3194	de Ruyter	140		60		40				
4	Integrated project environmental science	M3031	vd Steen	140	5			70	30			
5	Industrial Resource Management & Cleaner Production	M3179	Raj	140	5	60		35	5			
6	Environmental systems analysis	M3171	Irvine	140	5	40		50	10			
7	Environmental engineering	M3081	Raj	140	5	75		25				
8	Environmental monitoring and modelling	M3187	Zuijdgeest	140	5	55		45				
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	140	5			100				
12	Summer courses				1			100			1	
13	Groupwork ES	M3197	Zuijdgeest	140	5			100				
14	Thesis Research Proposal Development for ES	M3283	Mendoza	250	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
	Elective modules:											
10	Aquatic ecosystems: processes and applications	M3202	Gettel	140	5			90	10			
10	Environmental assessment for water related policies and develop	M3080	Mendoza	140	5	50		50				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

ENVIRONMENTAL POLICY MAKING		C1127										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1	M3172	de Ruyter	140	5	100						
2	Introduction to environmental science 2	M3173	de Ruyter	140				100				
3	Introduction to environmental science 3	M3194	de Ruyter	140		60		40				
4	Integrated project environmental science	M3031	vd Steen	140	5			70	30			
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
6	Environmental systems analysis	M3171	Irvine	140	5	40		50	10			
7	Water and environmental policy analysis	M3212	Mendoza	140	5	50		50				
8	Environmental planning and implementation	M3021	Evers	140	5	50		50				
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	140	5			100				
12	Summer courses				1			100				
13	Groupwork ES	M3197	Zuijdgeest	140	5			100				
14	Thesis Research Proposal Development for ES	M3283	Mendoza	250	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
	Elective modules:											
10	Aquatic ecosystems: processes and applications	M3202	Gettel	140	5			90	10			
10	Environmental assessment for water related policies and develop	M3080	Mendoza	140	5	50		50				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER QUALITY MANAGEMENT		C1166										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to environmental science 1	M3172	de Ruyter	140	5	100						
2	Introduction to environmental science 2	M3173	de Ruyter	140				100				
3	Introduction to environmental science 3	M3194	de Ruyter	140		60		40				
4	Integrated project environmental science	M3031	vd Steen	140	5			70	30			
5	Water and environmental law	M1003	Jaspers	122	5	70		30				
6	Water quality assessment	M3169	Zuijdgeest	140	5	40		60				
7	Constructed wetlands for wastewater treatment	M2216	vd Vossenbergh	140	5	60		40				
8	Environmental planning and implementation	M3021	Evers	140	5	50		50				
9	Foreign fieldtrip and fieldwork ES	M1766	de Ruyter	140	5			100				
12	Summer courses				1			100				
13	Groupwork ES	M3197	Zuijdgeest	140	5			100				
14	Thesis Research Proposal Development for ES	M3283	Mendoza	250	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
	Elective modules:											
10	Aquatic ecosystems: processes and applications	M3202	Gettel	140	5			90	10			
10	Environmental assessment for water related policies and develop	M3080	Mendoza	140	5	50		50				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3001	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

LIMNOLOGY AND WETLAND MANAGEMENT			C1155										
Location	Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab report (%)	Home work (%)	Integrated in modules (%)
BOKU		Limnology (812340)											
		Aquatic Biomonitoring and -Assessment (812384)											
		Ecology of Aquatic Ecosystems (812342)											
		Water Legislation (812348)											
		Taxonomy and Ecology of Benthic Invertebrates (812343)											
		Human Impacts in Riverine Landscapes (812347)											
		Ecology of Fishes (812344)											
		Statistical Analyses of Ecological Data (812352)											
		Scientific Reading and Presentation in Aquatic Ecology (812351)											
		Physical Environment of Riverine Landscape (812345)											
		Applications in River Landscape Management (812350)											
		Limnochemistry and Nutrient Cycling (812341)											
		Ecological River Landscape Management (812349)											
EGERTON		Ecology of Streams and Rivers (LIWM714)											
		Lake Ecology (LIWM713)											
		Wetlands for Water Quality (LIWM721)											
		Fisheries & Aquaculture (LIWM722)											
		MSc Thesis: Research and Thesis writing (LIWM736)											
		MSc Proposal; Research Plan, logistics, site assessment, application & societal relevance (LIWM735)											
UNESCO-IHE	9	Data Analysis and Modeling for Aquatic Ecosystems	M3273	van Dam		5	40		40	20			
	10	Aquatic ecosystems: processes and applications	M3202	Gettel	140	5			90	10			
	11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
	12	Summer courses				1			100				
	13	Groupwork ES	M3197	Zuijdgeest	140	5			100				
	14	MSc research methodology and proposal development	M3283	Mendoza	250	9			100				
	15	MSc research, thesis and defence	M2927	various		36			100				
		TOTAL				120							

### 3. Water Science and Engineering programme

RIVER BASIN DEVELOPMENT		C1477										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
3	River basin hydraulics, geotechnics and remote sensing	M3129	Paron	136	5	75		25				
4	River morphodynamics	M2730	Crosato	140	5	80		20				
5	Data collection and analysis and design	M3090	Werner	138	5	70		30				
6	River Basin Development and EIA	M1703	Masih	140	5	50		50				
7	River structures	M1171	Cattapan	140	5	100						
9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
12	Summer courses				1			100				
13	Groupwork WSE	M1284	Veerbeek	140	5				100			
14	Thesis Research Proposal Development for WSE	M3284	Foppen	196	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
Elective modules:												
8	Integrated hydrological and river modelling	M1309	Maskey	138	5			85	15			
8	Climate change impacts and adaptation in coastal areas	M3204	Alvaro	140	5			100				
8	Dams and hydropower	M3009	Marence	149	5	90		10				
8	Planning and delivery of flood resilience	M3275	Gersonius	132	5			30	50		20	
8	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
8	International Port Seminar	M3166	Dastgheib	140	5				100			
8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40				
10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerrero	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				



COASTAL ENGINEERING AND PORT DEVELOPMENT		C1427										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
3	Introduction to coastal science and engineering	M3178	Semedo	132	5	90				10		
4	Port planning and infrastructure design	M3165	Dastgheib	150	5			100				
5	Coastal systems	M3163	Ranasinghe	140	5	100						
6	Design of breakwaters	M3164	Dastgheib	134	5			100				
7	Process-based Coastal Modeling	M3162	Reyns	152	5			100				
9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
12	Summer courses				1			100				
13	Groupwork WSE	M1284	Veerbeek	140	5				100			
14	Thesis Research Proposal Development for WSE	M3284	Foppen	196	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
Elective modules:												
8	Integrated hydrological and river modelling	M1309	Maskey	138	5			85	15			
8	Climate change impacts and adaptation in coastal areas	M3204	Alvaro	140	5			100				
8	Dams and hydropower	M3009	Marence	149	5	90		10				
8	Planning and delivery of flood resilience	M3275	Gersonius	132	5			30	50		20	
8	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
8	International Port Seminar	M3166	Dastgheib	140	5				100			
8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40				
10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerrero	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

LAND AND WATER DEVELOPMENT		C1505										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
3	Principles and practices of land and water development	M3255	Hayde	140	5	44		56				
4	Design aspects of irrigation and drainage	M3252	Hayde	140	5	31		69				
5	Irrigation and drainage design	M3180	Suryadi	142	5	40		60				
6	Socio-economic and environmental aspects of land and water de	M3177	Duker	128	5	45		55				
7	Conveyance and irrigation structures	M3025	Suryadi	142	5	35		65				
9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
12	Summer courses				1			100				
13	Groupwork WSE	M1284	Veerbeek	140	5				100			
14	Thesis Research Proposal Development for WSE	M3284	Foppen	196	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
Elective modules:												
8	Integrated hydrological and river modelling	M1309	Maskey	138	5			85	15			
8	Climate change impacts and adaptation in coastal areas	M3204	Alvaro	140	5			100				
8	Dams and hydropower	M3009	Marence	149	5	90		10				
8	Planning and delivery of flood resilience	M3275	Gersonius	132	5			30	50		20	
8	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
8	International Port Seminar	M3166	Dastgheib	140	5				100			
8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40				
10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerrero	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

LAND AND WATER DEVELOPMENT WITH NEBRASKA			C1048										
	Module number	Module Name	Code	Module coordinator	Workload	UNL credits/ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
UNESCO-IHE	1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
	2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
	3	Principles and practices of land and water development	M3255	Hayde	140	5	44		56				
	4	Design aspects of irrigation and drainage	M3252	Hayde	140	5	31		69				
	5	Irrigation and drainage design	M3180	Suryadi	142	5	40		60				
	6	Socio-economic and environmental aspects of land and water de	M3177	Duker	128	5	45		55				
	7	Conveyance and irrigation structures	M3025	Suryadi	142	5	35		65				
	8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
	9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
University of Nebraska, Lincoln, USA		Plant-Water Relations	AGRO807			3 (5)							
		Groundwater Geology	NRES 488			3(5)							
		Advanced Irrigation and Drainage Systems Engineering	AGEN953			3 (5)							
		Advanced Irrigation Management	MSYM855			3 (5)							
		Water Law, Planning and Policy	AECN 876			3 (5)							
		Masters Water for Food Project	MSYM898			3 (5)							
		Remote Sensing	GEOG 818			4 (6)							
		Global Water and Food Seminar	BSEN 892			3(5)			100				
	Water Resources Seminar	NRES884			1(2)								

LAND AND WATER DEVELOPMENT WITH AIT			C1054											
Location	Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)	
AIT		Watershed Hydrology				7.5	30+40		30					
		Hydrodynamics				7.5	40+50		10					
		Irrigation and Drainage Engineering				7.5	30+40		30					
		Integrated Water Resources Management				7.5	20+30		50					
		MSc thesis work												
U-IHE	4	Design aspects of irrigation and drainage	M3252	Hayde	140	5	31		69					
	5	Irrigation and drainage design	M3180	Suryadi	142	5	40		60					
	6	Socio-economic and environmental aspects of land and water de	M3177	Duker	128	5	45		55					
	7	Conveyance and irrigation structures	M3025	Suryadi	142	5	35		65					
	8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40					
	9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100					
	Elective modules:													
	10	Applied Groundwater Modelling	M2841	Zhou	142	5			100					
	10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70					
	10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40					
	10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40					
	10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60					

HYDROINFORMATICS		C1490										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
3	Information technology and software engineering	M3184	Alfonso Segura	124	5	50		50				
4	Modelling theory and Computational Hydraulics	M3244	Popescu	138	5	55	25	20				
5	Modelling and information systems development	M2128	van Andel	136	5			100				
6	Computational Intelligence and Operational water management	M2847	Solomatine	140	5	55		45				
7	River basin modelling	M3232	Jonoski	138	5	100						
9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
12	Summer courses				1			100				
13	Groupwork WSE	M1284	Veerbeek	140	5				100			
14	Thesis Research Proposal Development for WSE	M3284	Foppen	196	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
Elective modules:												
8	Integrated hydrological and river modelling	M1309	Maskey	138	5			85	15			
8	Climate change impacts and adaptation in coastal areas	M3204	Alvaro	140	5			100				
8	Dams and hydropower	M3009	Marence	149	5	90		10				
8	Planning and delivery of flood resilience	M3275	Gersonius	132	5			30	50		20	
8	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
8	International Port Seminar	M3166	Dastgheib	140	5				100			
8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40				
10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerrero	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

HYDROLOGY AND WATER RESOURCES		C1501										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Introduction to Water Science and Engineering	M2131	Foppen	132	5	55		45				
2	Hydrology and hydraulics	M2208	Maskey	142	5	80		20				
3	Hydrogeology	M2166	Zhou	140	5	70		30				
4	Surface hydrology	M2367	Venneker	110	5	70		30				
5	Water quality	M2497	McClain	111	5	70		30				
6	Tracer hydrology and flow systems analysis	M1903	Foppen	142	5	100						
9	Fieldtrip and Fieldwork	M3167	Duker	140	5			100				
12	Summer courses				1			100				
13	Groupwork WSE	M1284	Veerbeek	140	5				100			
14	Thesis Research Proposal Development for WSE	M3284	Foppen	196	9			100				
15	MSc research, thesis and defence	M2927	various		36			100				
Elective modules:												
7	Hydrological data collection and processing	M1554	Venneker	136	5	60				40		
7	Groundwater data collection and interpretation	M3160	Stigter	140	5	35		65				
8	Integrated hydrological and river modelling	M1309	Maskey	138	5			85	15			
8	Climate change impacts and adaptation in coastal areas	M3204	Alvaro	140	5			100				
8	Dams and hydropower	M3009	Marence	149	5	90		10				
8	Planning and delivery of flood resilience	M3275	Gersonius	132	5			30	50		20	
8	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
8	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
8	International Port Seminar	M3166	Dastgheib	140	5				100			
8	Management of irrigation and drainage systems	M3203	Duker	142	5	60		40				
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
10	Geotechnical Engineering and Dredging	M2214	vd Wegen	140	5		60	40				
10	Innovative Water Systems for Agriculture	M3238	Karimi	132	5	40		60				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerrero	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

FLOOD RISK MANAGEMENT			C1440										
Location	Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
TU-Dresden		Flood Risk Management				10	50		30+20				
		Climatology and Hydrology				5	100						
		Geodesy				5	100						
		Two courses out of the following four:											
		Hydraulic Engineering				5	100						
		Hydromechanics				5							
		Ecology				5	75			25			
		Hydrochemistry				5							
		Courses without credits:											
		GIS and Remote Sensing				0							
		Statistics				0							
		Fieldtrip				0							
						<b>Total ECTS</b>							
						<b>30</b>							
U-IHE	6	Computational Intelligence and Operational water management	M2847	Solomatine	140	5	55		45				
	7	River basin modelling	M3232	Jonoski	138	5	100						
		One course out of the following two:											
	8a	River Flood Analysis and Modelling	M2709	Popescu	134	5	50		50				
	8b	Urban flood management and disaster risk mitigation	M1710	Vojnovic	140	5	40		60				
	9	International Fieldtrip (12 days)	M3167	Duker		5						100	
	10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
	11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
						<b>Total ECTS</b>							
						<b>30</b>							
UPC		Global warming effects, Flood and Drought				3		40	60				
		Coastal flooding: impacts, conflicts and risks				3	100						
		Debris flow and flash floods: risk, vulnerability, hazard and resilience concepts				5	40		55				5
		The application of radar-based rainfall observations and forecast in Early Warning				4	100						
						<b>Total ECTS</b>							
						<b>30</b>							
UL		Spatial planning for flood protection and resilience				5	20		80				
		Socio-economic and institutional framework of floods				5							
TUD/IHE /UPC/UL		MSc thesis work				<b>Total ECTS</b>							
						<b>30</b>							

GROUNDWATCH		C1441											
Location	Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
IST Lisbon		Hydrogeology				4,5							
		Hydrology, Environment and Water Resources				6							
		Atmospheric physics and chemistry				4,5							
		Integrated River Basin Management				4,5							
		Groundwater Pollution and Protection				6							
		Environmental policies and law				4,5							
U-IHE	6	Tracer hydrology and flow systems analysis	M1903	Foppen	142	5	100						
	7	Groundwater data collection and interpretation	M3160	Stigter	140	5	35		65				
	8	Groundwater in adaptation to global change impacts	M3096	Stigter	140	5			100				
	9	Fieldtrip and Fieldwork	M3167	Duker	140	5						100	
	10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
	11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
TU-Dresden		Climate Systems and Climate Modelling				5							
		Soil Water				5							
		Study Project IWRM				10							
		Ecology (optional)				5							
		Integrated Land Use Management in the Landscape (optional)				5							
		Water Quality and Water Treatment				5							
		Watershed Management II				5							
	Treatment plant design				5								
IST/IHE/TUD		MSc research, thesis and defence	M2927			30							



## 4. Water Management programme

WATER RESOURCES MANAGEMENT		C1396										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3181	Evers	114	5	45		55				
2	The water resources system	M3182	Susnik	143	5	70		30				
3	Water governance	M3228	Kemerink	172	5		40	60				
4	Water economics	M3227	Yong	144	5	70		30				
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
6	Water resources assessment	M3235	Yasir	139	5	65		35				
7	Water systems modelling	M2054	Masih	149	5	60			40			
8	Water resources planning	M3241	Cauwenberg	143	5	60		40				
9	International fieldwork	M3045	Cabrera	168	5			100				
12	Summer course				1			100				
13	Groupwork WMG	M3229	Susnik	149	5			100				
14	Thesis Research Proposal Development for WMG	M3236	Fantini	252	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36		100					
	Elective modules:											
10	Partnerships for Water Supply and Sanitation	M3199	Torio	143	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M3202	Gettel	140	5			90	10			
10	Institutional Analysis	M3234	Smit	189	5			80	20			
10	Drought management and reservoir operations	M3036	Werner	138	5	60		40				
10	Flood risk management	M3243	Biswa	132	5	30		70				
10	Applied groundwater modelling	M2841	Zhou	142	5			100				
10	Innovative water systems for agriculture	M3238	Karimi	140	5	40		60				
10	Environmental assessment for water related policies and develo	M3080	Mendoza		5	50		50				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER CONFLICT MANAGEMENT		C1370										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3181	Evers	114	5	45		55				
2	The water resources system	M3182	Susnik	143	5	70		30				
3	Water governance	M3228	Kemerink	172	5		40	60				
4	Water economics	M3227	Yong	144	5	70		30				
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
6	Water conflict management 1	M3069	Shubber	91	5	50		50				
7	Water conflict management 2	M3070	Shubber	121	5	60		40				
8	Water resources planning	M3241	Cauwenberg	143	5	60		40				
9	International fieldwork	M3045	Cabrera	168	5			100				
12	Summer course				1			100				
13	Groupwork WMG	M3229	Susnik	149	5			100				
14	Thesis Research Proposal Development for WMG	M3236	Fantini	252	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36		100					
	Elective modules:											
10	Partnerships for Water Supply and Sanitation	M3199	Torio	143	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M3202	Gettel	140	5			90	10			
10	Institutional Analysis	M3234	Smit	189	5			80	20			
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER MANAGEMENT		C1362										
Code	Module Name	Code	Module coordinator		ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3181	Evers	114	5	45		55				
2	The water resources system	M3182	Susnik	143	5	70		30				
3	Water governance	M3228	Kemerink	172	5		40	60				
4	Water economics	M3227	Yong	144	5	70		30				
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
9	International fieldwork	M3045	Cabrera	168	5			100				
12	Summer course				1			100				
13	Groupwork WMG	M3229	Susnik	149	5			100				
14	Thesis Research Proposal Development for WMG	M3236	Fantini	252	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36		100					
Elective modules:												
6	Water quality assessment	M3169	de Ruyter	140	5	60		30		10		
6	Water resources assessment	M3235	Yasir	139	5	65		35				
6	Water conflict management 1	M3069	Shubber	91	5	50		50				
6	Managing water organisations	M3170	Tutusaus	96	5			100				
7	Environmental Engineering	M3081	Raj	140	5	75		25				
7	Water systems modelling	M2054	Masih	149	5	60			40			
7	Water conflict management 2	M3070	Shubber	121	5	60		40				
7	Environmental management and water services	M3200	Cabrera	188	5			90	10			
8	Environmental planning and implementation	M3021	Evers	140	5	50		50				
8	Water resources planning	M3241	Cauwenberg	143	5	60		40				
8	Finance in the water sector	M3044	Torio	140	5	50		50				
10	Partnerships for Water Supply and Sanitation	M3199	Torio	143	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M3202	Gettel	140	5			90	10			
10	Institutional Analysis	M3234	Smit	189	5			80	20			
10	Applied Groundwater Modelling	M2841	Zhou	142	5			100				
10	Flood Risk Management	M3243	Bhattacharya	132	5	30		70				
10	Environmental assessment for water related policies and develo	M3080	Mendoza		5	50		50				
10	Drought Management and Reservoir Operations	M3036	Werner	138	5	60		40				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER SERVICES MANAGEMENT		C1409										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3181	Evers	114	5	45		55				
2	The water resources system	M3182	Susnik	143	5	70		30				
3	Water governance	M3228	Kemerink	172	5		40	60				
4	Water economics	M3227	Yong	144	5	70		30				
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
6	Managing water organisations	M3170	Tutusaus	96	5			100				
7	Environmental management and water services	M3200	Cabrera	188	5			90	10			
8	Finance in the water sector	M3044	Torio	140	5	50		50				
9	International fieldwork	M3045	Cabrera	168	5			100				
12	Summer course				1			100				
13	Groupwork WMG	M3229	Susnik	149	5			100				
14	Thesis Research Proposal Development for WMG	M3236	Fantini	252	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36		100					
	Elective modules:											
10	Partnerships for Water Supply and Sanitation	M3199	Torio	143	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M3202	Gettel	140	5			90	10			
10	Institutional Analysis	M3234	Smit	189	5			80	20			
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER QUALITY MANAGEMENT		C1383										
Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
1	Principles of integrated water resources management	M3181	Evers	114	5	45		55				
2	The water resources system	M3182	Susnik	143	5	70		30				
3	Water governance	M3228	Kemerink	172	5		40	60				
4	Water economics	M3227	Yong	144	5	70		30				
5	Water and environmental law	M1003	Jaspers	132	5	70		30				
6	Water quality assessment	M3169	de Ruyter	140	5	60		30		10		
7	Constructed wetlands for wastewater treatment	M2216	Vossenbergh	140	5	60		40				
8	Environmental planning and implementation	M3021	Evers	140	5	50		50				
9	International fieldwork	M3045	Cabrera	168	5			100				
12	Summer course				1			100				
13	Groupwork WMG	M3229	Susnik	149	5			100				
14	Thesis Research Proposal Development for WMG	M3236	Fantini	252	9		100					
15	MSc research, thesis and defence	M2927	various	1008	36		100					
Elective modules:												
10	Partnerships for Water Supply and Sanitation	M3199	Torio	143	5		50	50				
10	Aquatic Ecosystems Processes and Applications	M3202	Gettel	140	5			90	10			
10	Institutional Analysis	M3234	Smit	189	5			80	20			
10	Environmental assessment for water related policies and develop	M3080	Mendoza		5	50		50				
11	Solid waste management	M3270	Hullebusch	140	5	60		4				
11	Strategic Planning for River Basins and Deltas	M3211	Evers	140	5	50		50				
11	IWRM as a tool for adaptation to climate change	M3207	de Ruyter	140	5	70			30			
11	Wetlands for livelihoods and conservation	M3214	Hes	140	5			80	20			
11	Urban water governance	M3261	Acevedo Guerre	139	5			100				
11	Advanced water transport and distribution	M3250	Trifunovic	139	5	60		40				
11	Faecal Sludge Management	M3217	Ronteltap	116	5	85		15				
11	Decentralised Water Supply and Sanitation	M2810	Sharma	140	5	60		30	10			
11	Hydroinformatics for Decision Support	M3233	Jonoski	136	5			100				
11	Water Sensitive Cities	M3048	Pathirana	160	5		25	50	25			
11	Modelling river systems and lakes	M3277	Cattapan	142	5	40		60				
11	Flood Protection in Lowland Areas	M3251	Roelvink	140	5	60		40				
11	Remote sensing for agricultural water management	M3237	Karimi	140	5	40		60				

WATER COOPERATION AND PEACE			C1045											
Location	Module number	Module Name	Code	Module coordinator	Workload	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)	
UPEACE		UPEACE Foundation Course				3.21			100					
		General Course on the UN system				2.14			100					
		Environment, Conflicts and Sustainability				3.21			50	50				
		Water Security and Peace (concept, theories, and field course)				3.21			50	50				
		Management of Coastal Resources (concepts, theories and field course)				3.21			50	50				
U-IHE	3	Water governance	M3228	Kemerink	142	5		40	60					
	4	Water economics	M3227	Yong	144	5	70		30					
	5	Water and environmental law	M1003	Jaspers	132	5	70		30					
	6	Water conflict management I	M3069	Shubber	91	5	50		50					
	7	Water conflict management II	M3070	Shubber	121	5	60		40					
	8	Elective module				5								
	Special course	Research methodology and thesis proposal work	M3254			3							100	
OSU		Natural Resources Leadership Academy				3.21	25		25				50	
		Applied Hydrology				3.21	25		25		25	25		
		Applied Field Problems/Technical and Academic Writing in Water Resources				7.49			25			50	25	
		Conducting Collaborative Projects/Directed research in hydrology/ Seminar/Journal club				6.42			25			50	25	
		Collaborative project/Directed research in water policy/ Seminar/Journal club				6.42				25		25	50	
		Collaborative project/Elective courses/Seminar/Journal Club				2.14				25		25	50	
ALL		MSc thesis period												
		TOTAL				76.87								

## Appendix E MSc thesis marking guidelines

Criterion 1	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	Very Good	Good	Sufficient	Fail
<b>Knowledge and understanding of the subject and answers to questions</b>	An excellent and informative introduction, well-researched, with appropriate and key references. Evidence of critical thinking. Clear aims and objectives, within an overall context, which identifies knowledge gaps. Sets the scene for the research succinctly and elegantly.	Good project background, with reference to key literature. A logical framework that identifies the research objectives, but may lack some thoroughness, or comprise a limited series of research questions. It might be competent but a little mundane.	Covers the main areas, but has minor flaws in logic or omissions of important detail, or minor flaws in structure. Aims and objectives comprehensible, but maybe slightly over or under ambitious, and/or lacking in clarity or precision. Objectives may be unrealistic.	Generally lacks some coherence; may be poorly referenced, but includes at least some points relevant to the research. Aims and objectives no more than adequate.	Poorly structured, with significant omissions of key background literature. No logical progression. Fails to set the context of the project. Research question not developed into appropriate or testable hypotheses

Criterion 2	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below	
	Excellent	Very Good	Good	Sufficient	Fail	
<b>Originality, analysis and interpretation</b>	Methods	Well-chosen and entirely appropriate and often novel methods identified clearly. Clear and easy to follow procedures and techniques. Where appropriate, good site description, with informative maps, diagrams etc.	Appropriate actions and methods identified and detailed. Where appropriate, setting of research well described with relevant maps etc	Methodology generally sound but with some lapses in detail of methods, and/or proposed analysis. Maps or diagrams may be poorly produced, or not clear in the context of the research	Significant gaps in methods, or methods not always appropriate to the research questions, or very difficult to comprehend. Lapses in detail in parts of methodology. Maps may be absent or poorly produced.	Methodology vague and poorly detailed. No obvious understanding of methodology relevant to research theme. Maps etc may be poorly produced or absent.
	Results	These are well analysed and presented with clarity, with clear and comprehensive relationship to the research questions.	Results reported well and with clarity. Some minor lapses in summary of findings. Shows ability to address methodological short-comings	Results comprehensible, generally linking with the research questions. Figures and tables convey adequate meaning, providing a summary of at least some of the key findings.	Some obvious flaws in analysis, but the general essence of the key findings conveyed.	Difficult to follow the results and analysis. Presentation careless and poor summary of the key findings
	Discussion	Elegant and well structured, placing the results in the context of the international literature and demonstrating a clear understanding of their significance, and/or shortcomings. Show some new ideas and novel interpretation.	Identifies the key finding and relevance of these to some key literature. A well ordered sequence to the chapter to produce a logical framework.	Recognises some interesting findings, but may be limited in placing these into a wider context. At least some use of key literature. There will likely to be some repetition with the results section.	Largely a repetition of the results section, with minimal context to wider understanding and relevant literature.	Fails to identify key findings and/or their wider significance. Little logical framework and lacking any individual ideas or interpretation.

Criterion 3	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	Very Good	Good	Sufficient	Fail
<b>Organisation, style, presentation and communication</b>	Writing elegant and succinct. Uses precise language and correct terminology throughout. Figs and tables well laid out to a publishable quality with accurate and succinct legends.	A clear and well-written report that is technically proficient.	A generally well-written report that is understandable. Uses appropriate terminology. Occasional spelling or grammatical errors. Presentation generally neat	Language generally clear and uses correct terminology, but with some misunderstandings and lapses in grammar or spelling. Presentation and use of tables and figures may be sloppy.	Sentences and/or paragraphs poorly constructed. Language inexact or ambiguous. Contains numerous grammatical and spelling mistakes.

Criterion 4	9.0 - 10.0	8.0 - 8.9	7.0 - 7.9	6.0 - 6.9	5.9 and below
	Excellent	Very Good	Good	Sufficient	Fail
<b>Creativity, independence, work planning and critical attitude</b>	Student self-motivated and independent. Engages in intelligent discussion and responds well to suggestions.	Significant help may be given, but students show ability to learn from suggestions and develop ideas and research approaches accordingly.	Needs clear guidance and support, but gradually develops the required competencies.	A need to repeat instructions a number of times. Generally finds taking initiative difficult, and limited self-reliance.	Lacks motivation, or much ability to develop competencies. Shows little self-reliance or interest in the topic.

## Appendix F Appeal procedure

(annex to the Examination Regulations 2015-17)

draft d.d. 28 April 2016

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A student has the right to lodge an appeal against:

- decisions by examiners, the MSc Examination Committee, or the Examination Board;
- termination of registrations by the Academic Registrar.

NB: An appeal against the decision of an Examiner or an MSc Examination Committee is lodged with the Examination Board. The Examination Board's decision is final and binding, and can therefore not be appealed against with the Academic Appeals Board.

Before starting an appeal procedure, the student has the obligation to attempt to solve the case amicably with the body or person who took the disputed decision.

### **Appeal against the decision of an Examiner or an MSc Examination Committee:**

1. The appeal shall be submitted in hard copy to the Examination Board (via its secretary) within 3 weeks following the date on which the decision was made known.
2. The appeal must be signed by the student (= appellant) and contain at least the following:
  - a. name and address, degree programme and student number of the appellant;
  - b. details of the Examiner or MSc Examination Committee concerned;
  - c. a clear description of the decision against which the appeal has been lodged, on submission of a copy of the decision, if possible, or, if the appeal has been lodged against a refusal to decide, a clear description of the decision which should have been taken in the appellant's opinion;
  - d. the grounds of the appeal;
  - e. an account of the initiatives taken by the appellant to come to an amicable agreement with the decision maker.
3. The chair of the Board will inform the appellant of any omissions on the appellant's part and will invite him to rectify these within a period of time to be set by the chair. In the event that the appellant fails to rectify the omissions on his/her part, the appeal may be declared inadmissible.
4. The Examination Board may decide to hear the concerned parties.
5. The Examination Board will take a decision within three (3) weeks of receipt of the letter of appeal and inform the parties concerned accordingly in writing, stating whether the initial decision is to be upheld or a new decision taken.
6. The decision of the Examination Board is final and binding.

### **Appeal against the decision of the Examination Board or the Academic Registrar:**

1. The appeal shall be submitted in hard copy to the Academic Appeals Board (via its secretary) within 3 weeks following the date on which the decision was made known.



2. The appeal must be signed by the student (= appellant) and contain at least the following:
  - a. name and address, degree programme and student number of the appellant;
  - b. details of the body or person who has taken the contested decision;
  - c. a clear description of the decision against which the appeal has been lodged, on submission of a copy of the decision, if possible, or, if the appeal has been lodged against a refusal to decide, a clear description of the decision which should have been taken in the appellant's opinion;
  - d. the grounds of the appeal;
  - e. an account of the initiatives taken by the appellant to come to an amicable agreement with the decision maker.
3. The chair of the Board will inform the appellant of any omissions on the appellant's part and will invite him to rectify these within a period of time to be set by the chair. In the event that the appellant fails to rectify the omissions on his part, the appeal may be declared inadmissible.
4. The Academic Appeals Board may decide to hear the concerned parties.
5. The Academic Appeals Board will take a decision within four (4) weeks of receipt of the letter of appeal and inform the parties concerned accordingly in writing, stating whether the initial decision is to be upheld or a new decision taken.
6. The decision of the Academic Appeals Board is final and binding.

## Appendix G Procedures when using eCampusXL for assessments

### GENERAL RULES

Students taking part in an examination are expected to have taken notice of these procedures and are expected to understand the implied meaning of these procedures.

Electronic examinations take place in lecture rooms A4, A5 and B6

In the examination room

1. The student brings his/her own laptop to the examination room.
2. When the examination takes place in rooms A4 and A5, students for safety reasons have to connect their laptops with the available network cables in that room instead of using the less stable Wi-Fi.
3. The student brings his/her student card and displays it on the table.
4. A check of attendance is required to proof that the student has taken part in the examination. The invigilator (examination supervisors) verifies the student card and confirms attendance by the student by ticking the box of the student on the attendance list.
5. The invigilators ensure a proper conduct of the examination and maintain order in the examination room. They will announce the beginning and the duration of the examination, and will warn the students 10 minutes before the ending of the examination.
6. The invigilators will instruct the students to log in to the safe browser environment for the examination.
7. At the start of the examination the invigilator announces the password to the students to get access to the examination.
8. The programme will automatically save all answers during an examination every 5 minutes. However during the examination students are strongly advised to save his/her current answers as well various times before the final submission to prevent loss of work in case the server goes down. Students remain responsible for the final submission of their work.
9. For a situation where the time of an examination expires without the final submission, for example when the server is not available on that specific moment, a grace period has been set where attempts can be submitted even after the deadline, but questions cannot be answered/changed.
10. When the laptop of the student stops working correctly, the student can restart the computer and will arrive at the same place in the examination. (this will also work when restart/login is made on a different machine).
11. At the end of the examination the invigilators return the attendance list to the Planning Office.

Other issues:

**Bags:** Bags and carrying cases, including penholders, are to be placed along the side of the room before the start of the examination.

**Dictionary:** The use of a printed language dictionary without any additional written annotations is allowed (all languages are allowed). Invigilators are allowed to check the dictionaries for hand-written annotations during the exam (spot checks while they are walking around).

Electronic dictionaries are not allowed.

**Calculators:** Use of calculators is not allowed and must be switched off. A scientific calculator inside the safe browser environment is available.

**Cell phones:** Use of cell phones is not allowed and must be switched off

**Communication:** During the examination, students are not allowed to exchange materials or to communicate with other students. If something is unclear, students have to inform the invigilator, who will contact the

programme coordinator, the examiner or planning officer if necessary.

**Other materials:** The use of materials other than listed above, including blank paper, texts, of any kind, is not allowed.

Examiners may nevertheless allow students to use specified text matter or other effects in a so-called 'open book' examination. These materials shall not include previous or example examinations and solutions.

**Toilet visit:** Only one student at a time will be allowed by the invigilator to leave the examination room for a short visit to the lavatory, except during the first 15 and the last 15 minutes of the examination. Examination materials and requirements may not be taken outside the examination room. Before leaving the examination room, students have to hand over their cell phone to the invigilator.



# Water Science and Engineering Programme Overview 2017-2019

INFO WSE programme		HWR Hydrology and Water Resources C1477	HI Hydroinformatics Modelling and Information Systems for Water Management C1490	HE-RBD Hydraulic engineering River Basin Development C1477	CEPD Hydraulic Engineering Coastal Engineering and Port Development C1427	LWD-FS Land and Water Development for Food Security C1505	LWD-FS Nebraska C1048	Groundwatch	Flood Risk Management		
1	.....-20/10 23/10-27/10	Week ONE Introduction (ALL)						IST Lisbon	TU Dresden		
	30/10-03/11 06/11-10/11	Introduction to water science and engineering (WSE/01/c) M2131				Hydrology and hydraulics (WSE/02/c) M2208					
	13/11-17/11 20/11-24/11 27/11-01/12										
	.. 04/12-08/12	Examination Week									
	3 11/12-15/12 18/12-22/12	Hydrogeology (WSE/HWR/03/s) M2166	Information technology and software engineering (WSE/03/s) M3184	River basin hydraulics, geotechnics and remote sensing (WSE/HERBD/03/s) M3129	Introduction to coastal science and engineering (WSE/HECEPD/03/s) M3178	Principles and practices of land and water development (WSE/LWDFS/03/s) M3255					
	.. 25/12-29/12 01/01-05/01	Free Period									
	3 08/01-12/01	3 continue..									
	4 15/01-19/01 22/01-26/01 29/01-02/02	Surface hydrology (WSE/HWR/04/s) M2367	Modelling theory and computational hydraulics (WSE/04/s) M3244	River morphodynamics (WSE/HERBD/04/s) M2730	Port planning and infrastructure design (WSE/HECEPD/04/s) M3165	Design aspects of irrigation and drainage (WSE/LWDFS/04/s) M3252					
	.. 05/02-09/02	Examination Week									
	5 12/02-16/02 19/02-23/02 26/02-02/03	Water quality (WSE/HWR/05/s) M2497	Modelling and information systems development (WSE/05/s) M2128	Data collection and analysis and design (WSE/HERBD/05/s) M3090	Coastal systems (WSE/HECEPD/05/s) M3163	Irrigation and drainage design (WSE/LWDFS/05/s) M3180					
Students enter: Erasmus Mundus Flood Risk Management and Groundwatch	6 05/03-09/03 12/03-16/03 19/03-23/03	Tracer hydrology and flow systems analysis (WSE/HWR/06/s) M1903	Computational intelligence and operational water management (WSE/06/s) M2847	River basin development and environmental impact assessment (WSE/HERBD/06/s) M1703	Design of breakwaters (WSE/HECEPD/06/s) M3164	Socio-economic and environmental aspects of LWD (WSE/LWDFS/06/s) M3177		Tracer hydrology and flow systems analysis (WSE/HWR/06/s) M1903	Computational intelligence and operational water management (WSE/06/s) M2847		
7	26/03-30/03	Examination Week						University of Nebraska, Lincoln, USA			
	7 02/04-06/04 09/04-13/04 16/04-20/04	Hydrological data collection and processing (WSE/HWR/07A/s) M1554  or Groundwater data collection and interpretation (WSE/HWR/07B/s) M3160  HWR: Click here to choose your module 7	River basin modelling (WSE/07s) M3232	River structures (WSE/HERBD/07/s) M1171	Process-based coastal modelling (WSE/HECEPD/07/s) M3162	Conveyance and irrigation structures (WSE/LWDFS/07/s) M3025				Groundwater data collection and interpretation (WSE/HWR/07B/s) M3160	River basin modelling (WSE/07s) M3232
	8 23/04-27/04 30/04-04/05 07/05-11/05	Choice for HWR only: M3096 - Groundwater in adaptation to global change impacts (WSE/HWR/08B/e/Groundwatch) All: M1309 - Integrated hydrological and river modelling (WSE/HWR/08/e) All: M2709 - River flood analysis and modelling (WSE/08A/e) All: M1710 - Urban flood management and disaster risk mitigation (WSE/08B/e) All: M3009 - Dams and hydropower (WSE/HERBD/08B/e/UniKL) All: M3275 - Planning and delivery of flood resilience (WSE/HERBD/08A/e) All: M3166 - International port seminar (WSE/HECEPD/08A/e) All: M3204 - Climate change impacts and adaptation in coastal areas (WSE/HECEPD/08B/e) All: M3203 - Management of irrigation and drainage systems (WSE/LWDFS/08/e)				M3203 Management of irrigation and drainage systems (WSE/LWDFS/08/e)				HWR only: M3096 - Groundwater in adaptation to global change impacts (WSE/HWR/08B/e/Groundwatch)	M2709 - River flood analysis and modelling (WSE/08A/e)  OR M1710 - Urban flood management and disaster risk mitigation (WSE/08B/e)
	WSE: Click HERE TO CHOOSE YOUR MODULE 8						--			--	--
	.. 14/05-18/05	Examination Week									
	9 21/05-25/05 28/05-01/06 04/06-08/06	Fieldtrip and fieldwork WSE (WSE/09/c) M3167				Fieldtrip and fieldwork WSE (WSE/09/c) M3167				Fieldtrip and fieldwork WSE (WSE/09/c) M3167	Fieldtrip and fieldwork WSE (WSE/09/c) M3167
10 11/06-15/06 18/06-22/06 25/06-29/06	All: M2841 - Applied groundwater modelling (WSE/HWR/10B/e) All: M3243 - Flood risk management (WSE/010A/e) All: M3036 - Drought management and reservoir operations (WSE/HERBD/10/e) All: M2214 - Geotechnical engineering and dredging (WSE/HECEPD/10/e) All: M3238 - Innovative water systems for agriculture (WSE/LWDFS/10/e)				M2841 - Applied groundwater modelling (WSE/HWR/10B/e)		M3243 - Flood risk management (WSE/010A/e)				
Click HERE TO CHOOSE YOUR MODULE 10 and 11 (2017-2019)						--	--				
11	02/07-06/07 09/07-13/07 16/07-20/07	All: M3048 - Water sensitive cities - (WSE/11) All: M3233 - Hydroinformatics for decision support - (WSE/011e) All: M3277 - Modelling river systems and lakes - (WSE/HERBD/11/e) All: M3251 - Flood protection in lowland areas - (WSE/HECEPD/11/e) All: M3237 - Remote sensing for agricultural water management - (WSE/LWDFS/11/e)  OR: a module from another Programme						> IWRM as a tool for adaptation to climate change (ES11X) M3207 or	> All: M3233 - Hydroinformatics for decision support - (WSE/011e)		
	.. 23/07-27/07	Examination Week						Examination Week			
Students leave: Erasmus Mundus Flood Risk Management, Groundwatch	12 30/07-03/08	Click here to choose your summer course (WSE12)						Free/Internship	Free		
13	06/08-10/08 13/08-17/08 20/08-24/08	Groupwork WSE (WSE/13/c) M1284				Free/Internship		Free			
	.. 27/08-31/08	Examination Week									
	.. 03/09-07/09	Free									
14	10/09-14/09 17/09-21/09 24/09-28/09 01/10-05/10 08/10-12/10	MSc research proposal development for WSE (WSE/14/c) M3284				TU Dresden (Sept 17, 2018)		UPC (Sept 17, 2018)			
	.. 15/10-19/10	MSc research, thesis and defence (6 months) (WSE/15) M2927						UL Dec'18-Feb'19			
15	22/10/18 .. ..... ..... ..... ..... 05/04/19	MSc research, thesis and defence (6 months) (WSE/15) M2927						MSc research (Start: March 2019) (Defence: September 2019)	MSc research Start: March'19 Defence: Aug'19		
	10/04-12/04 15/04-17/04	Final Examination Week - Diploma awarding 25/04/2019						MSc research (Start: March 2019) (Defence: September 2019)	MSc research Start: March'19 Defence: Aug'19		

# **Water Science and Engineering**

**Certificate course**

**2017/2018**

**Coastal Systems**

# M3163

## Coastal Systems

<b>Term</b>	201718
<b>Coordinator</b>	R.W.M.R.J.B. Ranasinghe
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

Students in coastal engineering and port development

### Prerequisites

Basic knowledge of waves and hydraulics

### Learning Objectives

- 1 understand the governing processes in coastal hydrodynamics and morphology
- 2 assess processes related to salt intrusion and density currents;
- 3 apply understanding of hydrodynamic and morphological processes in diverse coastal environments, such as reefs, mangroves and rocky coasts
- 4 apply understanding of the role of ecosystems in coastal zone dynamics and its management

### Assessments

%	Type	Name
100	Written examination (open book)	Written exam Coastal Systems

### Topics

#### 1 Coastal Hydrodynamics and Morphology

Estuarine morphodynamics; salt intrusion; inlet morphodynamics

#### 2 Coastal Hydrodynamics and Morphology

Wave energy balance; Longshore currents; wind driven circulation; tides in shallow seas; coastline models; sediment transport;

## Topics

### 3 Coastal Hydrodynamics and Morphology

Coastline and beach types; surf zone cross-shore hydrodynamics; introduction to rip currents; Cross-shore morphodynamics; beach states; introduction to coastal models

### 4 Coastal hydrodynamics and morphology

Hydrodynamics and morphodynamics of coral reefs and mangroves

### 5 Barrier island coasts

Geomorphology of barrier island systems; processes governing long-term change of tidal basins

### 6 Rip currents

Infragravity waves and associated hydrodynamics; rip current generation and evolution

### 7 Coastal ecosystems and management

Environmental considerations in coastal zone management, EIAs

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Coastal Hydrodynamics and Morphology	4	0	4	0	0	0	8	16	M. van der Wegen
2	Coastal Hydrodynamics and Morphology	8	0	16	0	0	0	24	40	J.A. Roelvink
3	Coastal Hydrodynamics and Morphology	10	0	0	0	0	0	10	30	R.W.M.R.J.B. Ranasinghe
4	Coastal hydrodynamics and morphology	4	0	0	0	0	0	4	12	J.A.H. Reyns
5	Barrier island coasts	4	0	0	0	0	0	4	12	A.J.F. van der Spek
6	Rip currents	4	0	0	0	0	0	4	12	M.A. de Schipper
7	Coastal ecosystems and management	6	0	0	0	0	0	6	18	F. van der Meulen
<b>Total</b>		<b>40</b>	<b>0</b>	<b>20</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>140</b>	

## Education Material

Lecture notes

Os, A.G. van, Salt intrusion and density currents - Lecture notes In 0286/98/



**Scientific Software**  
Matlab

# M3298

## Data Assimilation for Operational Hydrological Modelling

<b>Term</b>	201718
<b>Coordinator</b>	M. Mazzoleni
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

Target groups are both scientists and practitioners in the field of operational reservoir management. Water Authorities interested in improving their early warning system by means of model updating techniques are also welcome.

### Prerequisites

Participants should have a good background with hydrological and mathematical theories. They are expected to be familiar with the contents of standard operational forecasting and reservoir management. Basic programming skills are also required.

### Learning Objectives

- 1 Recognise the main challenges in operational hydrological forecasting in case of reservoir management
- 2 Explain the concept of model updating using data assimilation techniques
- 3 Identify the advantages and disadvantages of each updating method to improve operational forecasting
- 4 To be able to apply different data assimilation approaches to operational reservoir management applications and analyses their usefulness
- 5 Discuss the concept of forecast uncertainty

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 1 **Overview to operational forecasting**
- 2 **Introduction to hydrological modelling**

## Topics

### 3 Assessment of forecast uncertainty

### 4 Introduction to Data Assimilation

1. Kalman Filter,
2. Ensemble Kalman Filter,
3. Particle Filter,
4. Asynchronous Filtering

### 5 Hands-on Exercise: practical applications

1. A simple update exercise and comparison of techniques
2. Assimilation of a single observation variable
3. Hindcasting experiments using operational forecasting systems
4. Simultaneous assimilation of multiple observations (e.g. discharge, soil moisture)

### 6 Outlook and further applications

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Overview to operational forecasting	2	0	0	0	0	0	2	6	
2	Introduction to hydrological modelling	3	0	0	0	0	0	3	9	
3	Assessment of forecast uncertainty	3	0	0	0	0	0	3	9	
4	Introduction to Data Assimilation	14	0	0	0	0	0	14	42	
5	Hands-on Exercise: practical applications	0	0	14	0	0	0	14	14	
6	Outlook and further applications	4	0	0	0	0	0	4	12	
Total		26	0	14	0	0	0	40	92	

## Education Material

### Scientific Software

Gewin Excel

Matlab

# M3164

## Design of Breakwaters

<b>Term</b>	201718
<b>Coordinator</b>	A. Dastgheib
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

This course is useful for engineers involved in the design of coastal structures specially breakwaters and/or the supervision of construction of breakwaters. Knowledge of the coastal processes such as wind, waves, tides and tidal currents is necessary.

### Prerequisites

Short Waves, Tides and Tidal Currents, Coastal Processes

### Learning Objectives

- 1 Understand the difference between alternative types of breakwaters and governing factors for their selection; Design breakwaters from conceptual to detailed and prepare the layouts and detailed cross-sections.
- 2 Understand the basic principles of physical scale model and know how to design such a model to test the design of coastal and port structures.

### Assessments

%	Type	Name
1	Assignment	Design of Breakwaters

### Topics

- 1 **Design of Breakwaters**  
Types, functions, design procedure for breakwaters, data collection; soils, hydraulic conditions, construction materials, definition of requirements, governing parameters for breakwater design such as wave parameters, structural parameters, conceptual design, selection, preliminary design for rubble mound breakwaters, hydraulic response, structural response for rubble mound breakwaters , design of composite type, vertical wall and berm breakwaters, design of low crested and submerged structures, construction methods, case studies, physical modelling. Applications using BREAKWAT, exercise on design of rubble mound and vertical type breakwaters, exercise on scaling a design for physical modeling.
- 2 **Design of Breakwaters Exercise**

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Design of Breakwaters	26	0	0	0	0	0	26	78	J.W. van der Meer
2	Design of Breakwaters Exercise	0	8	0	0	0	16	16	56	A. Dastgheib, J.W. van der Meer
Total		26	8	0	0	0	16	42	134	

## Education Material

Lecture notes Breakwater Design; J.W. van der Meer, H. Ligteringen; In0026/18

Lecture notes Exercise Breakwater Design J.W. van der Meer, A. Dastgheib; In0027/18

## Scientific Software

Breakwat

# M3312

## Google Earth Engine for Spatio-Temporal Analysis of Hydrological Extremes

<b>Term</b>	201718
<b>Coordinator</b>	M. Mazzoleni
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

Prospective participants are both scientists and practitioners in the field of hydrological extremes (floods and droughts) management and remote sensing. Water Authorities interested in improving water resources management by means of multiple remote sensing sources and Google Earth Engine are also welcome.

### Prerequisites

Participants should have a good background with hydrological theories. Basic programming skills are also required

### Learning Objectives

- 1 To acquire a theoretical understanding of the remote sensing products available for water resources management purposes
- 2 To master the Google Earth Engine platform for data collection, visualization and classification.
- 3 To be able to perform complex spatial-temporal analysis with Google Earth Engine using the latest remote sensing products.
- 4 To apply Google Earth Engine for large scale hydrological extremes management

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 1 **Theoretical background on remote sensing**
- 2 **Introduction to Google Earth Engine and Java scripting**
- 3 **Data collection, visualization and classification with Google Earth Engine**

## Topics

- 4 Time series analysis
- 5 Hydraulic modelling for flood management
- 6 Application of Google Earth Engine in flood management
- 7 Drought analysis

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Theoretical background on remote sensing	4	0	0	0	0	0	4	12	
2	Introduction to Google Earth Engine and Java scripting	2	0	2	0	0	0	4	8	
3	Data collection, visualization and classification with Google Earth Engine	1	0	3	0	0	0	4	6	
4	Time series analysis	2	0	2	0	0	0	4	8	
5	Hydraulic modelling for flood management	3	0	5	0	0	0	8	14	
6	Application of Google Earth Engine in flood management	3	0	5	0	0	0	8	14	
7	Drought analysis	3	0	5	0	0	0	8	14	
Total		18	0	22	0	0	0	40	76	

## Education Material

### Scientific Software

Gewin Excel  
HEC-RAS

# M3160

## Groundwater Data Collection and Interpretation

<b>Term</b>	201718
<b>Coordinator</b>	T.Y. Stigter
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

MSc students in Hydrology and Water Resources, short course participants involved in groundwater and environmental impacts investigation and monitoring activities.

### Prerequisites

Approved BSc degree and basic hydraulics/hydrology subjects

### Learning Objectives

- 1 outline the methodology for designing groundwater surveying programmes (GSP), including the main desk and field activities to be performed;
- 2 interpret the results from geophysical surveys, exploration borehole logging, pumping tests and groundwater observations within the context of GSP;
- 3 plan a GSP for a certain area based on the analysis of available data and field conditions;
- 4 interpret hydro(geo)logical time series and spatial data;
- 5 learn methods and procedures used in groundwater monitoring;
- 6 design a groundwater monitoring network and to assess the required measurement frequencies

### Assessments

%	Type	Name
0,3	Assignment	Groundwater Monitoring
0,2	Assignment	Groundwater Surveys
0,2	Written examination (closed book)	Groundwater Surveys
0,15	Assignment	Hydrogeostatistics
0,15	Written examination (closed book)	Hydrogeostatistics



## Topics

### 1 Groundwater Surveys

This subject deals with groundwater exploration and resources assessment. The first part deals with methods including desk studies, hydrogeological mapping and well inventories, and surface geophysical measurements. Insight into the interpretation of borehole data and geophysical measurements is obtained with an exercise regarding a case study in the northeastern part of The Netherlands. Then follow outlines on exploration drilling and logging techniques and the interpretation of results. Finally, the practical set up and execution of pumping tests and the interpretation of test results is dealt with.

### 2 Electromagnetic Surveys

This topic deals specifically with electro-magnetic surveying techniques for groundwater exploration.

### 3 Groundwater Monitoring

Principles and concepts of groundwater monitoring. The lectures and exercises discuss and practice the design and operational aspects of groundwater observation networks. Introduction: basic concepts and procedures; Network density for estimating the global mean; Monitoring of diffusive pollution; Monitoring of waste disposal sites; Network density graphs; Determination of network density with Kriging; Determination of sampling frequency with time series analysis.

### 4 Hydrogeostatistics

Statistical descriptors and their use in hydrological data analysis: Correlation and regression analysis; Time series analysis: autocorrelation, trend, periodicity and stochastic components; statistical test of trend; harmonic analysis; AR models; Spatial description: spatial hydrological and hydrogeological variables; spatial variability; trend surfaces; simple and ordinary kriging; intrinsic hypothesis; variograms; estimation of variograms using measurements; spatial interpretation with kriging.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater Surveys	11	4	9	0	4	0	24	50	T.Y. Stigter
2	Electromagnetic Surveys	2	0	2	0	0	0	4	8	
3	Groundwater Monitoring	12	0	8	0	0	0	20	44	Y. Zhou
4	Hydrogeostatistics	10	0	8	0	0	0	18	38	T.Y. Stigter, Y. Zhou
Total		35	4	27	0	4	0	66	140	

## Education Material

Book	Handouts from presentations, whiteboard, exercise book, participant laptop with dedicated software
Lecture notes	Nonner, J., Stigter, T., Introduction to groundwater exploration (Lecture notes LNO072/15/1)
Lecture notes	Zhou, Y., Groundwater monitoring, Lecture notes, LN0053/09/1
Lecture notes	Zhou, Y., Hydrogeostatistics, Lecture notes

## **Scientific Software**

Aqtesolv

Freq

Gewin Excel

netgraph

surfer

# M3275

## Planning and Delivery of Flood Resilience

<b>Term</b>	201718
<b>Coordinator</b>	B. Gersonius
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

- Flood risk managers, local planners and river basin council members
- Others (i.e. consultants) involved in supporting decision making with regard to flood risk management

### Prerequisites

Basic knowledge of the behaviour of river and delta systems (e.g. discharge variations, floods), and their management. Good command of English.

### Learning Objectives

- 1 Define the concept of flood resilience, together with its added value for flood risk management
- 2 Define objectives for reducing flood risk and improving flood resilience, and stress-test these objectives against climate change
- 3 Develop a variety of adaptation strategies, focusing on all aspects of flood risk management: protection, prevention, preparedness, emergency response and recovery
- 4 Evaluate adaptation strategies and pathways under the influence of climate change
- 5 Design an adaptive plan based on the developed pathways, including the necessary arrangements for implementation and monitoring

### Assessments

%	Type	Name
3	Assignment	Classroom assignments
2	Homework	Homework assignment (4-page reflection)
5	Presentation	

## Topics

### 1 Resilience of flood risk systems

Flooding can have devastating impacts on societies and their economies. Recovering from these impacts might be very difficult, especially in urban areas where social and technical systems are interdependent. Over the coming decades, it is expected that the frequency and intensity of floods will increase due to climate and socio-economic change. Building resilience to flooding, therefore, is an important need to sustain the liveability and economic competitiveness of cities. This topic introduces resilience as the ability of an area or community to remain functioning under a range of flood events.

### 2 Objectives and stress-testing objectives

This topic deals with the objectives and associated performance indicators for flood risk management, to be identified in consultation with the stakeholders. This also includes the definition of critical threshold values of the performance indicators that are used to indicate vulnerabilities to climate and socio-economic change. The vulnerability assessment is conducted using the “climate stress test” methodology, which systematically tests the flood risk system with climate changes so that the problematic climate changes can be identified.

### 3 Strategies to improve flood resilience

This topic identifies a range of strategies to reduce flood risks and improve resilience. It focuses on pre-event mitigation: protection, prevention and preparedness. Protection is directed at reducing the likelihood of floods, such as by giving rivers more space; prevention involves sustainable spatial planning and protection of infrastructure; and preparedness concerns taking organisational measures, like preparing evacuation and recovery plans. It also deals with the management of flood events: emergency relief and recovery. Emergency relief concerns e.g. evacuating communities and providing assistance, and recovery aims at mitigating the impacts on affected communities.

### 4 Evaluation within adaptation pathway sequences

This topic provides guidance to evaluate and help justify the choices between different possible adaptation strategies in terms of costs, benefits and tradeoffs in the short and long term through the possible realization of pathways, and considerations of robustness or flexibility build into the flood risk system. It also provides the analytical justifications for choices in the long term or short term.

### 5 Adaptive plan, incl. institutional and monitoring arrangements

This topic addresses the design of an adaptive plan to improve flood resilience. This plan contains the following elements: 1) a preferred adaptation strategy; 2) actions to be taken on the short term and maybe on the mid term; 3) options to keep open for the long term; 4) arrangements (organizational, financial, legal etc.) to be made for implementing the actions; and 5) a monitoring plan.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Resilience of flood risk systems	6	4	4	0	0	0	10	26	B. Gersonius, W. Veerbeek
2	Objectives and stress-testing objectives	4	4	6	0	0	0	10	22	B. Gersonius, J.S. Rijke
3	Strategies to improve flood resilience	8	2	4	0	8	0	20	38	C. Zevenbergen, K.A. Anema, M.F. van Staveren, W. Veerbeek
4	Evaluation within adaptation pathway sequences	4	4	6	0	0	0	10	22	B. Gersonius, M.H.J.L. Jeuken, W. Veerbeek
5	Adaptive plan, incl. institutional and monitoring arrangements	6	2	4	0	0	0	10	24	C.J.L. Seijger, P. Bloemen
<b>Total</b>		<b>28</b>	<b>16</b>	<b>24</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>60</b>	<b>132</b>	

## Education Material

E-book	Collaborative Risk-Informed Decision Analysis (CRIDA) manual
Scientific journal	Key (3-5) relevant scientific articles

## Scientific Software

# M3232

## River Basin Modelling

<b>Term</b>	201718
<b>Coordinator</b>	A. Jonoski
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants in WSE programme - hydroinformatics specialisation; Participants in Erasmus Mundus Flood Risk Management Programme; Participants in short course "River Basin Modelling"

### Prerequisites

Hydrology and Hydraulics

### Learning Objectives

- 1 Explain the multi-purpose nature of river basins and approaches for their integrated planning and management, with special focus on role of modelling
- 2 Interpret solutions of groundwater flow problems based on governing physical laws and their mathematical representation
- 3 Apply MODFLOW modelling system to solve groundwater flow problems and examine the solutions
- 4 Model hydrological processes in catchments using MIKE SHE modelling system
- 5 Examine results of MIKE-SHE models that include both surface and groundwater flow in a natural catchment, including the unsaturated zone

### Assessments

%	Type	Name
1	Written examination (closed book)	The exam will include questions from all topics of this module.

### Topics

#### 1 River basin management

Introduction to the management of river basins; water resources; Integrated Water Resources Management (IWRM); framework for analysis in water resources planning and management projects; role of modelling; case studies. Exercises and workshops with RIBASIM.

## Topics

### 2 Groundwater modelling

The continuum approach; definitions; Darcy's law; groundwater flow in the saturated zone: equations for 1D, 2D and 3D flow; modelling approaches; modelling protocol; contaminant transport through advection and diffusion; exercises and workshops with the MODFLOW modelling system (PMWin) for solving basic problems of groundwater flow through aquifers and moderately complex water resources and engineering problems: problem definition, model building, results analysis and interpretation.

### 3 Catchment modelling

Types of hydrological models: empirical/data-driven/black box; conceptual and physically based models; NAM lumped-conceptual model: model-set-up of a catchment & calibration from rainfall & discharge records; focus on distributed physically based catchment modelling with MIKE-SHE: 1) introduction to the modelling exercises and workshops; presentation of MIKE-SHE software package and the catchments used for the exercises; 1) Initial model building - saturated zone; 2) Overland and river flow modelling - comparison of models with and without the river network; 3) Unsaturated zone modelling 4) Fully integrated catchment model: river + drainage + saturated + unsaturated zone;

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	River basin management	6	0	4	4	0	0	14	30	E. van Beek, W.N.M. van de Krogt
2	Groundwater modelling	8	0	6	6	0	0	20	42	A. Jonoski
3	Catchment modelling	12	0	10	10	0	0	32	66	A. Jonoski, I.I. Popescu, M.E Butts
Total		26	0	20	20	0	0	66	138	

## Education Material

Handout Handouts: Jonoski: Groundwater modelling using MODFLOW; Jonoski and Popescu: Catchment modelling with MIKE SHE; van der Krogt: RIBASIM user manual;

## Scientific Software

Mike 11

Mike SHE

PmWin

Ribasim

# M2131

## Introduction to Water Science and Engineering

<b>Term</b>	201718T01
<b>Coordinator</b>	J.W.A. Foppen
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Entry level with a background in engineering, geoscience, and related disciplines

### Prerequisites

Entry requirements of the WSE-programme

### Learning Objectives

- 1 Tell the relevant issues of the global agenda for water and sustainable development; understand the field of water science and engineering, identify its different specialisations and understand the structure of the programme at UNESCO-IHE
- 2 Apply mathematical, statistical and frequency analysis concepts and techniques relevant to water science and engineering
- 3 Describe geologic, geomorphological and anthropogenic processes at the surface of the Earth that form and sculpt landscapes

### Assessments

%	Type	Name
45	Assignment	Review of Mathematics and Statistics
55	Written examination (open book)	The Earth System

### Topics

#### 2 Review of Mathematics

Coordinate systems: Cartesian, cylindrical, spherical; Calculus: functions, differentiation and integration, complex numbers; Linear algebra: vector spaces, matrix algebra; Differential equations: ODEs, PDEs, differential operators; Fourier series and har

#### 3 Review of Statistics and Frequency Analysis

Data, variables, classification, stat. moments, frequency distributions; samples, populations and probability models; parameter estimation and confidence intervals.

#### 4 The Earth System (geology, geomorphology, the anthropocene)

Overview of the geological materials, processes and shapes of the earth at different time and space scales that are interconnected with the water system and engineering. Overview of the geomorphological processes shaping the Earth's surface and interactin



## Topics

### 5 Fieldwork Excursion Delaworks

Excursion to hydraulic engineering flood protection works in the south-western delta of The Netherlands.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
2	Review of Mathematics	8	0	4	0	0	0	12	28	I.I. Popescu
3	Review of Statistics and Frequency Analysis	6	4	0	0	0	0	6	22	P.H.A.J.M. van Gelder
4	The Earth System (geology, geomorphology, the anthropocene)	18	14	14	0	0	0	32	82	A.C. Seijmonsbergen, C.M.S de Fraiture, P. Paron
5	Fieldwork Excursion Delaworks	0	0	0	0	0	0	0	0	
<b>Total</b>		<b>32</b>	<b>18</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>50</b>	<b>132</b>	

## Education Material

Handout	1 Various material, handouts, and references: Lecturing material available as on-line resource
Handout	2 Price, R. & Popescu, I.: Review of Mathematics Handouts: Lecturing material available as on-line resource
Handout	3 LN00072, Van Gelder, P.: Review of Statistics and Frequency Analysis Handouts: Lecturing material available as on-line resource
Handout	5 (a) LN0194/10/1, Rondeel, H.E.: Geology. (b) LN0410/09/1. Seijmonsbergen, A.C.: Introduction to Air-Photo interpretation Handouts: Lecturing material available as on-line resource
Handout	6 De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.

## Scientific Software

# M2630

## Short Course on Where there is Little Data: How to Estimate Design Variables in Poorly Gauged Basins

<b>Term</b>	201718T01
<b>Coordinator</b>	P. Paron
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

### Prerequisites

### Learning Objectives

- 1 To apply the latest new Open Source GIS and Remote Sensing software and data for deriving hydro-geomorphological and hydro-meteorological information
- 2 To apply an advanced theoretical understanding of selected hydrological variables: flow duration curves, hydrological extremes, mean annual flow
- 3 To evaluate, select and apply different advanced statistical and geo-statistical methods for estimating hydrological variables in poorly gauged basins

### Assessments

%	Type	Name
1	Attendance	

### Topics

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

## Education Material

## Scientific Software

# M2208

## Hydrology and Hydraulics

<b>Term</b>	201718T02
<b>Coordinator</b>	S. Maskey
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All WSE participants; and participants of Joint International Master Programmes IMHI, IMCEPD and IMHWR (following the programme in partner institutes).

### Prerequisites

Entry requirements for WSE

### Learning Objectives

- 1 Describe the main concepts of steady/unsteady and uniform/non-uniform flow.
- 2 Understand and describe the principles and basic equations of water flow and to apply them to various practical situations.
- 3 Carry out basic measurements in the wave and current flumes at the hydraulic laboratory.
- 4 Understand, describe and apply the concepts of hydrology needed for their specialisation.
- 5 Understand the concepts of Geographical Information Systems and apply them in practical examples relevant to their specialization.
- 6 Understand the main techniques of remote sensing and know when their use is appropriate or inappropriate.

### Assessments

%	Type	Name
20	Assignment	GIS & Remote Sensing
40	Written examination (open book)	Written exam Engineering Hydrology
40	Written examination (open book)	Written exam Free Surface Hydrodynamics

### Topics

#### 1 Free-Surface Hydrodynamics

Topics include: Introduction to free-surface hydrodynamics; 1-D Channel Flow and Equations; Uniform and Non-uniform Flow Computations (exercises); 2-D and 3-D Shallow Water Equations; Hydraulic Laboratory

##### 1.1 Introduction to Free Surface Hydrodynamics

Introduction. Governing Laws of free-surface hydrodynamics. Development of hydrodynamic equations.

## Topics

### 1.2 1-D Channel Flow and Equations

Steady uniform flow, normal depth, Chezy and Manning's formulas. Specific energy, critical depth, Froude number. Sub-critical and supercritical flows. Non-uniform flow; rapid and gradually varied flow; computation of water surface profiles. Unsteady flow; Saint-Venant equations for 1-D flow.

### 1.3 Uniform and Non-uniform Flow Computations

Exercises: Computation of uniform flow in open channel (single and composite channels); Computation of non-uniform steady flow in open channel (flow surface profiles and backwater curve); Application of Bernoulli equation.

### 1.4 2-D and 3-D Shallow Water Equations

Introduction to 2-D and 3-D flows and application examples.

### 1.5 Hydraulics Laboratory

Various types of measuring equipment. Choice of various flow types: over a broad crested weir, through a contraction, underneath a gate; wave propagation and dissipation in a flume.

## 2 ENGINEERING HYDROLOGY

Topics include: Engineering Hydrology (lectures and exercises); Engineering Hydrology Workshop

### 2.1 Engineering Hydrology (lectures and exercises)

Hydrological cycle, water balance, catchment, water divide, influence of man, rainfall measurement, areal rainfall, depth-duration-frequency curves, types of evaporation, evaporation equations, infiltration (formula of Horton), soil moisture, groundwater, measurement of water level and discharge, flow duration curves, rainfall-runoff relationship, rainfall-runoff analysis, Rational Method for estimating peak discharge.

### 2.2 Engineering Hydrology Workshop

Workshop exercises on duration curve, extreme value analysis, flood routing, reservoir simulation.

## 3 Geographical Information Systems and Remote Sensing

Introduction to geographic information systems and remote sensing technologies; active and passive remote sensing; data structures, map projections and coordinate systems; processing of digital geographic information; creation of digital elevation models; visualisation, mapping of water and environmental features; watersheds, streams and aquifers delineation; digitisation, soil and land use mapping; map algebra; terrain analysis for hydrological and hydraulic modeling; production of thematic maps; GIS as a decision support tool. Exercise and assignment using a case study data.

Software: ArcGIS.

### 3.1 Introduction to GIS

### 3.2 Introduction to Remote Sensing

### 3.3 GIS exercises

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Free-Surface Hydrodynamics	0	0	0	0	0	0	0	0	
1.1	Introduction to Free Surface Hydrodynamics	2	0	0	0	0	0	2	6	J.A. Roelvink
1.2	1-D Channel Flow and Equations	6	0	0	0	0	0	6	18	S. Maskey
1.3	Uniform and Non-uniform Flow Computations	0	0	2	4	0	0	6	10	L.G. Hayde, S. Maskey
1.4	2-D and 3-D Shallow Water Equations	4	0	0	0	0	0	4	12	J.A. Roelvink
1.5	Hydraulics Laboratory	2	0	0	4	0	0	6	14	L.G. Hayde
2	ENGINEERING HYDROLOGY	0	0	0	0	0	0	0	0	
2.1	Engineering Hydrology (lectures and exercises)	10	0	0	4	0	0	14	38	J.W. Wenninger
2.2	Engineering Hydrology Workshop	0	0	4	4	0	0	8	12	R.G.W. Venneker, S. Maskey
3	Geographical Information Systems and Remote Sensing	0	0	0	0	0	0	0	0	
3.1	Introduction to GIS	2	0	0	0	0	0	2	6	J.L. Alfonso Segura
3.2	Introduction to Remote Sensing	2	0	0	2	0	0	4	10	W.G.M. Bastiaanssen
3.3	GIS exercises	0	0	0	8	0	0	8	16	F.X. Suryadi, J.L. Alfonso Segura, M. Mazzoleni
<b>Total</b>		<b>28</b>	<b>0</b>	<b>6</b>	<b>26</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>142</b>	

## Education Material

Lecture notes      Paron P., 2009. Introduction to GIS and Remote Sensing, Lecture Notes

## Scientific Software

ArcGIS

# M2166

## Hydrogeology

<b>Term</b>	201718T03
<b>Coordinator</b>	Y. Zhou
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydrology and Water Resources

### Target Group

Participants in Hydrology and Water Resources specialisation

### Prerequisites

Approved BSc degree and basic hydrology/hydraulics and earth sciences subjects.

### Learning Objectives

- 1 understand groundwater occurrences, aquifer classification and aquifer properties in various geological settings;
- 2 understand the concepts related to groundwater storage, recharge and discharge;
- 3 understand steady state and transient groundwater flow processes and their physical description;
- 4 the ability to apply analytical solutions to solve steady state and transient groundwater problems;
- 5 determine groundwater balances and to carry out pumping test analyses.

### Assessments

%	Type	Name
30	Assignment	Hydrogeology and Groundwater Hydraulics
70	Written examination (closed book)	Hydrogeology and Groundwater Hydraulics

### Topics

#### 1 Hydrogeology

Hydrogeological principles and concepts, and the underlying physics of groundwater flow processes. The place of groundwater systems in the hydrological cycle. The interaction between rock and water and the concepts of porosity and permeability. Definition of aquifer, aquitard, aquifuge and aquiclude. Rock types and the related groundwater system. Concepts of regional flow based on Darcy and Continuity equations. Flow computation methods. The concept and formulation of groundwater balances. Estimation of recharge terms. Groundwater management and the concept of groundwater availability.

#### 2 Steady Groundwater Hydraulics

Principles of groundwater flow: hydraulic head, Darcy's law, continuity equation; steady state groundwater flow equations; Analytical solutions of steady state groundwater flow in aquifers and towards wells; Methods of superposition and image; Flow net.

## Topics

### 3 Transient Groundwater Hydraulics

Dynamics of groundwater systems; Concepts of storage of water in groundwater systems; Analytic solutions and their implementation and use (groundwater hydraulics); Superposition in time and convolution; Pumping tests; Exercises.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydrogeology	16	0	4	0	0	0	20	52	T.Y. Stigter
2	Steady Groundwater Hydraulics	14	0	4	0	0	0	18	46	Y. Zhou
3	Transient Groundwater Hydraulics	12	0	6	0	0	0	18	42	
Total		42	0	14	0	0	0	56	140	

## Education Material

## Scientific Software



# M3184

## Information Technology and Software Engineering

<b>Term</b>	201718T03
<b>Coordinator</b>	J.L. Alfonso Segura
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydroinformatics: Modelling and Information Systems for Water Management

### Target Group

Participants in WSE Programme - Hydroinformatics, including the IMHI participants (following the courses at partner institutions).

### Prerequisites

Acquaintance with computing

### Learning Objectives

- 1 Develop computer code for general and water-related problems, applying the main principles of software engineering and computer programming
- 2 Describe the Python environment, explain its working philosophy and use it to perform basic operations and plots
- 3 Explain and apply the main operation principles of computers, networks and Internet
- 4 Select and apply software tools to increase productivity

### Assessments

%	Type	Name
50	Written examination (closed book)	Information Technology, Software Engineering and Database Systems
50	Assignment	Software Engineering

### Topics

- 1 **Information and communication technology**
- 2 **Introduction to Python**
- 3 **Software Engineering**
- 4 **Introduction to database systems**
- 5 **Visit to Deltares**

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Information and communication technology	4	0	4	8	0	0	16	32	G.A. Corzo Perez
2	Introduction to Python	0	0	0	0	0	0	0	0	
3	Software Engineering	6	0	26	8	0	0	40	60	D. Solomatine, G.A. Corzo Perez, J.L. Alfonso Segura
4	Introduction to database systems	6	0	6	0	0	0	12	24	D. Solomatine, S.J. van And
5	Visit to Deltares	0	0	0	0	8	0	8	8	
<b>Total</b>		<b>16</b>	<b>0</b>	<b>36</b>	<b>16</b>	<b>8</b>	<b>0</b>	<b>76</b>	<b>124</b>	

## Education Material

Lecture notes	L. Alfonso and Gerald Corzo, Lecture Notes on Introduction to Python
Lecture notes	Solomatine, Lecture Notes on Information Technology and Computer Science: An Introduction
Lecture notes	Solomatine, Lecture Notes on Object Oriented Programming: A Practical Introduction
Lecture notes	Solomatine, Lecture Notes on Software Development with Borland Delphi
Lecture notes	Solomatine, Lecture Notes on Software Engineering: An Introduction

## Scientific Software

ArcGIS  
Matlab

# M3178

## Introduction to Coastal Science and Engineering

<b>Term</b>	201718T03
<b>Coordinator</b>	A.A. Milho Semedo
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Coastal Engineering and Port Development

### Target Group

Graduates from civil and coastal engineering, environmental engineering graduates and managers with interest in the coastal area, oceanographers, ocean engineers, and marine science graduates.

### Prerequisites

Basic knowledge of calculus and hydraulics.

### Learning Objectives

- 1 Understand the basics of coastal engineering.
- 2 Explain wave key concepts, wave propagation and breaking (deep and shallow waters) from linear theory, observations and models, describe the concept of radiation stress and its importance in forcing currents and shallow water level gradients at the coast.
- 3 Generate wave statistics, including extremes, understand concept of wave spectra and bulk parameters, identify the basics of wave climate, from global to regional/local scales, apply wave growth curves and understand wave energy balance concept.
- 4 Explain the origin and generation of tides, understand the tide generating forces, describe the analysis and prediction of tides process, and understand tidal currents in one and two dimensions.
- 5 Recognize the different areas of the Matlab environment, and explain their purpose, as well as being able to perform basic operations with Matlab, related to matrix manipulation, programming and plotting.
- 6 Understand techniques of in-situ soil investigation and laboratory tests, have basic understanding of most common types of soft soil, understand basics of soil mechanics, based on the Mohr Coulomb model, and be able to make calculations regarding slope.

### Assessments

%	Type	Name
0,05	Written examination (closed book)	Introduction to Coastal Engineering
0,1	Lab. Report	Introduction to Matlab
0,4	Written examination (closed book)	Ocean waves dynamics
0,2	Written examination (closed book)	Soil Mechanics
0,25	Written examination (closed book)	Tides and Tidal Currents

## **Topics**

### **1 Introduction to Coastal Engineering**

- Introduction of the Module
- Coastal Environments
- Sediment balances in coastal environments

## Topics

### 2 Ocean Waves Dynamics

Basic wave characteristic

- Types of waves in the ocean
- Wave parameters (wave height and amplitude, wave period and length, etc.)

Linear wave theory

Non-linear waves

Wave propagation

- Deep to shallow waters
- Dispersive characteristics of waves
- Wave group concept

Wave transformation in shallow waters

- Wave shoaling
- Wave refraction and diffraction
- Wave reflection
- Standing waves

Waves in the nearshore zone

- Wave breaking processes

## Topics

- Influence of bathymetry
- Types of breaking
- Radiation stress
- Wave set-up and set-down

### Wave generation

- Wave generation theories (sheltering, Miles and Phillips theories)
- Fetch concept
- Wave generation curves (nomograms)
- Empirical wave generation expressions

### Wave modelling

- Spectral wave energy balance
- Different wave models
- Global and regional domains
- < >  
1D and 2D wave spectra
- Bulk parameters: significant wave height, peak period, mean wave period, etc.
- Wind sea and swell

## Topics

- Extremes (POT, return values, yearly maxima)

### Wave data sources

- Wave observations (buoys, remote sensing, ADCP, HF radars, etc.)
- Reanalysis and hindcasts

### Wave climate

- Global and regional winds and wave climates
- Wind sea and swell and wave age concept

### Wave climate projections

## Topics

### 3 Tides and Tidal Currents

- Origin and generation of tides
- Tide generating forces
- Analysis and prediction of tides
- Main constituents of the tide
- Types of tides
- Equations for tidal waves in one dimension
- Harmonic waves, resonance
- Short basin
- Tidal waves on a river
- Tidal windows for navigation



## Topics

### 4 Soil Mechanics

- Elements of soil mechanics
- Soil particles
- Grain size distribution
- Soil classification
- Atterberg limits
- soil: a system with 3 phases
- Stress in soil
- Water pressure and effective stress in soil
- Shear stress and shear strength in soil
- Mohr Coulomb circles and stress dependant strength

## Topics

### 5 Introduction to Matlab

- Introduction to MATLAB environment
- Expression and commands
- Vectors and strings
- Simple input and output
- Useful and handy commands
- Basic plotting
- Saving figures
- Array indexing
- Programming with M Files
- Introduction to functions
- Importing external data

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to Coastal Engineering	2	0	2	0	0	0	4	8	J.A. Roelvink
2	Ocean Waves Dynamics	10	0	22	0	0	0	32	52	A.A. Milho Semedo
3	Tides and Tidal Currents	10	0	10	0	0	0	20	40	A.A. Milho Semedo
4	Soil Mechanics	6	0	6	0	0	0	12	24	A. Dastgheib
5	Introduction to Matlab	0	0	8	0	0	0	8	8	J.L. Alfonso Segura
	<b>Total</b>	<b>28</b>	<b>0</b>	<b>48</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>76</b>	<b>132</b>	

## Education Material

### Scientific Software

Matlab

# M3255

## Principles and Practices of Land and Water Development

<b>Term</b>	201718T03
<b>Coordinator</b>	L.G. Hayde
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Land and Water Development for Food Security

### Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development.

### Prerequisites

Basic knowledge in alternative land and water development approaches, irrigation and drainage systems, soil physical and chemical properties

### Learning Objectives

- 1 Analyse the relevance, concept, elements and needs of irrigation and drainage.
- 2 Analyse soil-water-crop yield relationships, management options under land or water scarcity and water saving techniques, and be able to determine crop water requirements
- 3 Explain commonalities and differences between traditional and improved agronomic practices and plan improved irrigation agronomy and field water management
- 4 Understand the unique characteristics and technical and practical conditions for optimum application of different irrigation methods.
- 5 Analyse and evaluate the design and operational aspects of various surface irrigation systems.
- 6 Assess and evaluate various types of flow and apply the hydraulic principles for uniform and non-uniform open channel flow, and flow in specific hydraulic structures in irrigation and drainage engineering.
- 7 Explain how to use different types of literature in scientific work in an ethical manner.

### Assessments

%	Type	Name
44	Written examination (open book)	Agronomy and Soil Water Plant Relations
29	Assignment	Applied Hydraulics of Irrigation Systems I
27	Assignment	Irrigation Methods

## Topics

### 1 Introduction Irrigation and Drainage Systems

Needs for irrigation and drainage systems. Basic functions, elements of the irrigation and drainage systems, topography, irrigation and drainage system lay-out, development and water management aspects, main d'eau, sizing tertiary units, required water levels, design cropping pattern, irrigation requirements, canal design discharges, longitudinal and cross sections, relative sediment transport capacity, shear stress. Structures and emergency measures.

### 2 Agronomy and Soil Water Plant Relations

This course will cover theoretical and practical knowledge and experiences focusing on the following four topics: 1) Commonalities and differences between traditional and improved agronomic practices with emphasis on crop selection, irrigation scheduling, farming practices; 2) Importance of irrigation agronomy for productivity and resistance to water and climate stress; 3) AquaCrop modelling: concepts, principles and simulation approaches, data creation, data input, simulation results and their interpretation; 4) Case study: Practical planning of improved irrigation agronomy and field water management (including groundwater and conjunctive use) for different types of irrigation systems (precision irrigation systems, surface irrigation systems, flood-based farming systems) with the help of AquaCrop Model.

Physical and chemical properties of soils: texture; structure; density; colour; temperature; specific surface of particles; structure of clays; cation exchange capacity; exchange equations. Soil moisture: potential energy of soil water, measurement of soil moisture content and water pressure, soil moisture characteristics (readily) available moisture. Unsaturated flow: equations of subsurface flow, hydraulic conductivity relation, steady flow situations, computation of pressure profiles, moisture distributions, infiltration of water in dry soil. Methods to determine the saturated hydraulic conductivity saturated media and the hydraulic conductivity relation in unsaturated media. Parameters that determine evapotranspiration, methods to estimate potential evapotranspiration; relation between actual evapotranspiration and soil moisture situation. Procedure to estimate crop water-, leaching- and irrigation requirements.

Estimating the potential crop yield in relation to atmospheric conditions; the actual evapotranspiration in relation to soil moisture conditions and the actual crop yield and crop production under limited water supply.

### 3 Irrigation Methods

Surface and sub-surface irrigation, sprinkler and drip irrigation, surface irrigation methods (furrow, border and basin): classification, advance and recession curves, operational aspects, efficiency and uniformity definitions, recent developments, application of WinSRFR programme to evaluate the performance of various irrigation systems.

## Topics

### 4 Applied Hydraulics of Irrigation Systems I

Classification of flow types in irrigation systems; energy and momentum principle, uniform flow; water surface profiles. Application of the energy principle and continuity concept in irrigation systems, e.g. flow over control sections, sills and contractions, outflow problems. Specific phenomena like the hydraulic jump, spillways, energy dissipation in general and small stilling basins. Gradually varied flow; basic equations and simplified equation for prismatic channels; determination of flow profiles. Computation of gradually varied flow in channels by direct integration and numerical methods. Exercise gradually varied flow. CANDES to design the dimensions of irrigation canals in view of erosion and sedimentation. FLOP to calculate gradually varied flow profiles in open (semi) prismatic channels based on either Manning or Chezy. Checking the design of irrigation and drainage canals under (semi) steady flow conditions.

### 5 Use of Literature and Plagiarism

Different types of literature, the relevance of literature, how to use it in assignments and research, how to make proper references, what plagiarism is and how to avoid it.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction Irrigation and Drainage Systems	4	0	2	0	0	0	6	14	L.G. Hayde
2	Agronomy and Soil Water Plant Relations	14	0	12	0	0	0	26	54	D.E. Eisenhauer
3	Irrigation Methods	8	4	6	0	0	0	14	34	R.H. Cuenca
4	Applied Hydraulics of Irrigation Systems I	8	4	8	0	0	0	16	36	L.G. Hayde
5	Use of Literature and Plagiarism	0	0	2	0	0	0	2	2	A.E.C. Duker
<b>Total</b>		<b>34</b>	<b>8</b>	<b>30</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>64</b>	<b>140</b>	

## Education Material

Lecture notes	Depeweg, H.W.Th., 1998. Field Irrigation and Drainage - Surface Irrigation Methods, LN0213/98/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Gradually Varried Flow, LN0443/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Manual Flop - Gradually Varried Flow Profiles, LN0333/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Supplementary notes, LN0442/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Synopsis, LN 0378/11/1
Lecture notes	L.G. Hayde, 2016. Basic Principles of Irrigation and Drainage - In0439/16/1
Lecture notes	de Laat, P.J.M., 2011. Soil-Water-Plant Relations, LN006/11/1

## **Scientific Software**

Basdev

Furdev

flop

# M3129

## River Basin Hydraulics, Geotechnics and Remote Sensing

<b>Term</b>	201718T03
<b>Coordinator</b>	P. Paron
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydraulic Engineering and River Basin Development

### Target Group

students and professionals with a basic knowledge of hydraulics, hydrology and earth science

### Prerequisites

Basic knowledge of hydraulics

### Learning Objectives

- 1 understand hydraulic concepts useful in river basin structure design and management
- 2 gain solid knowledge of optical remotely sensed data collection and analysis for water resources and river basin development
- 3 manage geotechnical (soil and rock) concepts relevant to river basin development

### Assessments

%	Type	Name
25	Written examination (open book)	Applied Hydraulics
25	Assignment	Remote Sensing
25	Written examination (closed book)	Rock Mechanics
25	Written examination (closed book)	Soil Mechanics

### Topics

#### 1 Applied Hydraulics

Advanced concepts in: non-uniform flow; unsteady flow; pressure flow; fluid forces on structures

#### 2 Remote Sensing for Water Resources

(1) Review of basic concepts and foundations of optical RS. (2) Freely available data sources and software. (3) Digital image processing: enhancement, filtering, and band combination. (4) Compound indexes for water resource analysis. (5) Digital image analysis: spectral profiles, supervised and unsupervised classification. (6) River Remote Sensing: methods and data to analyse river characteristics and changes. (7) Multitemporal analysis (land use/land cover, soil moisture, lake and river channel changes, river bathymetry, flood extent, etc). (8) (Kite) Aerial Photography and UAV principles.



## Topics

### 3 Rock mechanics

Geotechnical characterization of rock mass; rock mass classification; rock mass parameter estimation; typical problems in rock mechanics (slope stability, tunnel excavation,...)

### 4 Soil mechanics

Elements of soil mechanics; soil particles, grain size distribution, soil classification, Atterberg limits, soil: a system with 3 phases. Stress in soil; water pressure and effective stress in soil, shear stress and shear strength in soil, Coulomb strength law. Laboratory tests for soil mechanics; direct shear test and 3-axial test. Mohre circle to determine failure in soil. Earth retaining structures; Rankine's theory of active and passive earth pressure, Coulomb method for retaining structures, stability conditions for retaining structures. Slope stability; the ordinary method of slices and simplified Bishop method.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Applied Hydraulics	11	0	1	0	0	0	12	34	A. Cattapan, M.J. Franca
2	Remote Sensing for Water Resources	6	0	9	10	0	0	25	47	M. Mazzoleni, M.J. Smith, P. Paron
3	Rock mechanics	7	0	0	3	0	0	10	27	M. Marence
4	Soil mechanics	6	0	6	0	0	0	12	24	A. Dastgheib
Total		30	0	16	13	0	0	59	132	

## Education Material

Handout                      Handouts, reading list will be provided by lecturers

## Scientific Software

Multispec  
Photoscan  
ROCLAB

# M3252

## Design Aspects of Irrigation and Drainage

<b>Term</b>	201718T04
<b>Coordinator</b>	L.G. Hayde
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Land and Water Development for Food Security

### Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development.

### Prerequisites

Good knowledge of global, regional and local land and water development perspectives, irrigation and drainage systems, soil characteristics and irrigation agronomy.

### Learning Objectives

- 1 Make a preliminary layout and design of gravity irrigation and drainage networks.
- 2 Analyse, evaluate and apply the hydraulic principles for pipe flow in irrigation and drainage engineering.
- 3 Assess the need and implications of drainage
- 4 Determine the requirements for water table in irrigated area and design a subsurface drainage system

### Assessments

%	Type	Name
31	Written examination (closed book)	Applied Hydraulics of Irrigation Systems II
45	Assignment	Irrigation and Drainage Main System Design
24	Assignment	Main and Subsurface Drainage

### Topics

#### 1 Irrigation and Drainage Main System Design

Layout and design of primary and secondary irrigation and drainage networks, including canals, drains, roads, farms, and tertiary blocks. Types, specifications and locations of various irrigation and drainage structures. Longitudinal terrain and water level profiles of one irrigation canal and one drain through the whole project area, also indicating design parameters and structures. Typical cross-sections of the (above) irrigation and drainage canals.

## Topics

### 2 Applied Hydraulics of Irrigation Systems II

Pipe flow: main dimensionless numbers, theory and application of the momentum principle in pipes, the Moody diagram. Pipe flow equations; Colebrook-White, Chezy, Hazen and Williams. Minor losses in pipes, pipe bends and other components.

### 3 Main and Subsurface Drainage

The need for drainage: water ponding, water logging and salinisation. Components of a surface drainage system. Factors related to drainage: agricultural objectives, environmental aspects, and soil and hydrological conditions. Drainage design criteria and layout. Drainage design equations: principles and applications.

Components of subsurface drainage systems. Subsurface drainage design considerations: design criteria and layout. Subsurface drainage design equations: principles and applications. Preparation of the layout and design of a subsurface drainage system.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Irrigation and Drainage Main System Design	8	0	13	0	0	9	30	64	P. Karimi
2	Applied Hydraulics of Irrigation Systems II	12	0	8	0	0	0	20	44	L.G. Hayde
3	Main and Subsurface Drainage	7	4	7	0	0	0	14	32	H.P. Ritzema
<b>Total</b>		<b>27</b>	<b>4</b>	<b>28</b>	<b>0</b>	<b>0</b>	<b>9</b>	<b>64</b>	<b>140</b>	

## Education Material

Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Supplementary notes, LN0442/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics; Pipe flow, LN0444/11/1
Lecture notes	Hayde, L.G., 2011. Applied Hydraulics - Synopsis, LN 0378/11/1
Lecture notes	L.G. Hayde, 2007. Canal design – In0326/13/1
Lecture notes	L.G. Hayde, 2011. Irrigation and Drainage System Design - In0321/13/1
Lecture notes	Ritzema, H., 2009. Main Drainage Systems, LN0340/09/1
Lecture notes	Ritzema, H., 2014. Subsurface Drainage LN0125/14/1

## Scientific Software

candes

# M3244

## Modelling Theory and Computational Hydraulics

<b>Term</b>	201718T04
<b>Coordinator</b>	I.I. Popescu
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydroinformatics: Modelling and Information Systems for Water Management

### Target Group

Hydroinformatics participants

### Prerequisites

Basic Mathematics ; Hydraulics & Computational Fluid Dynamics ;

### Learning Objectives

- 1 Explain the structure of the 1D, 2D and 3D flow equations as representations of conservation laws and know when to use the full dynamic equations and their approximations
- 2 Understand and explain the foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, selecting modelling software
- 3 Understand and use main principles and methods of analysing and predicting models uncertainty; be able to develop computer code for analysing uncertainty of a hydrological model
- 4 Identify differential equations, as well as indicating the nature of the initial and boundary conditions for well posed problems.
- 5 Implement finite difference schemes to solve differential equations.
- 6 Analyse a numerical scheme and indicate its behaviour, as well as implement different numerical schemes for solution of equations used in water related problems.

### Assessments

%	Type	Name
25	Written examination (closed book)	Equations of Water Flows
25	Oral examination	Modelling Theory and Uncertainty
20	Assignment	Numerical Methods I
30	Written examination (closed book)	Numerical Methods I

## Topics

### 1 Equations of water flows

Basic concepts; basic physical laws; mass, momentum and energy fluxes; Eulerian equations; differential forms in common use; De Saint Venant equations; unsteady flow in pipes; Navier-Stokes equations; 3D Navier-Stokes equations to De Saint Venant equations; advection and diffusion; dimensional and order of magnitude analyses

### 2 Modelling theory and uncertainty

Foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, sequence of steps in building a model, selecting modelling software, use of models by decision makers and other stakeholders. Essence of data collection and analysis, model calibration and testing, models integration. Analysis of a number of examples of using models in solving water-related issues (floods, urban water). Main principles and methods of analysing and predicting models uncertainty, with exercises (using MATLAB)

### 3 Numerical methods I

Introduction to numerical solutions of differential equations used in fluid dynamics. Initial and boundary value problems, method of characteristics, finite differences for ODEs and PDEs. Consistency, stability, convergence of a numerical method. Exercises that will show the application of the numerical methods.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Equations of water flows	12	0	0	4	0	0	16	44	Mazzoleni, I.I. Popescu
2	Modelling theory and uncertainty	8	0	6	0	0	0	14	30	D. Solomatine
3	Numerical methods I	12	0	4	12	0	0	28	64	I.I. Popescu
Total		32	0	10	16	0	0	58	138	

## Education Material

Book	Popescu: Computational Hydraulics, IWA Publishing, 2014
Lecture notes	Popescu: Lecture notes on Numerical methods for Differential Equations
Lecture notes	Price: Lecture notes on Mathematical Basis of Computational Hydraulics

## Scientific Software

Matlab

# M3165

## Port Planning and Infrastructure Design

<b>Term</b>	201718T04
<b>Coordinator</b>	A. Dastgheib
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

This course is useful for engineers involved in the design and/or supervision of ports and coastal structures. Having knowledge about the coastal processes such as wind, waves, tides and tidal currents is necessary

### Prerequisites

Short Waves, Tides and Tidal Currents,

### Learning Objectives

- 1 List different types of Sea going vessels and identify the main characteristics of the ship and Explain the International functions of a port, governance and economic and financial aspects of port management
- 2 Explain the administration models of ports and the various steps in port masterplanning
- 3 Determine the main dimensions of the Terminals in the port. Determine the alignment and dimensions of the approach channel base on the PIANC guideline and the main dimensions of the wet infrastructure in the port
- 4 Choose the equipments needed in a Container Terminal and Design the Terminal
- 5 Design the layout of the port and the details of berthing facility for different type of berths and Evaluate a port layout based on multi-criteria analysis
- 6 Include uncertainty in port planning and management

### Assessments

%	Type	Name
1	Assignment	Port Planning and Marine Structures

### Topics

- 1 **Maritime transport**  
Overview of main maritime trade routes, different sea going vessels and different commodities
- 2 **Port Planning**
  - 2.1 Port Functions
  - 2.2 Introduction to Master Planning
  - 2.3 Adaptive Port Planning
  - 2.4 Design of Wet Areas

## Topics

- 2.5 Design of General cargo/ Multipurpose/ RoRo Terminals
- 2.6 Container Terminals
- 2.7 Queuing theory and traffic simulation
- 2.8 Design of Liquid Bulk Terminals
- 2.9 Design of Dry Bulk Terminals
- 2.10 Design of LNG Terminals**
- 3 Marine Structures**
- 4 Excursion Port of Rotterdam**
- 5 Serious game on container terminals**

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Maritime transport	0	0	4	0	0	0	4	4	A. Dastgheib
2	Port Planning	0	0	0	0	0	0	0	0	A. Dastgheib
2.1	Port Functions	2	0	0	0	0	0	2	6	M. van Schuylenburg
2.2	Introduction to Master Planning	2	0	0	0	0	0	2	6	M. van Schuylenburg
2.3	Adaptive Port Planning	2	0	0	0	0	0	2	6	P. Taneja
2.4	Design of Wet Areas	4	0	0	0	0	0	4	12	A. Dastgheib
2.5	Design of General cargo/ Multipurpose/ RoRo Terminals	2	0	0	0	0	0	2	6	P. Quist
2.6	Container Terminals	4	0	0	0	0	0	4	12	C.J. Klaver
2.7	Queuing theory and traffic simulation	6	0	0	0	0	0	6	18	A. Dastgheib
2.8	Design of Liquid Bulk Terminals	0	0	2	0	0	0	2	2	P. Quist
2.9	Design of Dry Bulk Terminals	0	0	2	0	0	0	2	2	J.G.C. Smits
2.10	Design of LNG Terminals	0	0	2	0	0	0	2	2	J.S.F.M. Huisman
3	Marine Structures	14	12	8	0	0	0	22	62	L.A.M. Groenewegen
4	Excursion Port of Rotterdam	0	0	0	0	8	0	8	8	A. Dastgheib
5	Serious game on container terminals	0	0	4	0	0	0	4	4	A. Dastgheib, M. van Schuylenburg
<b>Total</b>		<b>36</b>	<b>12</b>	<b>22</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>66</b>	<b>150</b>	

## Education Material

## Scientific Software



# M2730

## River Morphodynamics

<b>Term</b>	201718T04
<b>Coordinator</b>	A. Crosato
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydraulic Engineering and River Basin Development

### Target Group

Environmental and Civil Engineers. Professionals dealing with river training and rehabilitation works. Scientists interested in the morphodynamics of alluvial systems.

### Prerequisites

Basic knowledge of river hydraulics (uniform and non-uniform flows, backwater curves) and of river hydrology (discharge variations, floods)

### Learning Objectives

- 1 understand some basic principles of river morphology and river morphological changes.
- 2 assess long-term and short-term impacts of human interventions.
- 3 understand the basics of river biogeomorphology.
- 4 perform 1-D morphodynamic modelling of rivers with mobile bed.

### Assessments

%	Type	Name
20	Assignment	
80	Written examination (open book)	Written Exam

### Topics

#### 1 Principles of River Morphodynamics

River morphology at different spatial scales. River patterns (multi-thread and single-thread channels). Morphodynamic processes (erosion, deposition and transport of sediment, bank erosion, bank accretion), resulting phenomena (river bed aggradation and degradation, bank advance and retreat, river planimetric changes, scour forming) and their temporal scales. Concept of geomorphological equilibrium. Hydraulic roughness with and without vegetation, backwater effects, spiral flow and morphology in river bends. Exner's principle, development of a trench and a shoal, celerity of bed-level perturbations. Morphological changes at the reach scale: short and long term river response to human interventions. Morphological changes at the cross-sectional scale: bar development. Concepts of mathematical modelling of rivers with mobile bed. River habitats and river geomorphology. Interactions between the river abiotic and biotic systems.

#### 2 River Morphodynamics in Engineering Projects

Flooding caused by sedimentation. River bifurcations. River bank erosion. River navigation.

## Topics

### 3 1-D modeling of Rivers with Mobile Bed

SOBEK-RE: model description and exercises dealing with the simulation of temporal bed level changes (development of a trench or shoal, effects of interventions)

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Principles of River Morphodynamics	25	0	8	0	0	5	38	98	A. Crosato
2	River Morphodynamics in Engineering Projects	7	0	3	0	0	2	12	30	E. Mosselman
3	1-D modeling of Rivers with Mobile Bed	0	0	12	0	0	0	12	12	C.J. Sloff
Total		32	0	23	0	0	7	62	140	

## Education Material

Handout

Mosselman, E. 2001. Morphological development side channels. Handout.

Handout

Sloff, K., 2007. SOBEK-RE exercises. Handout.

## Scientific Software

sobek-RE

# M2367

## Surface Hydrology

<b>Term</b>	201718T04
<b>Coordinator</b>	R.G.W. Venneker
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydrology and Water Resources

### Target Group

Students WSE/HWR Programme

### Prerequisites

Previous modules in the WSE/HWR Programme

### Learning Objectives

- 1 Explain the global hydrological cycle and water budget, the global energy budget, and the relation between, hydrology, climate, soils and vegetation.
- 2 Explain the surface hydrological processes related to evapotranspiration, soil water movement and rainfall-runoff dynamics, and the concepts and theories that describe the physics of these processes.
- 3 Independently apply the understanding with analytical methods and conceptual models to quantitatively assess the surface hydrology for situations at catchment scales.

### Assessments

%	Type	Name
30	Assignment	
70	Written examination (closed book)	Written exam

### Topics

#### 1 Radiation, energy and hydrological balances

The role and physical description of radiation and energy balances and the relation with the hydrological cycle. Climate, climate change and the relation with hydrology. Land surface hydrological processes and interactions with the atmosphere, and the relationships between hydrology, hydrology, climate vegetation and soils. Precipitation processes and the physics of evaporation and energy exchange between the land surface and the atmosphere.

#### 2.1 Soil water and evaporation I

#### 2.2 Soil water and evaporation II

Application of practical methods for open water evaporation, potential evaporation and transpiration and actual evapotranspiration. Concepts to describe soil water transport and derivation of relations between hydraulic properties and soil water characteristics. Practical methods to compute infiltration, water movement in the unsaturated zone and the availability of soil water for crops.

## Topics

### 3 Conceptual catchment modelling

Types of models and the use of conceptual models for rainfall-runoff modelling. Catchment hydrograph analysis and application to simulating runoff components. Model performance criteria, calibration and validation methods.

### 4 Examination

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Radiation, energy and hydrological balances	12	0	0	0	0	0	12	36	R.G.W. Venneker
2.1	Soil water and evaporation I	7	0	4	0	0	0	11	25	R.G.W. Venneker
2.2	Soil water and evaporation II	7	0	4	0	0	0	11	25	J.W. Wenninger
3	Conceptual catchment modelling	6	0	6	0	0	0	12	24	J.W. Wenninger
4	Examination	0	0	0	0	0	0	0	0	
Total		32	0	14	0	0	0	46	110	

## Education Material

Lecture notes	Soil-Water-Plant Relations, lecture notes
Lecture notes	Surface Hydrology, lecture notes
Lecture notes	Workshop Hydrology, lecture notes

## Scientific Software

# M3163

## Coastal Systems

<b>Term</b>	201718T05
<b>Coordinator</b>	R.W.M.R.J.B. Ranasinghe
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

Students in coastal engineering and port development

### Prerequisites

Basic knowledge of waves and hydraulics

### Learning Objectives

- 1 understand the governing processes in coastal hydrodynamics and morphology
- 2 assess processes related to salt intrusion and density currents;
- 3 apply understanding of hydrodynamic and morphological processes in diverse coastal environments, such as reefs, mangroves and rocky coasts
- 4 apply understanding of the role of ecosystems in coastal zone dynamics and its management

### Assessments

%	Type	Name
100	Written examination (open book)	Written exam Coastal Systems

### Topics

#### 1 Coastal Hydrodynamics and Morphology

Estuarine morphodynamics; salt intrusion; inlet morphodynamics

#### 2 Coastal Hydrodynamics and Morphology

Wave energy balance; Longshore currents; wind driven circulation; tides in shallow seas; coastline models; sediment transport;

## Topics

### 3 Coastal Hydrodynamics and Morphology

Coastline and beach types; surf zone cross-shore hydrodynamics; introduction to rip currents; Cross-shore morphodynamics; beach states; introduction to coastal models

### 4 Coastal hydrodynamics and morphology

Hydrodynamics and morphodynamics of coral reefs and mangroves

### 5 Barrier island coasts

Geomorphology of barrier island systems; processes governing long-term change of tidal basins

### 6 Rip currents

Infragravity waves and associated hydrodynamics; rip current generation and evolution

### 7 Coastal ecosystems and management

Environmental considerations in coastal zone management, EIAs

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Coastal Hydrodynamics and Morphology	4	0	4	0	0	0	8	16	M. van der Wegen
2	Coastal Hydrodynamics and Morphology	8	0	16	0	0	0	24	40	J.A. Roelvink
3	Coastal Hydrodynamics and Morphology	10	0	0	0	0	0	10	30	R.W.M.R.J.B. Ranasinghe
4	Coastal hydrodynamics and morphology	4	0	0	0	0	0	4	12	J.A.H. Reyns
5	Barrier island coasts	4	0	0	0	0	0	4	12	A.J.F. van der Spek
6	Rip currents	4	0	0	0	0	0	4	12	M.A. de Schipper
7	Coastal ecosystems and management	6	0	0	0	0	0	6	18	F. van der Meulen
<b>Total</b>		<b>40</b>	<b>0</b>	<b>20</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>140</b>	

## Education Material

Lecture notes

Os, A.G. van, Salt intrusion and density currents - Lecture notes In 0286/98/

**Scientific Software**  
Matlab

# M3090

## Data Collection and Analysis and Design

<b>Term</b>	201718T05
<b>Coordinator</b>	M.G.F. Werner
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydraulic Engineering and River Basin Development

### Target Group

Engineers, geoscientists, and other professionals with an interest for data collection and analysis, including field monitoring techniques, remote sensing & GIS methods.

### Prerequisites

Experience with basic statistics, basic GIS & Remote Sensing, and hydrology and hydraulics are welcome

### Learning Objectives

- 1 Gain an in-depth knowledge of the monitoring schemes and field techniques for water and sediment sampling.
- 2 Be able to apply methods for validation and processing of data, including developing flood frequency statistics.
- 3 Gain an introduction to the concepts of deterministic and probabilistic design for river and coastal structures.

### Assessments

%	Type	Name
10	Assignment	Data Collection in the River Basin
40	Written examination (closed book)	Data Collection in the River Basin
20	Assignment	Deterministic and Probabilistic Design
30	Written examination (closed book)	Examination Deterministic and Probabilistic Design

### Topics

- 1 Data collection in the River Basin**  
Collection, management, and analysis of data in the river basin; Data measurement and analysis for water resources and floods, water quality, and sediments. Quality control of data and optimisation of data collection networks, management of data in the ri
- 2 Deterministic & Probabilistic Design**



## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Data collection in the River Basin	24	0	16	0	0	0	40	88	F. Diermanse, M.G.F. Werner
2	Deterministic & Probabilistic Design	12	0	14	0	0	0	26	50	M.G.F. Werner
Total		36	0	30	0	0	0	66	138	

## Education Material

- Lecture notes      2 Hand-outs and Lecture Notes provided by the instructor, reading list  
 Lecture notes      Hydrometry, W. Booiten, 3rd Edition, UNESCO-IHE Lecture Notes Series, 2008

## Scientific Software

- HEC-SSP  
 Matlab

# M3180

## Irrigation and drainage design

<b>Term</b>	201718T05
<b>Coordinator</b>	F.X. Suryadi
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Land and Water Development for Food Security

### Target Group

Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development (LWDFS)

### Prerequisites

Irrigation agronomy, applied hydraulics, plant water relationships

### Learning Objectives

- 1 Analyse, evaluate and apply the hydraulic principles in irrigation and drainage engineering.
- 2 Present, process and interpret results of hydraulic laboratory measurements in a technical report
- 4 Prepare detailed irrigation and drainage system layout and design that leads to optimum field water distribution uniformity, optimum productivity, minimizes costs, mitigates conflicts and facilitates cooperation among beneficiaries.

### Assessments

%	Type	Name
40	Assignment	Drip Irrigation Design
0	Lab. Report	Hydraulic Laboratory 2
60	Oral examination	Irrigation and Drainage - Tertiary Unit Design Assignment

### Topics

#### 1 Irrigation and Drainage - Tertiary Unit Design

Detailed layout of basin and furrow tertiary units: Alternative canal, drainage and road networks that result in short canals and drains, compact field blocks with easily accessible roads, convenient irrigation delivery schedules; requires less water distribution, drainage and road structures, allow furrow length and basin size that deliver good water distribution uniformity (>80%) and good tertiary system efficiency (65 to 75%). The distribution uniformity and efficiency for furrow and basin irrigation systems are evaluated using Furdev and Basdev programmes respectively. Longitudinal profile of tertiary canals and drains as well as typical cross-sections of these canals.

#### 2 Hydraulics Laboratory 2

Various types of measuring equipment. Various flow types: over a broad crested weir, through a contraction, underneath a gate. Gradually varied flow profiles. Forces due to flowing water. Discharge-depth relationship.

## Topics

### 3 Drip irrigation design

Historical background, modern irrigation, definition, decision variables. Sprinkle irrigation: The sprinkler: classification of types; hydraulics, theoretical and empirical equations, water patterns; The lateral: distribution, length, diameter, spacing between the sprinklers, uniformity; The set: decision variables, uniformity and coefficients, winds, efficiency, automation, fertigation, control; Design procedures and considerations, analysis of factors affecting uniformity, optimal design of networks using Linear Programming. Planning: data, objectives, constraints, and optimisation. Economic evaluation. Drip irrigation: The emitter: types, hydraulics, theoretical and empirical equations; the lateral: hydraulics, length; The set: decision variables, uniformity, automation, control, fertigation.

### Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Irrigation and Drainage - Tertiary Unit Design	12	0	18	0	0	8	38	78	F.X. Suryadi
2	Hydraulics Laboratory 2	2	0	0	4	0	0	6	14	L.G. Hayde
3	Drip irrigation design	8	0	0	0	0	8	16	48	F.B. Reinders
Total		22	0	18	4	0	16	60	140	

### Education Material

Lecture notes Depeweg, H.W.Th., 2001. Off-Farm Irrigation and Drainage - Design and Operation of Tertiary Units, LN0185/01/1

### Scientific Software

Basdev

Furdev

candes

# M2128

## Modelling and Information Systems Development

<b>Term</b>	201718T05
<b>Coordinator</b>	S.J. van Andel
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydroinformatics: Modelling and Information Systems for Water Management

### Target Group

Participants of WSE Programme - Hydroinformatics

### Prerequisites

Modules 1-4

### Learning Objectives

- 1 Develop a computer code for calculating free-surface flow in canals and provide interpretation of a series of test involving various initial and boundary conditions
- 2 Use advanced GIS procedures and tools related to aquatic systems
- 3 Understand the process of river model building: data analysis, model calibration and verification.
- 4 Specify, design and build a prototype modelling system with the graphical user interface using MATLAB

### Assessments

%	Type	Name
20	Assignment	Advanced GIS
20	Assignment	Modelling Systems Development
30	Assignment	Numerical Methods II
30	Assignment	River Modelling

### Topics

- 1 **Numerical methods II**  
Introduction to finite volume method. Introduction to finite element method. Exercises.
- 2 **Advanced GIS**  
Exercises in GIS, advanced topics
- 3 **River modelling**  
Application of 1D river modelling using Mike11 and Sobek modelling systems. Model development, calibration and validation

## Topics

### 4 Modelling system development

Developing modelling and graphical user interface components of a water-based system using standard numerical and graphics toolboxes (in the MATLAB environment).

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Numerical methods II	8	0	0	10	0	0	18	44	I.I. Popescu
2	Advanced GIS	0	0	0	8	0	0	8	16	S. Velickov
3	River modelling	4	0	4	10	0	0	18	36	I.I. Popescu, K. Yan, S.J. van Andel
4	Modelling system development	2	0	6	14	0	0	22	40	Chacon Hurtado, G.A. Corzo Perez
Total		14	0	10	42	0	0	66	136	

## Education Material

Lecture notes

Popescu: Lecture notes on Numerical methods

Lecture notes

Price: Lecture notes on Modelling theory and practice

## Scientific Software

Matlab

Mike 11

sobek-RUR

# M2497

## Water Quality

<b>Term</b>	201718T05
<b>Coordinator</b>	M.E. McClain
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydrology and Water Resources

### Target Group

All WSE students

### Prerequisites

No special prerequisites

### Learning Objectives

- 1 Apply basic chemical principles and determine reactions that play a role in the determination and evolution of water quality.
- 2 Apply appropriate methods to monitor, analyze and assess the water quality characteristics of hydrological systems.
- 3 Determine the various transport mechanisms taking place in (sub)surface hydrology.

### Assessments

%	Type	Name
50	Written examination (open book)	Hydrochemistry
20	Written examination (open book)	Organic matter and nutrient biogeochemistry
30	Assignment	Water Quality Monitoring and Assessment

### Topics

#### 1 Biogeochemistry

- 1.1 Forms and causes of water pollution
- 1.2 Carbon Cycling
- 1.3 Nutrient Cycling

#### 2 Water Quality Monitoring

- 2.1 Water quality standards
- 2.2 Designing a monitoring program
- 2.3 Physico-chemical and bio-Monitoring
- 2.5 Case study - monitoring program design

## Topics

### 3 Hydrochemistry

- 3.1 Introduction to hydrochemistry: parameters, units, sampling and graphical representations
- 3.2 Importance of rainwater for surface and groundwater quality
- 3.3 Minerals and water quality: reactions, solubility, carbonate and silicate chemistry
- 3.4 Redox processes
- 3.5 Cation exchange and seawater intrusion

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Biogeochemistry	0	0	0	0	0	0	0	0	M.E. McClain
1.1	Forms and causes of water pollution	3	0	0	0	0	0	3	9	
1.2	Carbon Cycling	2	0	2	0	0	0	4	8	
1.3	Nutrient Cycling	2	0	2	0	0	0	4	8	
2	Water Quality Monitoring	0	0	0	0	0	0	0	0	M.E. McClain
2.1	Water quality standards	1	0	0	0	0	0	1	3	
2.2	Designing a monitoring program	3	0	0	0	0	0	3	9	
2.3	Physico-chemical and bio-Monitoring	2	0	0	0	0	0	2	6	
2.5	Case study - monitoring program design	0	0	8	0	0	0	8	8	
3	Hydrochemistry	0	0	0	0	0	0	0	0	T.Y. Stigter
3.1	Introduction to hydrochemistry: parameters, units, sampling and graphical representations	2	0	2	0	0	0	4	8	T.Y. Stigter
3.2	Importance of rainwater for surface and groundwater quality	2	0	2	0	0	0	4	8	T.Y. Stigter
3.3	Minerals and water quality: reactions, solubility, carbonate and silicate chemistry	4	0	3	0	0	0	7	15	T.Y. Stigter
3.4	Redox processes	4	0	3	0	0	0	7	15	
3.5	Cation exchange and seawater intrusion	4	0	2	0	0	0	6	14	
<b>Total</b>		<b>29</b>	<b>0</b>	<b>24</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>53</b>	<b>111</b>	

## Education Material

Lecture notes

Lecture Notes

**Scientific Software**  
QUAL2K



# M2847

## Computational Intelligence and Operational Water Management

<b>Term</b>	201718T06
<b>Coordinator</b>	D. Solomatine
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants of the WSE programme (specialisation "Hydroinformatics", and specialisation "Flood Risk Management"), participants of the short course "Computational Intelligence and Operational Water Management".

### Prerequisites

### Learning Objectives

- 1 Understand and be able to formulate and solve an optimisation problem in relation to water systems (model calibration, reservoirs, urban pipe networks)
- 2 Understand and explain how real-time control systems work
- 3 Identify the potential of control to solve hydrological problems
- 4 Sketch a general plan for a regional real-time control system
- 5 Appreciate and apply the main techniques of data-driven modelling (machine learning): neural networks, model trees, instance-based learning, and select proper methods and tools for building data-driven models
- 6 Correctly classify a modelling problem as a physically-based, data-driven, or hybrid

### Assessments

%	Type	Name
20	Assignment	Data driven modelling and computational intelligence
30	Written examination (open book)	Data driven modelling and computational intelligence
25	Written examination (closed book)	Operational water management and real-time control
25	Assignment	Operational water management

## Topics

### 1 Introduction to optimisation

Introduction to classical optimisation. Linear and non-linear optimisation. Derivative-based and direct methods. Notion of dynamic programming. Global (multi-extremum) optimisation. Randomized search, genetic and evolutionary approaches. Multi-objective optimization. Applications in water-related problems (model calibration, reservoir optimization, urban networks rehabilitation).

### 2 Operational water management

Introduction to operational water management and real-time control; modelling for control; optimal control problems; characterisation of control systems; operational forecasting; data assimilation

### 3 Data driven modelling and computational intelligence

Modelling in the framework of Hydroinformatics. Data-driven and physically based models. Overview of machine learning and computational intelligence. Main types of machine learning: classification, association, clustering, numeric prediction. Decision, regression and model trees. Artificial neural networks. Instance-based learning. Committees of models. Fuzzy logic and fuzzy rule-based systems. Applications in flow/flood forecasting.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Introduction to optimisation	4	0	8	0	0	0	12	20	D. Solomatine
2	Operational water management	12	0	20	0	0	0	32	56	A.H. Lobbrecht, J.L. Alfonso Segura, S.J. van An del
3	Data driven modelling and computational intelligence	14	0	22	0	0	0	36	64	B. Bhattacharya, D. Solomatine
Total		30	0	50	0	0	0	80	140	

## Education Material

Lecture notes                      Lobbrecht: Lecture notes on Real time control of water systems  
 Lecture notes                      Solomatine. Lecture notes on Data-driven modelling.

## Scientific Software

Aquarius  
 Lingo  
 Matlab  
 Weka

# M3164

## Design of Breakwaters

<b>Term</b>	201718T06
<b>Coordinator</b>	A. Dastgheib
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

This course is useful for engineers involved in the design of coastal structures specially breakwaters and/or the supervision of construction of breakwaters. Knowledge of the coastal processes such as wind, waves, tides and tidal currents is necessary.

### Prerequisites

Short Waves, Tides and Tidal Currents, Coastal Processes

### Learning Objectives

- 1 Understand the difference between alternative types of breakwaters and governing factors for their selection; Design breakwaters from conceptual to detailed and prepare the layouts and detailed cross-sections.
- 2 Understand the basic principles of physical scale model and know how to design such a model to test the design of coastal and port structures.

### Assessments

%	Type	Name
1	Assignment	Design of Breakwaters

### Topics

#### 1 Design of Breakwaters

Types, functions, design procedure for breakwaters, data collection; soils, hydraulic conditions, construction materials, definition of requirements, governing parameters for breakwater design such as wave parameters, structural parameters, conceptual design, selection, preliminary design for rubble mound breakwaters, hydraulic response, structural response for rubble mound breakwaters , design of composite type, vertical wall and berm breakwaters, design of low crested and submerged structures, construction methods, case studies, physical modelling. Applications using BREAKWAT, exercise on design of rubble mound and vertical type breakwaters, exercise on scaling a design for physical modeling.

#### 2 Design of Breakwaters Exercise

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Design of Breakwaters	26	0	0	0	0	0	26	78	J.W. van der Meer
2	Design of Breakwaters Exercise	0	8	0	0	0	16	16	56	A. Dastgheib, J.W. van der Meer
Total		26	8	0	0	0	16	42	134	

## Education Material

Lecture notes Breakwater Design; J.W. van der Meer, H. Ligteringen; In0026/18

Lecture notes Exercise Breakwater Design J.W. van der Meer, A. Dastgheib; In0027/18

## Scientific Software

Breakwat

# M1703

## River Basin Development and Environmental Impact Assessment

<b>Term</b>	201718T06
<b>Coordinator</b>	I. Masih
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydraulic Engineering and River Basin Development

### Target Group

Students of Hydraulic Engineering and River Basin Development

### Prerequisites

Working knowledge in topics such as Hydrology, Hydraulics, Sediment and Morphology, Water Quality, Ecology and River Dynamics. Affinity to water management and governance issues.

### Learning Objectives

- 1 Explain and apply the concepts of river basin development including integrated water resources management (IWRM) and principles and advances in integrated planning
- 2 Explain the principles of environmental impact assessment (EIA) and apply EIA for a River Basin Development Plan and clearly communicate the outcomes and recommendations
- 3 Describe the basics of economics in river basin development and the importance of good governance for the implementation of river basin development plans and the operational management of river basins.
- 4 Apply state of the art modelling tools to simulate the distribuion of water to stakeholders within a river basin, and evaluate the impact of future scenarios and develop strategies to manage expected consequences
- 5 Formulate a plan for the development of a river basin following the basic steps in a river basin planning process and design alternative strategies and assess their consequent social, economic and environmental impacts

### Assessments

%	Type	Name
15	Assignment	EIA
35	Assignment	River Basin Development Exercise (Nile)
50	Written examination (closed book)	River Basin Development and EIA

## Topics

### 1 Module Introduction and Basin Development Trajectory

Trajectory and phases of river basin development, open, close and closing basins, implications of basin closure

### 2 Water Resources Development

Water resources development and management, Integrated Water Resources Management, Water allocation, Participation, River Basin Governance

### 3 Environmental Impact Assessment for WRM Projects

EIA and River Basin Development, EIA case studies

### 4 River Basin Development Exercise

RIBASIM model application for developing an integrated planning strategy for the Nile Basin case

### 5 River Basin Planning

Planning frameworks and main steps, Planning approaches and scales, Planning tools and models, River Basin Development Economics, Cost-Benefit Analysis, Multi-criteria Analysis

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Module Introduction and Basin Development Trajectory	2	0	0	0	0	0	2	6	I. Masih
2	Water Resources Development	12	4	0	0	0	0	12	40	I. Masih, J.S. Kemerink - Seyoum, P. van der Zaag
3	Environmental Impact Assessment for WRM Projects	10	4	4	0	0	0	14	38	A. Mendoza - Sammet, V.T. Langenberg
4	River Basin Development Exercise	2	8	8	0	0	0	10	22	I. Masih, W.N.M. van der Krogt
5	River Basin Planning	8	2	8	0	0	0	16	34	I. Masih, Y. Jiang
<b>Total</b>		<b>34</b>	<b>18</b>	<b>20</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>54</b>	<b>140</b>	

## Education Material

Handout                      Various Handouts

**Scientific Software**  
Ribasim

# M2292

## Short Course on Hydropower Water Conduit Design

<b>Term</b>	201718T06
<b>Coordinator</b>	M. Marence
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

Participants (scientists, engineers) interested in design principles of hydropower or interested in these topics

### Prerequisites

Working knowledge in Hydraulics, Geoscience and structural engineering

### Learning Objectives

- 1 select proper power waterway type and layout integrating geological, geo-morphological and hydraulic characteristics of the site
- 2 implement hydraulic and structural design of the power waterway and all their parts
- 3 predict the construction and operational costs of the power waterway and identify the environmental impacts of the power waterway
- 4 implement knowledge in practical design of the hydropower schemes

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 1 Introduction
- 2 Layout selection
- 3 Hydraulics of PWW
- 4 Civil structure
- 5 Environmental impact
- 6 Workshop



## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction	2	0	0	0	0	0	4	6	M. Marence
2	Layout selection	2	0	0	0	0	0	2	6	M. Marence
3	Hydraulics of PWW	10	0	0	0	0	0	10	30	A. Cattapan, I.I. Popescu, I.W.M. Pothof
4	Civil structure	20	0	0	0	0	0	20	60	M. Marence
5	Environmental impact	4	0	0	0	0	0	4	12	A. Mendoza - Sammet
6	Workshop	8	0	0	0	0	0	8	24	A. Cattapan, M. Marence
Total		46	0	0	0	0	0	48	138	

## Education Material

## Scientific Software

# M3177

## Socio-economic and Environmental Aspects of Land and Water Development

<b>Term</b>	201718T06
<b>Coordinator</b>	A.E.C. Duker
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Land and Water Development for Food Security

### Target Group

All Land and Water Development participants.

### Prerequisites

Main and tertiary irrigation system design, agronomy, soil plant water relationship.

### Learning Objectives

- 1 Discuss the importance of environmental and social aspects that define the feasibility, implementation and continuation of land and water development projects
- 2 Explain the importance of irrigation and drainage for food security and economy
- 3 Explain the role of economics in irrigation
- 4 Assess the need and implications of proper irrigation and drainage management for salinity control.
- 5 Explain the opportunities and implications of wastewater use for irrigation
- 6 Identify major potential health benefits and disease risks of agricultural water management

### Assessments

%	Type	Name
45	Written examination (open book)	Economics, Wastewater Irrigation and Irrigation and Health
25	Assignment	Environmental Impact Assessment
10	Assignment	Salinity Control
20	Assignment	Sociological Aspects of LWD

### Topics

#### 1 Food security and irrigation economics

Role of water in food security, types of irrigation and their importance, irrigation as common pool resource, water pricing, valuing environmental costs & benefits of irrigation

## Topics

### **2 Sociological aspects of land and water development**

Introduction to the social sciences of irrigation and drainage. Challenges of water distributions among competing users. Understanding the influence of irrigation technology, projects, management and organization on social constellations. The influence of various distributions on social aspects of irrigation: distributions of water, distributions of authority and voice (incl. gender), distributions of knowledge and expertise (incl. the role of the social sciences in irrigation knowledge). Case studies based on participants' experiences.

### **3 Environmental Impact Assessment of irrigation and drainage**

Environment as a system; environmental impacts. Examples; Environmental impact assessment (EIA); social process; legal requirements and the environmental impact statement (EIS); assessment methodologies and procedures. Description of the irrigation environment.

### **4 Salinity control**

Application of irrigation water means input of salts. What are the primary and secondary effects of salts for agricultural production. How to sustain a feasible production area considering a proper management of irrigation and drainage. Factors related to irrigation development: agricultural objectives, environmental aspects, and soil and hydrological conditions.

### **5 Wastewater irrigation**

Opportunities and challenges of wastewater irrigation, pathogenic risks and heavy metal contamination in crop production and consumption, multi-barrier approach to risk-mitigating measures, institutional aspects of wastewater use in agriculture.

### **6 Irrigation and health**

Assessment and mitigation of impacts of agricultural water management on human health and well-being. Health implications of design of irrigation, drainage and storage infrastructure, its operation & maintenance, as well as the actual water use for multiple purposes. Links with ecology, water quality, behaviour, livelihoods, health and disease. Engineering options for enhancing health benefits and reducing disease risks.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Food security and irrigation economics	6	0	2	0	0	0	8	20	C.M.S. de Fraiture
2	Sociological aspects of land and water development	6	0	6	0	0	0	12	24	J.G. Evers
3	Environmental Impact Assessment of irrigation and drainage	8	6	6	0	0	0	14	36	W.J.R. Buydens
4	Salinity control	6	0	0	0	0	0	6	18	P.H.J. Hollanders
5	Wastewater irrigation	4	0	4	0	0	0	8	16	A.E.C. Duker
6	Irrigation and health	4	0	2	0	0	0	6	14	E.D.C. Boelee
<b>Total</b>		<b>34</b>	<b>6</b>	<b>20</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>54</b>	<b>128</b>	

## Education Material

Handout                      Van Hoorn and Van Alphen. Salinity Control

## Scientific Software

# M1903

## Tracer Hydrology and Flow Systems Analysis

<b>Term</b>	201718T06
<b>Coordinator</b>	J.W.A. Foppen
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Interested students.

### Prerequisites

Approved BSc degree and basic hydraulics/hydrology, earth sciences, hydrogeology, and water quality.

### Learning Objectives

- 1 apply knowledge of the concepts of tracer hydrology, with emphasis on environmental isotopes.
- 2 derive and describe hydrosomes from (combinations of) hydrochemical facies to assess characteristics of groundwater flow systems.
- 3 integrate geology, flow field, isotope data and hydrochemistry into a comprehensive analysis of groundwater flow systems for different hydro-climatic regions and geological conditions.

### Assessments

%	Type	Name
50	Written examination (closed book)	Flow Systems Analysis
50	Written examination (closed book)	Tracer Hydrology

### Topics

- 1 **Tracer Hydrology**  
This course treats different methods to analyse and assess hydrological flow systems. Special attention will be given to hydro-chemical and tracer hydrological approaches to delineate flow systems and understanding flow patterns in the environment. The us
- 2 **Flow Systems Analysis**
- 3 **Case study**

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Tracer Hydrology	16	6	0	4	0	4	24	74	J.W. Wenninger
2	Flow Systems Analysis	8	8	0	0	8	7	23	61	J.W.A. Foppen
3	Case study	1	4	0	0	0	0	1	7	J.W. Wenninger, J.W.A. Foppen
Total		25	18	0	4	8	11	48	142	

## Education Material

Lecture notes

Lecture Notes

## Scientific Software

Phreeqc

# M3309

## Conveyance and Irrigation Structures

<b>Term</b>	201718T07
<b>Coordinator</b>	F.X. Suryadi
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Land and Water Development for Food Security

### Target Group

All Land and Water Development for Food Security participants.

### Prerequisites

Agronomy, irrigation methods, applied hydraulics

### Learning Objectives

- 1 Make simple unsteady flow computations for open channel systems;
- 2 Apply DUFLOW for non-steady flow phenomena in open irrigation and drainage networks; to evaluate the results and to assess the advantages and disadvantages of the model for solving surface flow problems;
- 3 Assess the advantages and disadvantages of various numerical schemes for solving sets of equations in surface flow modelling and to select the appropriate models for stationary and non-stationary flow in open channels and in pipes and to evaluate the
- 4 Select the appropriate type of structure for irrigation and drainage networks, to establish the boundary conditions and to prepare a preliminary hydraulic design;
- 5 Select a suitable flow control system, the appurtenant flow control systems and to specify the operation rules of the hydraulic structures and social implications of applied irrigation techniques for different users.
- 6 Understand the sediment transport mechanism and how to control sediment transport in canal systems

### Assessments

%	Type	Name
15	Assignment	Flow Control Systems
35	Assignment	Irrigation Structures
15	Assignment	Sediment Transport in Canals
35	Written examination (open book)	Unsteady Flow / DUFLOW

## Topics

### 1 Unsteady Flow / DUFLOW

Basic equations of unsteady flow and their numerical treatment; development of the St.Venant equations; solutions to these equations;- Applications to rectangular channels; - Simple wave theory; - Surge formation; - Rapidly varied unsteady flow; - Flood waves in rivers; - Introduction to hydrodynamic models and the general structure of the DUFLOW model; - Application of DUFLOW for water quantity analysis in irrigation and drainage networks; - Propagation of waves through canals; - Effect of response time on operation; - Effect of maintenance on water levels and operation of off takes; - Exercises on the operation of an irrigation network with flow control systems.

### 2 Irrigation Structures

Overview of the boundary conditions for design. Hydraulic background: sub-critical and critical flow over a weir; - Basic equations and their application to side channel spillways, side weirs and bottom withdrawal; - Design of spillways, stilling basins, and weirs in irrigation and drainage canals; Flume is a computer programme to design long-throated (measuring) flumes and to evaluate the water flow through them; - Calculation methods; - Construction related aspects; - Hydraulic characteristics of conveyance structures under various flow conditions: culverts, drop structures, aqueducts, siphons and inverted siphons, cross regulators an drainage structures, transition, canal lining; - Spatially varied non-uniform flow, Basic equations and their application to side channel spillways, side weirs and bottom withdrawal; - Design od spillways, stilling basins, and weirs in irrigation and drainage canals; - Case studies on structure/controller design; - Modern irrigation systems; - Automated control systems: aspects of design, operation and maintenance.

### 3 Flow Control Systems

Introduction on flow control systems: purpose, classification, selection criteria, performance parameters; - Proportional control: sensitivity of structures, application; - Upstream control: principle, hydraulics, design of system, application; - Downstream control: principle, hydraulics, design of system, application; - Combined control: upstream and proportional control, mixed control, down- to upstream control, up- to downstream control, night reservoirs; - Electronic control systems: Bival control, EI-flow control, Card control, Dynamic control, step controllers, PID controller; - Application of different flow systems: case studies.

### 4 Sediment Transport in Canals

- Properties of transported material and of water; - Initiation of particle motion; - Transportation mechanics, bed forms, alluvial roughness; - Examples of computation of sediment transport in canal systems.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Unsteady Flow / DUFLOW	10	0	8	0	0	0	18	38	F.X. Suryadi
2	Irrigation Structures	12	0	12	0	0	0	24	48	A. Clemmens, L.G. Hayde
3	Flow Control Systems	8	2	6	0	0	0	14	32	F.X. Suryadi
4	Sediment Transport in Canals	6	2	2	0	0	0	8	22	F.X. Suryadi, L.G. Hayde
<b>Total</b>		<b>36</b>	<b>4</b>	<b>28</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>64</b>	<b>140</b>	

## Education Material



**Scientific Software**  
Duflow

# M3160

## Groundwater Data Collection and Interpretation

<b>Term</b>	201718T07
<b>Coordinator</b>	T.Y. Stigter
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

MSc students in Hydrology and Water Resources, short course participants involved in groundwater and environmental impacts investigation and monitoring activities.

### Prerequisites

Approved BSc degree and basic hydraulics/hydrology subjects

### Learning Objectives

- 1 outline the methodology for designing groundwater surveying programmes (GSP), including the main desk and field activities to be performed;
- 2 interpret the results from geophysical surveys, exploration borehole logging, pumping tests and groundwater observations within the context of GSP;
- 3 plan a GSP for a certain area based on the analysis of available data and field conditions;
- 4 interpret hydro(geo)logical time series and spatial data;
- 5 learn methods and procedures used in groundwater monitoring;
- 6 design a groundwater monitoring network and to assess the required measurement frequencies

### Assessments

%	Type	Name
0,3	Assignment	Groundwater Monitoring
0,2	Assignment	Groundwater Surveys
0,2	Written examination (closed book)	Groundwater Surveys
0,15	Assignment	Hydrogeostatistics
0,15	Written examination (closed book)	Hydrogeostatistics

## Topics

### 1 Groundwater Surveys

This subject deals with groundwater exploration and resources assessment. The first part deals with methods including desk studies, hydrogeological mapping and well inventories, and surface geophysical measurements. Insight into the interpretation of borehole data and geophysical measurements is obtained with an exercise regarding a case study in the northeastern part of The Netherlands. Then follow outlines on exploration drilling and logging techniques and the interpretation of results. Finally, the practical set up and execution of pumping tests and the interpretation of test results is dealt with.

### 2 Electromagnetic Surveys

This topic deals specifically with electro-magnetic surveying techniques for groundwater exploration.

### 3 Groundwater Monitoring

Principles and concepts of groundwater monitoring. The lectures and exercises discuss and practice the design and operational aspects of groundwater observation networks. Introduction: basic concepts and procedures; Network density for estimating the global mean; Monitoring of diffusive pollution; Monitoring of waste disposal sites; Network density graphs; Determination of network density with Kriging; Determination of sampling frequency with time series analysis.

### 4 Hydrogeostatistics

Statistical descriptors and their use in hydrological data analysis: Correlation and regression analysis; Time series analysis: autocorrelation, trend, periodicity and stochastic components; statistical test of trend; harmonic analysis; AR models; Spatial description: spatial hydrological and hydrogeological variables; spatial variability; trend surfaces; simple and ordinary kriging; intrinsic hypothesis; variograms; estimation of variograms using measurements; spatial interpretation with kriging.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater Surveys	11	4	9	0	4	0	24	50	T.Y. Stigter
2	Electromagnetic Surveys	2	0	2	0	0	0	4	8	
3	Groundwater Monitoring	12	0	8	0	0	0	20	44	Y. Zhou
4	Hydrogeostatistics	10	0	8	0	0	0	18	38	T.Y. Stigter, Y. Zhou
Total		35	4	27	0	4	0	66	140	

## Education Material

Book	Handouts from presentations, whiteboard, exercise book, participant laptop with dedicated software
Lecture notes	Nonner, J., Stigter, T., Introduction to groundwater exploration (Lecture notes LNOO72/15/1)
Lecture notes	Zhou, Y., Groundwater monitoring, Lecture notes, LN0053/09/1
Lecture notes	Zhou, Y., Hydrogeostatistics, Lecture notes

## **Scientific Software**

Aqtesolv

Freq

Gewin Excel

netgraph

surfer

# M1554

## Hydrological Data Collection and Processing

<b>Term</b>	201718T07
<b>Coordinator</b>	R.G.W. Venneker
<b>Credit points</b>	5.000000000
<b>Specialization</b>	

### Target Group

Students of the WSE/HWR Programme, and selected short course participants

### Prerequisites

Good foundation and understanding in hydrology, hydrometeorology, and the water resources-related interactions taking place in hydrological basins

### Learning Objectives

- 1 Comprehend the need for hydrological data and information, and the roles and functions of National Hydrological Services.
- 2 Comprehend the activities involved in water resources-related data collection, processing, storage and retrieval.
- 3 Explain the principles and concepts used in hydrological observing networks and routine data collection.
- 4 Apply standard methods for processing and analyzing hydrological data to prepare water resources information.
- 5 Apply hands-on experience with collecting, processing and comparative analysis of hydrometeorological station data.

### Assessments

%	Type	Name
40	Lab. Report	
60	Written examination (closed book)	

### Topics

#### 1 Hydrological data processing and analysis

Overview of data collection, storage and information provision. Institutional and organizational aspects of national capabilities in hydrological data and information services. Data collection networks, observation, transmission, primary and secondary processing, and archiving. Principles of measurement and methods of observing hydrometeorological elements. Streamflow measurements and rating curve construction. Integration of data sources. Analysis of time series for provision of water resources information. Spatial integration of hydrological data for water resources assessment.

## Topics

### 2 Practical: hydrometeorological data collection and analysis

In this practical the students carry out daily routine observations at the Institute's "roof hydromet station", and process and evaluate the measurements in order to produce a small report that includes a comparison with published data.

### 3 Excursion

A one-day excursion is part of this module to provide examples of practical hydrological data monitoring activities in the Netherlands.

### 4 Examination

## Study load

Nr	Topic	Study load								Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Hydrological data processing and analysis	28	0	20	0	0	0	48	104	R.G.W. Venneker, T.A. Bogaard, Y. Zhou
2	Practical: hydrometeorological data collection and analysis	4	0	20	0	0	0	24	32	R.G.W. Venneker
3	Excursion	0	0	0	0	0	0	0	0	
4	Examination	0	0	0	0	0	0	0	0	
Total		32	0	40	0	0	0	72	136	

## Education Material

Book: Boiten, W. Hydrometry 2nd edition, CRC Press, 2008.  
Lecture notes: Presentations, Lecture notes, and exercise materials.

## Scientific Software

# M3162

## Process-based Coastal Modeling

<b>Term</b>	201718T07
<b>Coordinator</b>	J.A.H. Reyns
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Coastal Engineering and Port Development

### Target Group

Master students in Coastal Engineering

### Prerequisites

- Knowledge of nearshore hydrodynamics and sediment transport
- Some experience with Matlab, Python or similar

### Learning Objectives

- 1 Apply commonly used numerical methods in coastal modelling
- 2 Choose the appropriate model for a given problem
- 3 Apply commonly used hydrodynamic and morphodynamic model systems in a practical situation
- 4 Apply input reduction and schematisation techniques for simulation speedup
- 5 Explain the results of complex models and translate them into practical outcomes
- 6 Work in a design team

### Assessments

%	Type	Name
0,75	Assignment	Marina design
0,25	Assignment	Numerical Methods

### Topics

- 1 **Numerical methods**
- 2 **Introduction to coastal modeling**

## Topics

### 3 Coastline modeling

Coastline model (ShorelineS)

–Time scale: decades

–Input reduction: actual wave climate vs schematized

–Calibration for IJmuiden 1970-1990

–Postprocessing

- Coastline trends

- Presentation of results on Google Earth

### 4 Detailed morphological modelling

Medium-term morphodynamic model (Delft3D/SWAN and XBeach):

–Time scale: years

–Spatial scale: 5 km longshore

–Hydrodynamic calibration for Coast3D

–Input reduction: derive wave climate from buoy data (energy flux method); morphological tide

–Postprocessing

- Integrated transports, sedimentation/erosion maps, volume changes

- Intercomparison of models and approaches



## Topics

### 5 Wave penetration modelling

Model: XBeach in nonhydrostatic mode

–Apply statistical analysis of incoming waves

–Design criteria: derive exceedance curves to calculate downtime, extreme waves to evacuate,...

–translate to set of boundary conditions for structure design

### 6 Data sources

Students will learn where to find open access datasets to derive boundary conditions for morphodynamic model setup (ERA Interim /ERA 5; high-resolution NORA10 wave data; Buoy data from NOAA, CDIP,...; Tides from TPXO 8.1)

### 7 Regional coastal modeling

The aim of this topic is to learn how to set up a regional hydrodynamic/wave model in which a more detailed morphodynamic model can be subsequently nested.

### 8 Final presentation

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Numerical methods	2	20	8	0	0	0	10	34	I.I. Popescu
2	Introduction to coastal modeling	4	0	0	0	0	0	4	12	J.A. Roelvink
3	Coastline modeling	1	5	3	0	0	0	4	11	J.A. Roelvink
4	Detailed morphological modelling	2	12	10	0	0	0	12	28	J.A. Roelvink, J.A.H. Reyns
5	Wave penetration modelling	2	10	10	0	0	0	12	26	A. Dastgheib
6	Data sources	0	0	2	0	0	0	2	2	A.A. Milho Semedo
7	Regional coastal modeling	2	15	10	0	0	0	12	31	
8	Final presentation	0	8	0	0	0	0	0	8	A. Dastgheib, J.A. Roelvink
Total		13	70	43	0	0	0	56	152	

## Education Material

### Scientific Software

Delft3D

Matlab

Xbeach

# M3232

## River Basin Modelling

<b>Term</b>	201718T07
<b>Coordinator</b>	A. Jonoski
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants in WSE programme - hydroinformatics specialisation; Participants in Erasmus Mundus Flood Risk Management Programme; Participants in short course "River Basin Modelling"

### Prerequisites

Hydrology and Hydraulics

### Learning Objectives

- 1 Explain the multi-purpose nature of river basins and approaches for their integrated planning and management, with special focus on role of modelling
- 2 Interpret solutions of groundwater flow problems based on governing physical laws and their mathematical representation
- 3 Apply MODFLOW modelling system to solve groundwater flow problems and examine the solutions
- 4 Model hydrological processes in catchments using MIKE SHE modelling system
- 5 Examine results of MIKE-SHE models that include both surface and groundwater flow in a natural catchment, including the unsaturated zone

### Assessments

%	Type	Name
1	Written examination (closed book)	The exam will include questions from all topics of this module.

### Topics

#### 1 River basin management

Introduction to the management of river basins; water resources; Integrated Water Resources Management (IWRM); framework for analysis in water resources planning and management projects; role of modelling; case studies. Exercises and workshops with RIBASIM.

## Topics

### 2 Groundwater modelling

The continuum approach; definitions; Darcy's law; groundwater flow in the saturated zone: equations for 1D, 2D and 3D flow; modelling approaches; modelling protocol; contaminant transport through advection and diffusion; exercises and workshops with the MODFLOW modelling system (PMWin) for solving basic problems of groundwater flow through aquifers and moderately complex water resources and engineering problems: problem definition, model building, results analysis and interpretation.

### 3 Catchment modelling

Types of hydrological models: empirical/data-driven/black box; conceptual and physically based models; NAM lumped-conceptual model: model-set-up of a catchment & calibration from rainfall & discharge records; focus on distributed physically based catchment modelling with MIKE-SHE: 1) introduction to the modelling exercises and workshops; presentation of MIKE-SHE software package and the catchments used for the exercises; 1) Initial model building - saturated zone; 2) Overland and river flow modelling - comparison of models with and without the river network; 3) Unsaturated zone modelling 4) Fully integrated catchment model: river + drainage + saturated + unsaturated zone;

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	River basin management	6	0	4	4	0	0	14	30	E. van Beek, W.N.M. van de Krogt
2	Groundwater modelling	8	0	6	6	0	0	20	42	A. Jonoski
3	Catchment modelling	12	0	10	10	0	0	32	66	A. Jonoski, I.I. Popescu, M.E Butts
Total		26	0	20	20	0	0	66	138	

## Education Material

Handout Handouts: Jonoski: Groundwater modelling using MODFLOW; Jonoski and Popescu: Catchment modelling with MIKE SHE; van der Krogt: RIBASIM user manual;

## Scientific Software

Mike 11

Mike SHE

PmWin

Ribasim

# M1171

## River Structures

<b>Term</b>	201718T07
<b>Coordinator</b>	A. Cattapan
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Hydraulic Engineering and River Basin Development

### Target Group

Students coming from:

- MSc programme in Water Science and Engineering with specialisation Hydraulic Engineering and River Basin Development

### Prerequisites

Working knowledge in Applied Hydraulics, Sediment Transport and River Dynamics

### Learning Objectives

- 1) to analyze the interaction between flow and hydraulic structures in natural open channels
- 2) to create preliminary hydraulic design of selected river structures
- 3) to determine the consequences of different design solutions on the natural river behavior

### Assessments

%	Type	Name
100	Written examination (closed book)	River Structures

### Topics

#### 1 Hydraulic structures in mountain river training

Check dams and debris dams: principles of design and operation; interaction between flow and structures.

#### 2 Hydraulic structures in low land river training and flood protection

Detention basins: principles of design and operation; interaction between flow and structures/Minor hydraulic structures: principles of design and operation/ Levee systems: failure, design and maintenance

## Topics

### 3 Hydraulic structures auxiliary to engineering works

Spillways; Bottom outlets; Energy dissipaters: principles of design and operation

### 4 Review of a scientific paper

Group review of a scientific paper and its presentation to the class

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydraulic structures in mountain river training	8	0	0	0	0	4	12	36	A. Cattapan
2	Hydraulic structures in low land river training and flood protection	22	0	0	0	0	4	26	78	Mazzoleni, A. Cattapan, M. Maglionico
3	Hydraulic structures auxiliary to engineering works	4	0	8	0	0	0	12	20	A. Cattapan
4	Review of a scientific paper	0	0	6	0	0	0	6	6	A. Cattapan
Total		34	0	14	0	0	8	56	140	

## Education Material

Book

Chen, Sheng-Hong. Hydraulic Structures. , 2015. Internet resource.

Handout

Handouts and references provided by Lecturers

Book

Wunderlich, W.O. 2005. Hydraulic structures: probabilistic approaches to maintenance. Reston, Va: ASCE.

## Scientific Software

HEC-RAS

# M3204

## Climate change impacts and adaptation in coastal areas

<b>Term</b>	201718T08
<b>Coordinator</b>	A.A. Milho Semedo
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Graduates from civil and coastal engineering, environmental engineering graduates and managers with interest in the coastal area, oceanographers, ocean engineers, and marine science graduates.

### Prerequisites

Bachelor degree in a field related to coastal or environmental engineering, spatial planning, port or maritime operations, or oceanography or ocean sciences.

### Learning Objectives

- 1 Explain the climate system and the principles of climate change.
- 2 • Comprehensively describe impacts of climate change in coastal areas and coastal infrastructure.
- 3 • Provide professional advice on the quantification of coastal risk posed by climate change.
- 4 • Provide professional advice on how to effectively adapting to climate change in coastal areas and ports.
- 5 • Provide an overview on how changes in climate are affecting seaports, navigation and maritime operations.
- 6 • Draft a road map for developing the climate change adaptation plan of a port.

### Assessments

%	Type	Name
1	Assignment	Presentation and report

## Topics

### 2 Coastal hazards and risk assessment

- Climate change drivers of coastal flood and erosion hazards
- Recap of climate change projections for drivers of coastal change
- Quantifying climate change driven coastal changes (global to local), including sea water intrusion, coastal flooding, and inlets
- Quantitative coastal risk assessment
- Stakeholder engagement in decision making

### 3 Climate adaptation

- IPCC advice on adaptation to climate change in coastal areas
- Adaptation beyond the climate
- Urban and rural domains of adaptation
- Different approaches for adaptation measures (hard/soft, flexible/rigid, central/decentralized etc.)
- Cost benefit analysis of climate change adaptation strategies
- Climate change and resilient cities

### 4 Climate change impacts on ports and maritime operations

- Introduction
- Ports and climate change
- Maritime industry CO2 footprint
- The green port concept
- Climate change impact in ship and offshore structures design standards
- Climate change impact on navigational hazards and shipping
- Economic opportunities and insurance issues
- Adaptation, the international response
- Case study and exercise

### 5 Presentation and report

Preparation of presentation and report.

## Topic Climate system and climate change

### 1

- The climate system, feedbacks, cycles and self-regulation
- The climates of the coastal areas
- Key principles and signs of climate change
- Ancient and recent past climate change
- How the global carbon cycle is changing
- Future projections and modelling future scenarios
- Impacts on the atmosphere and ocean
- Water cycle and fluvial and coastal sediment supply



## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
2	Coastal hazards and risk assessment	8	0	8	0	0	0	16	32	R.W.M.R.J.B. Ranasinghe
3	Climate adaptation	6	2	0	0	0	0	6	20	P.D.A. Pathirana
4	Climate change impacts on ports and maritime operations	12	0	8	0	0	0	20	44	
5	Presentation and report	0	20	0	0	0	0	0	20	A.A. Milho Semedo
Topic 1	Climate system and climate change	6	0	6	0	0	0	12	24	A.A. Milho Semedo
Total		32	22	22	0	0	0	54	140	

## Education Material

## Scientific Software

# M3009

## Dams and Hydropower

<b>Term</b>	201718T08
<b>Coordinator</b>	M. Marence
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Students interested in principles of dam, reservoir and hydropower structures design

### Prerequisites

Working knowledge in Hydraulics, Hydrology and Geoscience

### Learning Objectives

- 1 apply main principles and practices used in the structural and hydraulic design of dams used for storage, level regulation and hydropower development
- 2 use principles of design, construction and operation, monitoring and maintenance of dam structure together with water and sediment management in reservoirs
- 3 solve common practical planning issues by definition of hydropower schemes and design of hydropower structures, including power waterways, powerhouses, turbines and electrical equipment.
- 4 develop and design of all types of hydropower plants including also small power and pump-storage plants
- 5 implement knowledge in practical design of the hydropower schemes

### Assessments

%	Type	Name
45	Written examination (closed book)	Written exam
45	Written examination (open book)	Written exam
10	Assignment	assignment

### Topics

#### 1.1 Dams and reservoirs - Introduction

Dams: importance, historical development & trends, examples, failures & lessons learned.

#### 1.2 Embankment dams

Types, layouts and of the embankment dams. Interaction of the dam with other structures. Design of embankment dams, materials and typical cross-sections. Types of sealing and filters. Construction.

## Topics

- 1.3 Gravity dams  
Gravity dam types and layouts. Structural features. Mass concrete and roller compacted concrete for dams. Design considerations.
- 1.4 Dam design considerations and modelling  
Systematic engineering approaches for dam design. Actions on dams, stability, static and dynamic analysis, seismic actions.
- 1.5 Arch dams  
Arch dam classification and structural features, Layouts. Construction. Loads and structural analysis and design.
- 1.6 Dam foundation treatment and grout curtain  
Dam foundation preparation, Grout curtain, Contact and consolidation grouting works.
- 1.7 Diversion, spillways and bottom outlets  
Need and layout of diversion works. Spillway types and design. Bottom outlet function and operation. Plug design.
- 1.8 Dam safety management  
Dam safety management. Dam risk assessment and lessons learned. Dam monitoring.
- 1.9 Reservoir design and environmental impact  
Function of reservoirs and their parts. Freeboard definition. Reservoir management. Losses in reservoir. Impounding. Reservoir indicators
- 2.1 Hydropower - Introduction  
Hydropower: basic concepts, past experience and trends, context society, energy & environment.
- 2.2 Hydropower schemes - Layouts and design requirements  
Hydropower schemes. Conventional low and high head schemes: factors principles and requirements for the design, typical arrangements and layouts. Basic data needed for hydropower definition.
- 2.3 Open power waterways  
Weir, intake and sand trap types and design. Open channels and free flow systems, Forebays. Penstock types, materials and design.
- 2.4 Power waterways  
Definition of the power waterway layout. Hydraulic (static and transient) design of power waterway. principles and experiences in analysis and design, tunnels, surge tanks and penstocks. Tunnel excavation, lining systems and grouting works. Intakes, gate shafts, valves, transitions and manifolds. Safety and monitoring of power waterways.
- 2.5 Powerhouse  
Types of powerhouses. main parts and auxiliary equipment. Transmission lines. Powerhouse design.
- 2.6 Electromechanical equipment  
Turbines, history and types. Pelton turbines. Cross flow turbines. Francis turbines. Kaplan turbines. Turbine design.
- 2.7 Small hydropower  
Definition and benefits of small hydro. Hydropower estimation. Inflatable rubber dam. Tyrolian weir. Special small machines. Small hydropower projects.
- 2.8 Pump storage powerplants  
Need and requirements for pump storage. Typical layouts. Artificial reservoirs. Pumps and machine types. Examples.
- 2.9 Cost control and financial analysis  
Hydropower project development. Project costs schedule. Live costs. Financial analyses. Project risks
- 2.10 Future developments and perspectives**  
Refurbishment of HPP, Future and challenges of hydropower

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1.1	Dams and reservoirs - Introduction	2	0	0	0	0	0	2	6	M. Marence
1.2	Embankment dams	2	0	0	2	0	0	4	10	M. Marence
1.3	Gravity dams	2	0	0	2	0	0	4	10	M. Marence
1.4	Dam design considerations and modelling	2	0	0	4	0	0	6	14	M. Marence
1.5	Arch dams	2	0	0	0	0	0	2	6	M. Marence
1.6	Dam foundation treatment and grout curtain	2	0	0	0	0	0	2	6	M. Marence
1.7	Diversion, spillways and bottom outlets	2	0	0	0	0	0	2	6	M. Marence
1.8	Dam safety management	2	0	0	0	0	0	2	6	M. Marence
1.9	Reservoir design and environmental impact	2	0	0	0	0	0	2	6	M. Marence
2.1	Hydropower - Introduction	2	0	0	0	0	0	2	6	M. Marence
2.2	Hydropower schemes - Layouts and design requirements	2	0	0	2	0	0	4	10	M. Marence
2.3	Open power waterways	3	0	0	2	0	0	5	13	M. Marence
2.4	Power waterways	3	0	0	2	0	0	5	13	M. Marence
2.5	Powerhouse	2	0	0	0	0	0	2	6	M. Marence
2.6	Electromechanical equipment	2	0	0	2	0	0	4	10	M. Marence
2.7	Small hydropower	2	0	0	0	0	0	2	6	M. Marence
2.8	Pump storage powerplants	2	0	0	0	0	0	2	6	M. Marence
2.9	Cost control and financial analysis	1	0	0	0	0	0	1	3	M. Marence
2.10	Future developments and perspectives	2	0	0	0	0	0	2	6	M. Marence
<b>Total</b>		<b>39</b>	<b>0</b>	<b>0</b>	<b>16</b>	<b>0</b>	<b>0</b>	<b>55</b>	<b>149</b>	

## **Education Material**

- Book Golze: Design of small dams.
- Book Jorde, K., Sommer, F. 2006: Design of Hydraulic Structures,Hydro Power Schemes.
- Book Mosonyi, E., 1987: Low head hydropower plants, Budapest, Hungary.
- Book Mosonyi, E., 1991: High head hydropower plants, Budapest, Hungary
- Lecture notes Petry, B. & N. Lukovac, 2002: Hydraulic Structures, UNESCO-IHE Lecture notes
- Lecture notes Presentations
- Book Stematiu, D., 2005: Dam engineering, UNESCO-IHE. Stematiu. D., 2005: Concrete Dams, UNESCO-IHE
- Book Stematiu, D.: 2006. Embankments Dams. Conspress, Bucharest.
- Book USBR: Design of arch dams. US Bureau of Reclamation, Denver, US.
- Book USBR: Design of small dams. US Bureau of Reclamation, Denver, US.

## **Scientific Software**

- D-geo stability
- cadam
- mseep

# M3096

## Groundwater in Adaptation to Global Change Impacts

<b>Term</b>	201718T08
<b>Coordinator</b>	T.Y. Stigter
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

MSc students in Erasmus+ Mundus Joint Master Programme in Groundwater and Global Change - Impacts and Adaptation

### Prerequisites

Approved BSc degree and basic hydrology/hydraulics and earth sciences subjects.

### Learning Objectives

- 1 assess the impacts of present and future global water consuming and contaminating activities on groundwater resources
- 2 analyze the occurrence, benefits and challenges of managed aquifer recharge as a tool for climate change adaptation;
- 3 carry out a feasibility study for the implementation of a managed aquifer recharge project
- 4 explain feedback mechanisms between groundwater, irrigation agriculture and socio-economics in water stressed regions;
- 5 use modeling tools for optimal management of coupled groundwater-agricultural systems
- 6 define the urban water balance concept including the role of groundwater;
- 7 differentiate between a number of key pollutants and processes in urban groundwater

### Assessments

%	Type	Name
30	Assignment	Groundwater in adaptation to global change impacts in agriculture
30	Assignment	Groundwater in adaptation to urbanization and pollution
40	Assignment	Managed aquifer recharge

### Topics

#### 1 Impacts of global change on groundwater resources

Global-to-local scale consequences of intensive groundwater (over)exploitation: depletion, seawater intrusion, land subsidence, decline in environmental flows (for rivers and wetlands).

## Topics

### 2 Managed aquifer recharge

Applications of managed aquifer recharge (MAR); methods of MAR; procedures for carrying out a feasibility study for the implementation of a MAR project; case studies of MAR around the world.

### 3 Groundwater in adaptation to urbanization and pollution

The urban (ground)water balance; adaptation solutions in the context of urban groundwater use and contamination; a closer look at the waste water term in the urban water balance; pollutants in urban groundwater; fate of chemical pollutants and pathogens in urban aquifers.

### 4 Groundwater in adaptation to global change impacts in agriculture

Global irrigation water use and future demand under global change; discussion of typical management problems using a coastal agricultural region as an example of a groundwater agricultural system; methods for monitoring and simulation to obtain relevant data to estimate water availability and demand under different sources of uncertainty; decision support systems to aggregate the single elements of the management of a groundwater agricultural system; procedures and optimization tools for an integrative water management assessing potential measures directed at both demand and supply

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Impacts of global change on groundwater resources	4	0	4	0	0	0	8	16	T.Y. Stigter
2	Managed aquifer recharge	8	8	8	0	8	0	24	48	J. Groen, T.Y. Stigter, Y. Zhou
3	Groundwater in adaptation to urbanization and pollution	8	6	8	0	0	0	16	38	J.W.A. Foppen
4	Groundwater in adaptation to global change impacts in agriculture	8	6	8	0	0	0	16	38	
Total		28	20	28	0	8	0	64	140	

## Education Material

Book	Books with specific chapters on the indicated topics
Handout	Handouts from presentations

## Scientific Software

Aqtesolv  
ArcGIS  
Cropwat  
QGis  
surfer

# M3105

## Integrated Coastal Zone Management

<b>Term</b>	201718T08
<b>Coordinator</b>	M. van der Wegen
<b>Credit points</b>	3.000000000
<b>Specialization</b>	

### Target Group

Young and mid-career professionals with a relevant degree or working experience in coastal engineering or coastal management (academic bachelor)

### Prerequisites

BSc degree or equivalent qualification in a relevant field from a recognised university Several years of relevant working experience

### Learning Objectives

- 1 learn the need for an integrated approach of problems in the coastal zone and become familiar with the multidisciplinary aspects of ICZM which is vital for sustainable development.

### Assessments

%	Type	Name
1	Oral examination	ICZM

### Topics

- 1 **Pesisir tropicana simulation game**  
Role play on decision making in Pesisir Tropicana



## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Pesisir tropicana simulation game	4	14	3	0	0	0	7	29	H.J. Verhagen, M. van der Wegen
Total		4	14	3	0	0	0	7	29	

## Education Material

Lecture notes

Verhagen, Van der Wegen, Pesisir Tropicana a Case study in caostal management, LN0090-04-1

## Scientific Software

# M1309

## Integrated Hydrological and River Modelling

<b>Term</b>	201718T08
<b>Coordinator</b>	S. Maskey
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All WSE participants and short course participants with hydrology/hydraulics/water resources/civil engineering background.

### Prerequisites

Approved BSc degree and appropriate hydrology and/or water engineering subjects.

### Learning Objectives

- 1 Understand and describe the structure of physically-based hydrological models and the methods used by these models to simulate the behaviour of distinct hydrological phenomena;
- 2 Distinguish components of hydrological modelling software for hydrodynamic simulation, catchment process simulation and surface water quality simulation;
- 3 Translate a given hydrological problem into a model definition using available data;
- 4 Conduct a model calibration/validation procedure and to interpret the simulation results to assess model performance and to suggest improvement in the model set-up;
- 5 Independently carry out a hydrological modelling study and to report the results.

### Assessments

%	Type	Name
35	Assignment	Catchment modelling
15	Presentation	Hydrological modelling - components/methods/tools
50	Assignment	River flow and water quality modelling

### Topics

#### 1 Introduction to integrated hydrological and river Modelling

This part includes definitions of physically-based/conceptual models, distributed/semi-distributed/lumped models; introduces various components of hydrological models and commonly used methods for modelling these components as well as commonly used hydrological modelling tools (software).

## Topics

### 2 River flow and water quality modelling

This part includes both flow- and water quality modelling. The flow modelling deals with the aspects involved in river flow modelling, including the simulation techniques applied in hydrodynamic modelling, river flow model networks, data requirements, and boundary conditions. Practicals are carried out using the Mike 11 flow simulation package (hydrodynamic river flow simulation). For each assignment, the results and findings are elaborated in a concise report. Quality modelling focuses on surface water quality and consists of a series of introductory classes, Excel-based BOD-DO modelling exercises and comprehensive practicals using Mike 11 and ECO lab. Results of the practical assignments are presented in a written report.

#### 2.1 River flow hydrodynamic modelling

Please see in Topic 2.

#### 2.2 River water quality modelling

Please see in Topic 2.

#### 2.3 River water quality modelling (exercise)

Please see in Topic 2.

### 3 Catchment modelling (lecture and exercise)

This part expands on the river flow modelling and consists of introductory classes and practicals on modelling surface and subsurface catchment processes using Mike SHE/Mike 11. The students elaborate two major assignments, each for a catchment with distinct hydrological characteristics, and present their findings in a written report.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to integrated hydrological and river Modelling	4	0	0	4	0	0	8	20	S. Maskey
2	River flow and water quality modelling	0	0	0	0	0	0	0	0	
2.1	River flow hydrodynamic modelling	4	0	0	12	0	0	16	36	S. Maskey
2.2	River water quality modelling	6	0	0	0	0	0	6	18	A.B.K. van Griensven, S. Maskey
2.3	River water quality modelling (exercise)	0	0	0	8	0	0	8	16	S. Maskey
3	Catchment modelling (lecture and exercise)	4	0	0	18	0	0	22	48	R.G.W. Venneker
<b>Total</b>		<b>18</b>	<b>0</b>	<b>0</b>	<b>42</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>138</b>	

## Education Material

Lecture notes

Guinot V. and Venneker R., Physically-based hydrological modelling - Lecture notes and tutorials.

Lecture notes

Maskey S., Hydrological/catchment modelling and river flow modelling - Lecture notes and tutorial:

**Scientific Software**

Mike 11

Mike SHE

# M3166

## International Port Seminar

<b>Term</b>	201718T08
<b>Coordinator</b>	A. Dastgheib
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Professionals in port operation, engineering, management and development.

### Prerequisites

Bachelor degree in hydraulic engineering, mechanical engineering or technical management or a comparable level obtained by 3-5 years working experience in the field of port management or port planning and engineering.

### Learning Objectives

- 1 Learn about the international character of a port; the supply chain and port logistics; economic aspects of ports, and port organisations.
- 2 Learn about strategic planning; design and construction of port infrastructure; life cycle approach, and port maintenance
- 3 Get acquainted with practical aspects of port management and engineering.
- 4 Get acquainted with incorporating uncertainty in port planning (Adaptive Port Planning)
- 5 Get acquainted with climate change challenges for ports

### Assessments

%	Type	Name
100	Presentation	International Port Seminar

### Topics

#### 1 International Port Seminar

A comprehensive overview of the managerial aspects of modern ports with a special focus on the technical management. Includes port and shipping logistics, containerization, cargo handling, terminals, economic aspects, port master planning, port simulation, hinterland connections, health, safety and environment, life cycle management, maintenance and monitoring. Port visits in the Netherlands and neighbouring countries.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	International Port Seminar	12	0	70	0	34	0	116	140	A. Dastgheib, M. van Schuylenburg
Total		12	0	70	0	34	0	116	140	

## Education Material

Handout                      Handouts

## Scientific Software

# M3186

## International Port Seminar

<b>Term</b>	201718T08
<b>Coordinator</b>	M. van Schuylenburg
<b>Credit points</b>	4.000000000
<b>Specialization</b>	

### Target Group

Preferably participants have a technical background and some years of working experience in a port environment.

Professionals in (or on their way to) management positions in the field of port management, port planning and development, port consultancy, port policy making, construction and maintenance are especially welcome at the seminar.

A bachelor level and a workable knowledge of English are required to benefit fully from the International Port Seminar.

### Prerequisites

Bachelor degree in hydraulic engineering, mechanical engineering or technical management or a comparable level obtained by 3-5 years working experience in the field of port management or port planning and engineering

### Learning Objectives

- 1 Get acquainted with incorporating uncertainty in port planning (Adaptive Port Planning)
- 2 Learn about the international character of ports in the global supply chain and port logistics, economic and financial aspects of ports and port organisation models
- 3 Get acquainted with modern port planning tools as simulation and serious gaming
- 4 Get acquainted with stakeholder management, sustainability, security and safety in ports

### Assessments

%	Type	Name
1	Attendance	Attendance
1	Presentation	Presentation about development plan of port of their home country

## Topics

- 1 Port management, Adaptive Port Planning, Port economics, Port Finance, Stakeholder management, Security and Safety in ports

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Port management, Adaptive Port Planning, Port economics, Port Finance, Stakeholder management, Security and Safety in ports	40	8	8	0	16	0	64	152	
Total		40	8	8	0	16	0	64	152	

## Education Material

Book Ports and terminals, H.Ligteringen

## Scientific Software



# M3203

## Management of Irrigation and Drainage Systems

<b>Term</b>	201718T08
<b>Coordinator</b>	A.E.C. Duker
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All Land and Water Development participants, and those interested in the management aspects of irrigation and drainage systems.

### Prerequisites

Agronomy, irrigation methods, socio-economic and environmental aspects of irrigation, irrigation flow control and conveyance

### Learning Objectives

- 1 Evaluate objectives, tasks and types of irrigation management arrangements and its implications for irrigation performance
- 2 Assess the relevance and concepts of stakeholder participation in irrigation management
- 3 Demonstrate the role of property creation for the management and development of irrigation and drainage system
- 4 Explain the theory, key concepts, conceptual framework and merits of water accounting in irrigation schemes
- 5 Use the IWMI water accounting framework to perform water accounting in irrigation schemes, interpret the results provide situation analysis and formulate relevant recommendations for improvements.
- 6 Apply key concepts of irrigation performance assessment, including its role, types of assessment, criteria, indicators, benchmarking and targets, in addressing problems related to irrigation performance

### Assessments

%	Type	Name
40	Assignment	Irrigation management transfer
60	Written examination (open book)	Property relations in irrigation systems, Irrigation performance assessment and irrigation water accounting

## Topics

### **1 Management tasks in different types of irrigation and drainage systems**

Terminology and definitions, management approaches, objectives in irrigation, interest groups, conflicting objectives and interests, large and small scale systems. Water delivery policies: entitlement to water, operational objectives (adequacy, equity, reliability), cropping policies. Water delivery systems: arranged, on-request, on-demand, irrigation scheduling. Formal and informal irrigation management. Concept of service oriented management: typology of goods and services, clients and stakeholders, service determining factors, levels of service, infrastructure, flow control and service potential, organisational structures, cost recovery, farmers participation, role of line agencies and accountability mechanisms in water management institutions.

### **2 Property relations in irrigation systems**

Dynamics of hydraulic property and ownership relations in irrigation systems, investments and interventions in irrigation and drainage, the relevance and impact of different water rights arrangements.

### **3 Irrigation water accounting**

Water accounting is a tool that serves to provide much needed information in formulation of decisions that aim to improve water productivity and overall water management in an irrigation scheme. The course will introduce and discuss the water accounting framework created by the International Water Management Institute (IWMI WA). The theory, terminologies, the conceptual framework of IWMI WA will be explained. The discussion on the conceptual framework will be followed by a practical problem solving in class, visualizing the results and discussing the implications.

### **4 Irrigation performance assessment**

Performance assessment in irrigation and drainage is the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement. It is an important management tool to improve overall function of a scheme in terms of service and productivity. The course will discuss the key concepts and theoretical framework of performance assessment by drawing examples from the past field projects. This theoretical knowledge will then be used to solve problems and discuss the results and implications.

### **5 Irrigation Management Game**

The students will engage in the roles of farmers or water judge in an irrigation management game in which water delivery and cropping choices will be implemented in the occurrence of several events.

### **6 Field trip**

Visits to Dutch water management institutions such as the water board and agricultural association.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Management tasks in different types of irrigation and drainage systems	16	0	0	0	0	0	16	48	A.E.C. Duker, M.A. Burton
2	Property relations in irrigation systems	6	0	0	0	0	0	6	18	J.A. Bolding
3	Irrigation water accounting	12	0	0	0	0	0	12	36	P. Karimi
4	Irrigation performance assessment	8	0	0	0	0	0	8	24	
5	Irrigation Management Game	0	0	8	0	0	0	8	8	M.A. Burton
6	Field trip	0	0	0	0	8	0	8	8	A.E.C. Duker
<b>Total</b>		<b>42</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>58</b>	<b>142</b>	

## Education Material

- Scientific journal Malano, H., Burton, M. and Makin, I. (2004), Benchmarking performance in the irrigation and drainage sector: a tool for change. *Irrig. and Drain.*, 53: 119–133. doi:10.1002/ird.126
- Scientific journal Molden, D., Burton, M. and Bos, M. G. (2007), Performance assessment, irrigation service delivery and poverty reduction: benefits of improved system management. *Irrig. and Drain.*, 56: 307–320. doi:10.1002/ird.313
- Scientific journal Molden, D.; Sakthivadivel, R. 1999. Water accounting to assess use and productivity of water. *International Journal of Water Resources Development* 15(1&2): 55-71.

## Scientific Software

# M3275

## Planning and Delivery of Flood Resilience

<b>Term</b>	201718T08
<b>Coordinator</b>	B. Gersonius
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

- Flood risk managers, local planners and river basin council members
- Others (i.e. consultants) involved in supporting decision making with regard to flood risk management

### Prerequisites

Basic knowledge of the behaviour of river and delta systems (e.g. discharge variations, floods), and their management. Good command of English.

### Learning Objectives

- 1 Define the concept of flood resilience, together with its added value for flood risk management
- 2 Define objectives for reducing flood risk and improving flood resilience, and stress-test these objectives against climate change
- 3 Develop a variety of adaptation strategies, focusing on all aspects of flood risk management: protection, prevention, preparedness, emergency response and recovery
- 4 Evaluate adaptation strategies and pathways under the influence of climate change
- 5 Design an adaptive plan based on the developed pathways, including the necessary arrangements for implementation and monitoring

### Assessments

%	Type	Name
3	Assignment	Classroom assignments
2	Homework	Homework assignment (4-page reflection)
5	Presentation	

## Topics

### 1 Resilience of flood risk systems

Flooding can have devastating impacts on societies and their economies. Recovering from these impacts might be very difficult, especially in urban areas where social and technical systems are interdependent. Over the coming decades, it is expected that the frequency and intensity of floods will increase due to climate and socio-economic change. Building resilience to flooding, therefore, is an important need to sustain the liveability and economic competitiveness of cities. This topic introduces resilience as the ability of an area or community to remain functioning under a range of flood events.

### 2 Objectives and stress-testing objectives

This topic deals with the objectives and associated performance indicators for flood risk management, to be identified in consultation with the stakeholders. This also includes the definition of critical threshold values of the performance indicators that are used to indicate vulnerabilities to climate and socio-economic change. The vulnerability assessment is conducted using the “climate stress test” methodology, which systematically tests the flood risk system with climate changes so that the problematic climate changes can be identified.

### 3 Strategies to improve flood resilience

This topic identifies a range of strategies to reduce flood risks and improve resilience. It focuses on pre-event mitigation: protection, prevention and preparedness. Protection is directed at reducing the likelihood of floods, such as by giving rivers more space; prevention involves sustainable spatial planning and protection of infrastructure; and preparedness concerns taking organisational measures, like preparing evacuation and recovery plans. It also deals with the management of flood events: emergency relief and recovery. Emergency relief concerns e.g. evacuating communities and providing assistance, and recovery aims at mitigating the impacts on affected communities.

### 4 Evaluation within adaptation pathway sequences

This topic provides guidance to evaluate and help justify the choices between different possible adaptation strategies in terms of costs, benefits and tradeoffs in the short and long term through the possible realization of pathways, and considerations of robustness or flexibility build into the flood risk system. It also provides the analytical justifications for choices in the long term or short term.

### 5 Adaptive plan, incl. institutional and monitoring arrangements

This topic addresses the design of an adaptive plan to improve flood resilience. This plan contains the following elements: 1) a preferred adaptation strategy; 2) actions to be taken on the short term and maybe on the mid term; 3) options to keep open for the long term; 4) arrangements (organizational, financial, legal etc.) to be made for implementing the actions; and 5) a monitoring plan.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Resilience of flood risk systems	6	4	4	0	0	0	10	26	B. Gersonius, W. Veerbeek
2	Objectives and stress-testing objectives	4	4	6	0	0	0	10	22	B. Gersonius, J.S. Rijke
3	Strategies to improve flood resilience	8	2	4	0	8	0	20	38	C. Zevenbergen, K.A. Anema, M.F. van Staveren, W. Veerbeek
4	Evaluation within adaptation pathway sequences	4	4	6	0	0	0	10	22	B. Gersonius, M.H.J.L. Jeuken, W. Veerbeek
5	Adaptive plan, incl. institutional and monitoring arrangements	6	2	4	0	0	0	10	24	C.J.L. Seijger, P. Bloemen
<b>Total</b>		<b>28</b>	<b>16</b>	<b>24</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>60</b>	<b>132</b>	

## Education Material

E-book	Collaborative Risk-Informed Decision Analysis (CRIDA) manual
Scientific journal	Key (3-5) relevant scientific articles

## Scientific Software

# M2709

## River Flood Analysis and Modelling

<b>Term</b>	201718T08
<b>Coordinator</b>	I.I. Popescu
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Water Science and Engineering and Short Course participants

### Prerequisites

Hydraulics and hydrology

### Learning Objectives

- 1 Understand and explain the main flood management problems
- 2 Understand and explain the governing processes of flood generation and propagation
- 3 Identify the proper modelling methodology for a given problem
- 4 Utilise their hands-on experience in the step-by-step modelling procedure needed to carry out a practical study with HEC-HMS and HEC-RAS
- 5 Understand and analyse the main sources of uncertainty in flood modelling

### Assessments

%	Type	Name
25	Assignment	HEC-HMS modelling
25	Assignment	HEC-RAS modelling
50	Written examination (closed book)	River Flood Modelling and Flood Routing

### Topics

- 1 **Climate change and its impact on hydrology (in common with module8b)**  
Climate change problematique. Global, regional and local climate models, development of climate change scenarios. Effects of climate variability on the hydrology that affects rainfall-runoff processes in river-basins.
- 2 **Introduction to 1D2D, 2D modelling**  
Introduction to the basic principles of 1D2D and 2D modelling.

## Topics

### 3 River flood analysis

Nature and characteristics of floods: rainfall and flood generation. Flood analysis, flood probability, return period analysis of hydrological events, design floods, estimation of peak flows, storm hydrographs and unit hydrograph methods. Modelling flood propagation and routing; Hydrological approach: Muskingum, reservoir routing, use of HEC-HMS; 1D hydraulic flood routing/modelling in rivers: use of HEC-RAS, modelling resistance for discharge estimation

### 4 River flood modelling

Nature and characteristics of floods: rainfall and flood generation. Flood analysis, flood probability, return period analysis of hydrological events, design floods, estimation of peak flows, storm hydrographs and unit hydrograph methods. Modelling flood propagation and routing; Hydrological approach: Muskingum, reservoir routing, use of HEC-HMS; 1D hydraulic flood routing/modelling in rivers: use of HEC-RAS, modelling resistance for discharge estimation

### 5 River morphology modelling

While modelling of floods is usually considered without morphological development of the river bed, it is important to understand how river morphology changes in time so that from one flood event to another the geometry of a river might change. This section of the module gives a description on how river morphology changes. Real case studies regarding models of river including morphological aspects will be explained during class.

### 6 Uncertainty in Flood Modelling

Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Climate change and its impact on hydrology (in common with module8b)	4	0	2	0	0	0	6	14	P.D.A. Pathirana
2	Introduction to 1D2D, 2D modelling	4	0	0	0	0	0	4	12	I.I. Popescu, R.K. Price
3	River flood analysis	20	0	0	0	0	0	20	60	A. Jonoski, R.K. Price, S.J. van Andel
4	River flood modelling	0	0	24	0	0	0	24	24	B. Bhattacharya, I.I. Popescu
5	River morphology modelling	4	0	0	0	0	0	4	12	M. van der Wegen
6	Uncertainty in Flood Modelling	4	0	0	0	0	0	4	12	D. Solomatine
<b>Total</b>		<b>36</b>	<b>0</b>	<b>26</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>62</b>	<b>134</b>	

## Education Material

Lecture notes

Lecture notes on River flood management and flood routing Presentation slides; Modelling packages with user manuals;



**Scientific Software**

HEC-HMS

HEC-RAS

Matlab

Mike 11

# M1837

## Short Course on Design of Hydropower Schemes

<b>Term</b>	201718T08
<b>Coordinator</b>	M. Marence
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

The course is designed for scientists, engineers and water managers involved in hydropower development and water resources management, or interested in these topics.

### Prerequisites

Basic knowledge of hydraulics, geotechnics and structural engineering

### Learning Objectives

- 1 get overview and working knowledge in design of the hydropower schemes and practical design of hydropower structures including power waterways, powerhouses, turbines and electrical equipment.
- 2 get overview of development and design of all types of hydropower structures including also small power plants and pump-storage plants

### Assessments

%	Type	Name
1	Attendance	

### Topics

#### 1 Hydropower - Introduction

Hydropower: basic concepts, past experience and trends, context society, energy & environment.

## Topics

### 2 **Hydropower schemes - Layout and design requirements**

Hydropower schemes. Conventional low and high head schemes: factors principles and requirements for the design, typical arrangements and layouts. Basic data needed for hydropower definition.

### 3 **Open power waterways**

Weir, intake and sand trap types and design. Open channels and free flow systems, Forebays. Penstock types, materials and design.

### 4 **Power waterways**

Definition of the power waterway layout. Hydraulic (static and transient) design of power waterway. principles and experiences in analysis and design, tunnels, surge tanks and penstocks. Tunnel excavation, lining systems and grouting works. Intakes, gate shafts, valves, transitions and manifolds. Safety and monitoring of power waterways.

### 5 **Powerhouse**

Types of powerhouses. main parts and auxiliary equipment. Transmission lines. Powerhouse design.

### 6 **Electromechanical equipment**

Turbines, history and types. Pelton turbines. Cross flow turbines. Francis turbines. Kaplan turbines. Turbine design.

### 7 **Small hydropower**

Definition and benefits of small hydro. Hydropower estimation. Inflatable rubber dam. Tyrolian weir. Special small machines. Small hydropower projects.

### 8 **Pump storage powerplants**

Need and requirements for pump storage. Typical layouts. Artificial reservoirs. Pumps and machine types. Examples.

### 9 **Cost control and financial analysis**

Hydropower project development. Project costs schedule. Live costs. Financial analyses. Project risks

### 10 **Future developments and perspectives**

Refurbishment of HPP, Future and challenges of hydropower

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Hydropower - Introduction	2	0	0	0	0	0	2	6	M. Marence
2	Hydropower schemes - Layout and design requirements	2	0	0	2	0	0	4	10	M. Marence
3	Open power waterways	3	0	0	2	0	0	5	13	M. Marence
4	Power waterways	3	0	0	0	0	2	5	15	M. Marence
5	Powerhouse	2	0	0	0	0	0	2	6	M. Marence
6	Electromechanical equipment	2	0	0	0	0	2	4	12	M. Marence
7	Small hydropower	2	0	0	0	0	0	2	6	M. Marence
8	Pump storage powerplants	2	0	0	0	0	0	2	6	M. Marence
9	Cost control and financial analysis	1	0	0	0	0	0	1	3	M. Marence
10	Future developments and perspectives	2	0	0	0	0	0	2	6	M. Marence
<b>Total</b>		<b>21</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>4</b>	<b>29</b>	<b>83</b>	

## Education Material

## Scientific Software

# M1710

## Urban Flood Management and Disaster Risk Mitigation

<b>Term</b>	201718T08
<b>Coordinator</b>	Z. Vojinovic
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants in WSE programme; Participants in short course "Urban Flood Management and Disaster Risk Mitigation"

### Prerequisites

Basic knowledge of hydrology and hydraulics

### Learning Objectives

- 1 Develop understanding of how to use the models to assess the performance of existing systems and how to design the new ones within the context of different flood risks (pluvial, fluvial, coastal and flash floods)
- 2 Learn how to produce different flood risk maps in a GIS environment and how to calculate different types of flood damages, and
- 3 Develop understanding of structural and non-structural flood resilience measures such as, conventional and innovative structures, early warning systems, etc., and understand how to develop effective flood disaster management plans

### Assessments

%	Type	Name
40	Written examination (closed book)	All Topics
60	Assignment	

### Topics

- 1 **Application domains of Hydroinformatics: floods, urban systems and environment**  
Introduction to floods and flooding. Introduction to urban floods and urban water systems. Introduction to environmental systems.
- 2 **Climate change and its impact on hydrology**  
Introduction to the effects of climate variability on the hydrology that affects urban areas, urban hydrology as a very fast rainfall-runoff process, selection of appropriate time steps in urban runoff modelling, global, regional and local climate models, development of climate change scenarios.
- 3 **Ethics of risk**  
Introduction to the basic theory of ethics and its application to the flood risk management.

## Topics

### 4 Introduction to 1D2D, 2D modelling

Introduction to the basic principles of 2D modelling, solutions of the 2D shallow-water equations, schemes for dealing with high velocity flows at shallow depths, numerical issues concerning interaction between 1D and 2D flow domains, below ground and above ground flows, subcritical and supercritical flows over urban floodplains, treatment of buildings in 2D models, etc

### 5 Urban Flood Modelling and Evaluation of Flood Risks

Stormwater collection systems; services provided, beneficiaries, structure and concepts of drainage networks, rainfall input, rainfall-runoff modelling, free-surface and pressurised pipe flows, LIDAR filtering of urban features, rainfall and flow measurements, instrumentation, SCADA, telemetry, weather radar, numerical weather forecasts, build-up, wash-off, surface runoff water quality modeling in pipe networks, familiarisation with MOUSE, MIKE11, MIKE21 and SWMM software, setting up 1D and 1D-2D models, calibrating and verifying models using flow survey data, calculation of flood damages (tangible, intangible, direct, indirect damages), production of flood hazard maps, sensitivity-based flood risk attribution.

### 6 Structural and Non-structural Urban Flood Management Measures

Sustainable structural and nonstructural urban flood management measures such as: amplification of pipe networks, open channels, detention/retention basins, on-site-detention, on-site-infiltration, on-site-retention, SUDS, stormwater sensitive urban design, asset management and multi-objective optimization of rehabilitation measures (use of computational intelligence), design and employment of early warning systems.

### 7 Managing urban flood disasters

Framework for urban flood disaster management (pre-disaster, during disaster, post disaster phase), disaster morphology, evaluation of disaster scenarios, development and testing of plans, emergency preparedness and response activities, use of GIS and communication and information systems.

## Study load

Nr	Topic										Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours		
1	Application domains of Hydroinformatics: floods, urban systems and environment	4	0	2	0	0	0	6	14		Z. Vojinovic
2	Climate change and its impact on hydrology	4	0	2	0	0	0	6	14		M. Radhakrishnan, P.D.A. Pathirana
3	Ethics of risk	2	0	0	0	0	0	2	6		N. Doorn
4	Introduction to 1D2D, 2D modelling	7	0	7	0	0	0	14	28		S. Djordjevic
5	Urban Flood Modelling and Evaluation of Flood Risks	9	3	0	3	0	0	12	36		A. Sanchez Torres, Z. Vojinovic
6	Structural and Non-structural Urban Flood Management Measures	4	0	0	2	0	0	6	16		B. Gersonius, Z. Vojinovic
7	Managing urban flood disasters	6	0	0	4	0	0	10	26		A. Sanchez Torres, D. Sakulski, Z. Vojinovic
<b>Total</b>		<b>36</b>	<b>3</b>	<b>11</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>56</b>	<b>140</b>		

## Education Material

**Scientific Software**

Aposs

Mike 11

Mike 21

Mike Flood

Mike Urban

SWMM

# M3167

## Fieldtrip and Fieldwork WSE

<b>Term</b>	201718T09
<b>Coordinator</b>	A.E.C. Duker
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

WSE participants

### Prerequisites

Knowledge about water management, hydraulic engineering, hydrology and water and environment

### Learning Objectives

- 1 Demonstrate a multidisciplinary overview of actual technical, research and organizational activities in the field of water management, hydraulic engineering and hydrology.
- 2 Report detailed technical information received.
- 3 Select and apply different, appropriate field instrumentation and measurement methods in practice and organise the measurements.
- 4 Critically analyse field results, and identify/recognise possible areas of error or uncertainty.
- 5 Integrate quantitative measurements with qualitative terrain observations and prior information to evaluate and analyse the relevant predominant processes in a study area.
- 6 Apply this assimilation of data to engineering cases.

### Assessments

%	Type	Name
1	Assignment	Fieldwork



## Topics

### 1 Design and Fieldwork

Field trip (Various staff UNESCO-IHE) - One week study tour (specializations HWR, HERBD, HECEPD, LWDFS). Visits to organizations and institutions active in hydraulic engineering and/or hydrology, for instance contractors, consultancy offices, governmental institutions, research laboratories, water resources and hydraulic engineering projects in development and operation. Depending on the number of participants of the specializations within the Water Engineering Department, the fieldtrip will be multidisciplinary with the aim of integrating specializations within the department and enabling a holistic view of Water Engineering. Travel is by coach and the accommodation is hotel (shared rooms) with breakfast.

Two week study tour in Florida, USA (HI) - Exposure tour with "on site" explanation of hydrological, hydraulic and environmental projects, particularly the Everglades Comprehensive Restoration project. Specific supplements to the taught part of the programme are the visits to projects with implemented Hydroinformatics components, or various centres involved in Hydroinformatics research.

Fieldwork (Various staff UNESCO-IHE) - Field measurements will be focusing on getting hands-on experience with the execution of measurements in a coastal environment: flow velocity, bottom profiles, sediment transport, drifter measurements. Introduction to combined use of field data and modelling. LWDFS specialization: Field experiments in irrigation, various types of measuring equipment, hydraulic characteristics of field channels, soil characteristics, various irrigation methods, water balance measurements, discharge-depth relationship for measuring structures, measurement of pump characteristics and of head losses in pipe systems, hydrometric measurements including current metering, salt dilution method and slope-area method, discharge calculations by various methods (mean and mid-section method).

HWR specialization - Two week fieldwork in southeast France focuses on integrating field observations of geology, geomorphology and physiography with surface and subsurface water data collection. Training in field instruments and measurement techniques is an integral part of the activities. ICT facilities for field data processing are provided. Small groups of students work partly under supervision but also carry out independent field assignments. At the end, each group will give a presentation.

HERBD specialization - The course focuses on developing field observation/measurement skills and integrating this with engineering knowledge. Measurements, observation, assimilation and critical analysis will be of key importance. Training in field instruments and techniques will be an integral part of the activities, followed by a period of group work where students will study a stretch of river in more depth with the purpose of gathering information to input into engineering designs.

HECEPD specialization - Field measurements will be focusing on getting hands-on experience with the execution of measurements in a coastal environment: flow velocity, bottom profiles, sediment transport, drifter measurements. Introduction to combined use of field data and modelling.

LWDFS specialization: Field Experiments in Irrigation - Various types of measuring equipment. Hydraulic characteristics of field channels. Soil characteristics. Various irrigation methods. Water balance measurements. Discharge-depth relationship for measuring structures. Measurement of pump characteristics and of head losses in pipe systems. Hydrometric measurements, current metering, salt dilution method and slope-area method. Discharge calculations by various methods; mean and mid-section method.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Design and Fieldwork	0	0	0	0	140	0	140	140	
Total		0	0	0	0	140	0	140	140	

## Education Material

Handout                      Fieldtrip Information and Documentation, (handout)

## Scientific Software

# M2841

## Applied Groundwater Modelling

<b>Term</b>	201718T10
<b>Coordinator</b>	Y. Zhou
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants in Hydrology and Water Resources specialisation and professionals working in water and environmental resources assessment and management

### Prerequisites

Approved BSc degree and appropriate groundwater and/or water engineering subjects

### Learning Objectives

- 1 be familiar with the principles and procedures of groundwater modelling;
- 2 construct a groundwater model using state of the art modelling software;
- 3 use the model for simulation of groundwater flow, contaminant transport and salt water intrusion;
- 4 apply groundwater modelling techniques for groundwater resources management and protection.

### Assessments

%	Type	Name
30	Assignment	Density Dependent Groundwater Flow
70	Assignment	Groundwater Modelling

### Topics

#### 1 Groundwater Modelling

Purposes of groundwater modelling; conceptual model: conceptualisation of aquifer-aquitard systems; specification of boundary conditions; hydrological stresses; design of numerical model: finite-difference solutions of flow problems; steady versus unsteady model; one layer versus multi-layer model; lay-out of grids; stress period/ time steps; model inputs: initial conditions; boundary conditions; hydrogeological parameters; hydrological stresses; model calibration and validation: selection of model code; calibration procedures; model prediction: purposes of prediction; simulation of scenarios; determination of capture zones. Contaminant transport processes and mechanisms: advective transport; dispersion; diffusion; sorption; degradation; contaminant transport models: mass fluxes; mass balance equations; initial conditions; boundary conditions; analytical solutions: 1D advective-dispersion-sorption-degradation; numerical solutions: Finite difference; method of characteristics; applied modelling of contaminant transport: problem definition; purpose of modelling; conceptual model; selection of model code; design of numerical model; model calibration; sensitivity analysis; model application.

## Topics

### 2 Saline Groundwater Modelling

Salt water intrusion in coastal aquifers; density dependent flow equations of a fresh-saline interface: Badon Ghijben-Herzberg principle; sharp interface; transition zone; numerical modelling: interface models; solute transport model; benchmark problems; applied modelling of seawater intrusion.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater Modelling	16	0	0	24	0	0	40	96	Y. Zhou
2	Saline Groundwater Modelling	10	0	0	8	0	0	18	46	
Total		26	0	0	32	0	0	58	142	

## Education Material

Lecture notes

Oude Essink, G., Density Dependent Groundwater Flow, Lecture notes, LN0302/04/1.

Lecture notes

Zhou, Y., Applied Groundwater Modelling, Lecture notes, LN0113/09/1.

## Scientific Software

# M3036

## Drought Management and Reservoir Operations

<b>Term</b>	201718T10
<b>Coordinator</b>	M.G.F. Werner
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Students and professionals interested in drought and water scarcity, how drought can be monitored, forecasted, and managed, and how reservoirs can be operated to meet multiple objectives such as water supply, flood protection, hydropower, and environmental requirements.

### Prerequisites

Working knowledge in hydrology and water resources management; Familiar with statistical principles such as distributions and probability theory. Familiarity with simple optimisation methods an advantage

### Learning Objectives

- 1 Be able to identify and describe the concept of drought, and describe the different types of drought, the influence of society on drought, and the relationship between drought and water scarcity
- 2 Be familiar with concepts of drought monitoring and forecasting, and data and modelling systems used.
- 3 Be able to describe the principles of reservoir operations and optimisation, and develop operational rules for (mult purpose) reservoir systems.

### Assessments

%	Type	Name
30	Written examination (closed book)	Drought, Drought Management, Monitoring and Forecasting (30%)
30	Written examination (closed book)	Reservoir optimisation and control (30%)
20	Assignment	on Drought Characterisation and Drought Management (20%)
20	Assignment	on Reservoir Simulation and Establishing and Testing Reservoir Rule Curves (20%)

## Topics

### 1 Drought and Drought Management

Introduction to the concept of drought and the different types of drought. How these are related in time. Drought as a natural phenomenon and the influence of society on drought. Concepts of drought risk, and the constituent components of drought hazard and drought vulnerability. Drought Management and the development of drought management planning.

This topic will include lectures and

### 2 Drought Monitoring and Forecasting

Concepts of drought indicators and the use of drought indicators in monitoring different types of drought. Drought Monitoring systems. Drought Forecasting and drought Forecasting systems. Data requirements. Exercise in using global data to characterise drought in different parts of the world.

### 3 Reservoir Control and Optimisation

Principles of reservoir operation rules, including standard operation policy, hedging and flood control rules. Designing reservoir operation policies using optimisation techniques such as linear and (stochastic) dynamic programming. Long term versus short term reservoir operation. Establishing objective functions for multiple-purpose reservoirs. Planning and implementation of environmental flows.

Exercise using reservoir simulation package (HEC-ResSim) to model a reservoir system, and developing operational rule curves through dynamic programming and testing these through simulation.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Drought and Drought Management	12	4	8	0	0	0	20	48	I. Masih, M.G.F. Werner, S. Maskey
2	Drought Monitoring and Forecasting	8	0	12	0	0	0	20	36	M.G.F. Werner, S. Maskey
3	Reservoir Control and Optimisation	14	0	12	0	0	0	26	54	M.G.F. Werner
<b>Total</b>		<b>34</b>	<b>4</b>	<b>32</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>66</b>	<b>138</b>	

## Education Material

Handout	Handouts on drought and drought management
Lecture notes	Reader on reservoir operations
Scientific journal	Selected scientific papers

## Scientific Software

# M3243

## Flood Risk Management

<b>Term</b>	201718T10
<b>Coordinator</b>	B. Bhattacharya
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

The course is designed for MSc participants in Water Science and Engineering at IHE, Erasmus Mundus MSc in Flood Risk Management (HIFRM) and Short course 'Flood Risk Management'

### Prerequisites

Hydraulics, hydrology, river basin and flood modelling, statistics

### Learning Objectives

- 1 Understand and apply the main principles of flood risk management; conceptualise and apply the main principles of flood risk assessment
- 2 Understand the Hydroinformatics tools available for flood risk management
- 3 Conceptualise the main principles of EU flood directive and have knowledge about European experience in flood risk management
- 4 Understand and explain the main principles of flood forecasting and warning and uncertainty issues associated with flood forecasts
- 5 Utilise their hands-on experience in the step-by-step modelling procedure to build flood inundation models

### Assessments

%	Type	Name
40	Assignment	Assignment reports on 1D-2D modelling, mapping and risk mapping (40%)
30	Assignment	Presentation and assignment report on case-studies (30%)
30	Written examination (closed book)	Written exam (30%)

### Topics

#### 1 Introduction to flood risk management

Introduction to FRM: Introduction to flood risk management, basic principles, sources of risk, modelling for FRM, flood risk mapping: principles and practices in different EU countries, EU Flood Directive.

#### 2 Flood risk analysis and case studies

Risk analysis and case studies: Flood risk management practices (Pre-, post- and during flood), quantifying flood risk, risk analysis, climate change impacts, uncertainty issues, risk mitigation measures, case studies.



## Topics

### 3 Dutch experiences in FRM

Dutch experiences in FRM: Dutch practices of FRM, history, principles and practices, Room for the River project.

### 4 Flood forecasting

Flood forecasting: Flood forecasting, principles and approaches, examples, workshop, flood damage assessment

### 6 1D-2D modelling

1D-2D modelling of flood inundation with Sobek-Rural; flood inundation and mapping with HEC-RAS

### 7 Flood risk mapping

Flood risk representation and mapping (using HEC-RAS and ArcGIS).

### 8 Fieldtrip

Visit to storm surge barrier (Maeslantkering)

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Introduction to flood risk management	8	0	2	0	0	0	10	26	B. Bhattacharya
2	Flood risk analysis and case studies	11	0	1	0	0	0	12	34	P. Samuels
3	Dutch experiences in FRM	0	0	4	0	0	0	4	4	K.M. de Bruijn
4	Flood forecasting	5	0	3	0	0	0	8	18	M.G.F. Werner
6	1D-2D modelling	0	0	14	6	0	0	20	26	I.I. Popescu, S.J. van Andel
7	Flood risk mapping	0	0	0	10	0	0	10	20	B. Bhattacharya
8	Fieldtrip	0	0	0	0	4	0	4	4	B. Bhattacharya
<b>Total</b>		<b>24</b>	<b>0</b>	<b>24</b>	<b>16</b>	<b>4</b>	<b>0</b>	<b>68</b>	<b>132</b>	

## Education Material

Lecture notes

Lecture notes on Hydroinformatics for flood management, EU framework directive, flood risk management Lecture notes on Flood modelling Presentation slides; Publications and reports; Modelling packages with user manuals

## Scientific Software

ArcGIS

HEC-RAS

sobek-RUR

# M2214

## Geotechnical Engineering and Dredging

<b>Term</b>	201718T10
<b>Coordinator</b>	M. van der Wegen
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Students interested in interaction between structures and geotechnics, dredging operations, dredging projects tender procedures and marine geotechnical investigations

### Prerequisites

basic knowledge in soil mechanics and coastal dynamics (waves/tides) (see for example WSE/HECEPD/03/s)

### Learning Objectives

- 1 assess geo-engineering aspects of different hydraulic engineering activities such as structure soil interaction and foundation methods and to apply standard soil mechanical calculation methods
- 2 assess the use of sheet piling in quay wall design and will be able to apply analytical and numerical methods used in designing a sheet pile
- 3 assess the need of dredging, project phasing, soil investigation and production, survey systems, cost estimating and pricing, tender procedures and contracts;
- 4 assess the technical and contractual aspects of geomarine investigations and will be able to set up and organise a survey programme;

### Assessments

%	Type	Name
40	Assignment	Exercise Geo-Engineering and Sheetpile Design
60	Oral examination	Geo-Engineering and Sheet-pile design - Open Book

## Topics

### 1 Geo-Engineering and Sheet Pile Design

Geo-Engineering - Earth retaining structures; gravity wall, analysis of sliding and overturning and allowable soil pressures; sheet pile wall, analytical and (Winkler) spring models, screwed anchors, grout anchors, anchor walls, struts, and anchor piles. Shallow foundations, calculations of bearing capacity under vertical and inclined loads according to Prandtl, Buisman and Meyerhof-s theory, settlement calculations, allowable deformations, mutual influencing of foundations. Deep foundations, overview of piling systems, determination of end bearing capacity and of positive and negative friction. Slope stability, according to Bishop's theory including the effect of an earthquake load and groundwater flow. General exercise with a cantilever wall, a sheet pile, a shallow and a pile foundation and slope stability of an embankment. Detailed analysis is made on a specific topic. The calculations are analytical and some numerical by use of the Delft Geosystems software (DSTAB).

Sheetpile design - For the design of quay walls the knowledge of sheet piling gained in Geo-Engineering A and B is deepened and extended. Several mechanisms are dealt with in detail: piping, Kranz stability, heave, anchorage and special load cases. An overview of the different kind of quay walls and examples of repair and upgrade of existing structures is given and lessons learned are presented. In the assignment a quay wall is designed: sheet pile length, strength, deformation and anchorage. In the assignment, analytical and numerical methods (computer program DSHEET) are used.

### 2 Marine Geotechnical Investigations

Characteristics of marine geotechnical investigations, geotechnical requirements, critical-path items, project planning, desk studies, existing sources, available geotechnical data, specification for engineering geophysics and/or ground investigation, geotechnical hazards identified by desk studies, marine engineering geophysics, positioning, side scan sonar technique, seismic reflection magnetometer survey, marine ground investigations, investigation techniques, working platforms, seabed in-situ testing techniques, downhole in situ testing techniques, seabed and downhole sampling techniques, common pitfalls, integration into contracts.

### 3 IADC Dredging Seminar

The seminar focuses on the need of dredging, project phasing, soil investigation and production, survey systems, cost estimating and pricing, tender procedures and contracts. The programme includes various workshops on identifying the need for dredging, preparation of a dredging and landfill project and preparing in competing groups a tender bid for a dredging contract as well as two field visits to the execution of a dredging and reclamation project and a yard of a dredging contractor (contractor logistics).

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Geo-Engineering and Sheet Pile Design	18	0	0	0	0	8	26	78	J.R. Salazar
2	Marine Geotechnical Investigations	0	0	6	0	0	0	6	6	J. Molle
3	IADC Dredging Seminar	0	0	32	0	0	8	40	56	
<b>Total</b>		<b>18</b>	<b>0</b>	<b>38</b>	<b>0</b>	<b>0</b>	<b>16</b>	<b>72</b>	<b>140</b>	

**Education Material**

Book Dredging Seminar Handbook, 2010, IADC  
Lecture notes Peuchen J. : Marine Geotechnical Investigation, Lecture notes.

**Scientific Software**

D-geo stability  
D-sheet piling

# M3238

## Innovative Water Systems for Agriculture

<b>Term</b>	201718T10
<b>Coordinator</b>	P. Karimi
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All WSE participants and from other programmes with specific interest.

### Prerequisites

General knowledge about groundwater use in irrigation and an interest in innovative solutions

### Learning Objectives

- 1 Critically reflect on the different aspects of the use of groundwater in irrigation and managed aquifer recharge
- 2 Identify the suitability of various types of pumps in specific situations, and define the boundary conditions for the application of pumps and lifting devices
- 3 Discuss the merits and the limitations of the use of solar energy as a renewable resource to support energy demand in irrigation systems
- 4 Identify problems, constraints and potentials of lowland and flood prone areas for sustainable development
- 5 Discuss the design principles of the lowland, flood prone areas and polder water management systems
- 6 Explain the contribution that drones can make to improved agricultural practices
- 7 Explain the effects of climate change on food security and the new debates mitigation strategies

### Assessments

%	Type	Name
0,2	Written examination (open book)	Climate change and Food Security
0,4	Assignment	GIS and polder systems
0,2	Written examination (open book)	Groundwater, Water lifting devices and Managed Aquifer Recharge
0,2	Assignment	Solar powered irrigation and drainage

### Topics

- 1 **Groundwater, Water lifting devices and Managed Aquifer Recharge**
- 2 **GIS and polder systems**

## Topics

### 3 Solar powered irrigation & drainage

Energy use and carbon footprint of groundwater irrigation, Introduction to the use of renewable energy in irrigation and drainage, Solar powered irrigation systems; characteristics, opportunities and limitations

### 4 Drones and agriculture

### 5 Climate change and Food security

### 6 Filed trip and demonstration

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groundwater, Water lifting devices and Managed Aquifer Recharge	10	0	6	0	0	0	16	36	P. Karimi, T.Y. Stigter, X Cai
2	GIS and polder systems	12	0	8	0	0	0	20	44	F.X. Suryadi
3	Solar powered irrigation & drainage	4	0	4	0	0	0	8	16	P. Karimi
4	Drones and agriculture	6	0	0	0	0	0	6	18	P. Paron
5	Climate change and Food security	6	0	0	0	0	0	6	18	C.M.S. de Fraiture
6	Filed trip and demonstration	0	0	0	0	8	0	8	8	P. Karimi, P. Paron
<b>Total</b>		<b>38</b>	<b>0</b>	<b>18</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>64</b>	<b>140</b>	

## Education Material

- Book                      Man made lowlands, G.P. van de Ven (Ed), 2004
- Book                      Suryadi, 2010. GIS and computer modelling of Water Management Systems.
- Book                      Urban polder guideline, Vol 1,2, 3 and 4, UNESCO-IHE, 2009

## Scientific Software

# M3006

## Urban Water Systems

<b>Term</b>	201718T10
<b>Coordinator</b>	Z. Vojinovic
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Programme target group

### Prerequisites

Urban Drainage and Sewerage (recommended, but not essential)

### Learning Objectives

- 1 describe the processes that are necessary for analysis and planning of urban water systems.
- 2 explain the processes that are necessary for modelling, analysis and planning of water distribution systems.
- 3 give a detailed description of the processes that are necessary for modelling, analysis and planning of sewerage and drainage systems.
- 4 Explain in detail the processes that are necessary for the modelling, analysis and planning of wastewater treatment plants.
- 5 understand and evaluate the impacts of urban water systems on the receiving environment.

### Assessments

%	Type	Name
60	Assignment	Computer workshop, Homework, Class work, participation
40	Written examination (closed book)	Written exam

### Topics

#### 1 Introduction to urban water systems

Introductory lecture, the urban water cycle, urbanization, urban growth, impacts of the urban water cycle, different components and integration

## Topics

### 2 Water distribution modelling

Components of water distribution systems. input data and water distribution networks modelling, pump scheduling, introduction to optimization.

### 3 Urban drainage and sewerage modelling

Introduction to urban drainage and sewerage modelling, estimation of loads, sewer measurement and data collection, dry weather flow estimation and model calibration, wet weather flow, rainfall runoff, wastewater quality load parameters and estimation, CSOs, reducing pollutant loads.

### 4 Wastewater treatment modelling

Wastewater treatment modelling, introduction to WEST, input data, wastewater parameters and model settings.

### 5 Impacts on receiving environment

Characterisation of pollutants, effect of pollutants on receiving water bodies, urban runoff characteristics

### 6 Site visit

Guided site visit to the City of Dordrecht

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to urban water systems	2	0	0	0	0	0	2	6	Z. Vojinovic
2	Water distribution modelling	8	8	4	0	0	0	12	36	D.A. Savic, N. Trifunovic
3	Urban drainage and sewerage modelling	12	10	4	0	0	0	16	50	A. Sanchez Torres, B. Tomicic, F.H.L.R. Clemens, Z. Vojinovic
4	Wastewater treatment modelling	8	0	8	0	0	0	16	32	I. Nopens
5	Impacts on receiving environment	4	0	0	0	0	0	4	12	A.B.K. van Griensven, M.E. McClain
6	Site visit	1	0	0	0	3	0	4	6	B. Gersonius
<b>Total</b>		<b>35</b>	<b>18</b>	<b>16</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>54</b>	<b>142</b>	



**Education Material**

Lecture notes

Lecture notes (provided by each lecturer) Workshop material (including the case study date)  
Additional material provided on the module web site.

**Scientific Software**

Aposs

ArcGIS

Epanet

Mike Flood

Mike Urban

West

# M3048

## Water Sensitive Cities

<b>Term</b>	201718T10
<b>Coordinator</b>	P.D.A. Pathirana
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All participants and external professionals dealing with urban water and flood risk management working for municipalities, water management organisation, consulting firms, educational institutions and NGOs.

### Prerequisites

BSc degree in Engineering or Social Sciences background; basic knowledge of urban water and flood risk management; good command of English.

### Learning Objectives

- 1 Describe the historical transition of cities from the viewpoint of water management. List salient features of that transition (both positive and negative). (ILO1:History)
- 2 Argue that the three main components of the urban water cycle (UWC) management are interdependent. Describe the interactions with other important aspects of UWC like groundwater, urban atmosphere, etc., and how they affect each. (ILO2:Integration)
- 3 Identify interactions between water system components, while following 'thematic' topics (e.g. urban hydrology, water transport and distribution). Describe how to exploit such interactions to enhance livability, sustainability and resilience of cities.
- 4 Argue that considering multiple aspects of the water systems could provide opportunities to add extra value and create substantial additional benefits related to water management projects. Estimate such benefits using toolkits. (ILO4:MultipleValues)
- 5 Illustrate the importance of 'mainstreaming' water sensitive elements to general urban development process. Describe concrete examples (real-world and hypothetical) of such mainstreaming. (ILO5: Mainstreaming)
- 6 Analyse the stakeholder involvement in the management of water in city. Argue that for effective embedding of water-sensitive features to urban development, stakeholders should also include traditionally 'non-water' domains. (ILO6:Stakeholders)
- 7 Reflect on the relationship of WSC principals and practice to existing cities and their sub-components (e.g. neighbourhoods). Propose (conceptual) next steps in moving towards a more water-sensitive state for a given concrete case-study. (ILO7:Vision)

### Assessments

%	Type	Name
50	Assignment	Case study reflection reports
25	Oral examination	
25	Presentation	

## **Topics**

### **T1 Introduction to water sensitive cities**

This module's structure is quite different from the 'traditional model' of teaching modules here at IHE. The Learning objectives are realized via a series of 'Case Studies' (between 10 and 14) each taking a half a day or full day. Each case study has a hands-on, workshop type part as well.

This section which precedes those case studies describe:

1. What is a water sensitive city? Why it is important? How cities can strive to arrive at more water sensitive states?
2. The components of the urban water cycle (Water supply, Surface/storm water system, Wastewater system + groundwater), each as a brief introduction and how they interact with each other and the broader urban processes that are outside the domain of water.

### **T2 Case studies (change every year)**

List of case studies. Each case study has

1. Lecture/discussion part
2. Workshop - hands-on part.

Since the number and content of the case studies change every year this section represents the 'collection' of the case studies.

### **T3 Field trip**

In most years, the module has a one day field trip.

### **T4 Final presentations**

Here students present their own impressions about the concept of WSC, its implementation, challenges, suitability, etc. They do peer-assessment.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
T1	Introduction to water sensitive cities	8	0	0	0	0	0	8	24	P.D.A. Pathirana
T2	Case studies (change every year)	28	12	28	0	0	0	56	124	
T3	Field trip	0	0	0	0	8	0	8	8	P.D.A. Pathirana, W. Veerbeek
T4	Final presentations	0	0	4	0	0	0	4	4	M. Radhakrishnan, P.D.A. Pathirana
<b>Total</b>		<b>36</b>	<b>12</b>	<b>32</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>76</b>	<b>160</b>	

## Education Material

Lecture notes

Every year a set of scientific papers, reports and book chapters will be provided in addition to the slides used in the class.

## Scientific Software

# M3250

## Advanced Water Transport and Distribution

<b>Term</b>	201718T11
<b>Coordinator</b>	N. Trifunovic
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Engineers and scientists with keen interest in modern methods, technologies and tools used in design, operation and maintenance of water transport & distribution networks.

### Prerequisites

BSc degree in Civil Engineering or similar; a few years of relevant experience; knowledge of steady-state hydraulics of pressurised flows; basic use of network models; good English command. Students without any WTD experience should first complete the module Water Transport and Distribution.

### Learning Objectives

- 1 distinguish between various sources of water quality problems in distribution networks; understand the basic mechanisms and suggest the list of preventive and reactive measures;
- 2 understand the theory of advanced hydraulic and water quality modelling; apply state-of-the-art network software for assessment of irregular operational scenarios and develop a reliability-based and cost effective design using computer model.
- 3 recognise the GIS and remote sensing technologies, and familiarise with the GIS-based techniques for sustainable planning and management of WTD systems;
- 4 understand the theory of transient flows, and plan the measures to prevent/control water hammer;
- 5 select modern tools for monitoring of operation, and planning of maintenance of WTD systems.

### Assessments

%	Type	Name
12	Assignment	GIS assignment on the exercise using ArcGIS
60	Written examination (closed book)	Multiple choice test covering theoretical aspects of (1) advanced water distribution modelling, (2) water quality in distribution networks and (3) water hammer (20% each)
28	Assignment	Report on four short assignments regarding advanced water distribution modelling done in WaterGEMS software: (1) Network design using GA optimiser, (2) Network criticality analysis, (3) Water quality analysis,

## Topics

### 1 Water Quality in Distribution Networks

Corrosion of pipe materials, indices of measure, corrosion assessment, prevention and control, optimal water composition, principles of water quality modelling of distribution networks, modelling of chlorine residuals.

### 2 Advanced Water Distribution Modelling

Principles of genetic algorithm; pressure-driven demand calculations; network calibration; failure analysis and calculation of demand losses; economic aspects of capital investments and network operation.

### 3 GIS in Water Distribution

The aim of this course is to provide both a solid theoretical understanding and a comprehensive practical introduction of how to use geographic information systems and remote sensing technologies for the analysis and solution of water distribution related problems. The course focuses on the analysis of digital spatial data, preparation for numerical modelling, presentation of modelling results and support to the decision making process. The topics covered in the course include the following: introduction to geographic information systems and remote sensing technologies, active and passive remote sensing, data structures, map projections and coordinate systems, processing of digital geographic information, creation of digital elevation models, visualisation, mapping of water related features, delineation of pressure zone areas, digitisation, soil and land use mapping, map algebra, export of GIS layers into a modelling package, incorporation of modelling results in GIS.

### 4 Introduction to Water Hammer

Basic equations and applications; computer modelling: model building, simulations of simple cases (full pump trip, emergency shut down; protection devices: practical methods of surge suppression, direct action, diversionary tactics, choice of protection strategy.

### 5 Advanced O&M Practices in Water Distribution

Monitoring of network condition and operation; data collection and management; organisation of maintenance, emergency water supply, asset management plans, water company organisation.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Water Quality in Distribution Networks	6	0	0	0	0	4	10	30	D. Ferras, N. Trifunovic, S. Velickov
2	Advanced Water Distribution Modelling	9	0	10	0	0	8	27	61	D. Ferras, N. Trifunovic, S. Velickov, Z. Kapelan
3	GIS in Water Distribution	0	0	8	0	0	0	8	8	A. Sanchez Torres
4	Introduction to Water Hammer	4	0	4	0	0	4	12	28	D. Ferras, S. Velickov
5	Advanced O&M Practices in Water Distribution	0	0	4	0	8	0	12	12	C.G. van der Drift, D. Ferras, N. Trifunovic
<b>Total</b>		<b>19</b>	<b>0</b>	<b>26</b>	<b>0</b>	<b>8</b>	<b>16</b>	<b>69</b>	<b>139</b>	

## Education Material

**Scientific Software**

ArcGIS

WaterGEMS

# M2810

## Decentralised Water Supply and Sanitation

<b>Term</b>	201718T11
<b>Coordinator</b>	S.K. Sharma
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Mid-career professionals, involved in planning and management aspects of decentralised, small-scale or low-cost water supply or sanitation systems, working for municipalities, universities, research institutes, government ministries, water supply agencies, NGOs and consultancies

### Prerequisites

MSc. programme entry requirements

### Learning Objectives

- 1 know different technologies/methods for small-scale water abstraction and water treatment that can be used at household or small community level
- 2 understand the basics of sustainable sanitation technologies including nutrient reuse in agriculture, solid waste management and fecal sludge management and their implementation in small towns, peri-urban and urban poor areas of developing countries
- 3 prepare concept design for small-scale water supply treatment and ecosan technology
- 4 facilitate planning, financing, implementation and operation and maintenance of decentralised water supply and sanitation infrastructures based on stakeholder participation and community management

### Assessments

%	Type	Name
30	Assignment	
10	Presentation	
60	Written examination (closed book)	

### Topics

#### 1 Introduction

Introduction to the module; Water Supply and Sanitation situations in small towns, peri-urban areas and urban poor areas. Rationale for decentralised water supply system

1.1 Module introduction

1.2 Introduction to decentralised water supply and sanitation



## Topics

### **2 Decentralised Water Supply and Treatment Systems**

Water Supply Systems (water sources, source selection, service levels, suitability of types of water supply systems under different conditions); Rainwater Harvesting (introduction, collection systems, advantages and limitations, design considerations). Small-scale Water Treatment Methods (design water treatment systems for small community or household. Roughing filtration, slow sand filters, small-scale disinfection)

2.1 Water supply systems

2.2 Rain water harvesting

2.3 Small-scale water treatment

### **3 Decentralised Sanitation Systems**

Ecological sanitation (introduction to ecosan approach; characteristics of urine, faeces and greywater; overview of technologies for ecosan; treatment aspects for urine, faeces and greywater; conventional on-site sanitation; storage and transport logistics; introduction to anaerobic treatment, composting and constructed wetlands; safe reuse of ecosan products in agriculture with WHO guidelines; financial institutional, social and policy aspects of ecosan). Faecal Sludge Management (treatment goals and standards, treatment options, faecal sludge management (planning, financial, economic, agronomic, institutional and legal aspects), transmission of excreta-related infections and risk management). Solid waste management in developing countries (technical and practical aspects of collection, transport, segregation, disposal and reuse)

3.1 Ecological sanitation

3.2 Solid waste management in small towns and urban poor areas

3.3 Sanitation planning and strategic tools

3.4 Fecal sludge management

### **4 Management Aspects of DWSS**

Participatory planning and evaluation of DWSS systems, demand responsive approach; Institutional arrangements (community based management; small-scale independent providers), Financial and Operational aspects (financing, cost recovery, operation and maintenance of DWSS systems)

4.1 Participatory planning and evaluation

4.2 Institutional arrangements

4.3 Financing and cost recovery aspects

4.4 Operation and maintenance aspects

### **5 Presentation of the Participants**

All participants make a presentation of 10 minutes in the field of decentralised water supply and sanitation in order to share experiences or problems they are facing now and learn from each others experience.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Introduction	0	0	0	0	0	0	0	0	S.K. Sharma
1.1	Module introduction	0	0	1	0	0	0	1	1	
1.2	Introduction to decentralised water supply and sanitation	2	0	0	0	0	0	2	6	
2	Decentralised Water Supply and Treatment Systems	0	0	0	0	0	0	0	0	S.K. Sharma
2.1	Water supply systems	3	0	0	0	0	0	3	9	
2.2	Rain water harvesting	2	0	2	0	0	0	4	8	
2.3	Small-scale water treatment	6	6	0	0	0	0	6	24	
3	Decentralised Sanitation Systems	0	0	0	0	0	0	0	0	
3.1	Ecological sanitation	6	0	2	0	4	0	12	24	M. Ronteltap
3.2	Solid waste management in small towns and urban poor areas	4	0	0	0	0	0	4	12	M.A. Siebel
3.3	Sanitation planning and strategic tools	2	0	2	0	0	0	4	8	
3.4	Fecal sludge management	2	0	4	0	0	0	6	10	M. Ronteltap
4	Management Aspects of DWSS	0	0	0	0	0	0	0	0	
4.1	Participatory planning and evaluation	2	2	0	0	0	0	2	8	M. Mulenga
4.2	Institutional arrangements	2	0	2	0	0	0	4	8	K.H. Schwartz
4.3	Financing and cost recovery aspects	2	0	2	0	0	0	4	8	
4.4	Operation and maintenance aspects	2	0	2	0	0	0	4	8	S.K. Sharma
5	Presentation of the Participants	0	0	6	0	0	0	6	6	S.K. Sharma
<b>Total</b>		<b>35</b>	<b>8</b>	<b>23</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>62</b>	<b>140</b>	

## Education Material

- Handout                      Schwartz, K. (2015) Institutional Arrangements (Handouts)
- Handout                      Siebel, M (2015) Solid Waste Management in Urban Poor Areas (Handouts)

## Scientific Software

# M3217

## Faecal Sludge Management

<b>Term</b>	201718T11
<b>Coordinator</b>	S. Singh
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

This course is a specialist course fitting within Sanitary Engineering. It is designed for sanitary, civil / wastewater and environmental engineers who are facing challenges with faecal sludge. As on-site sanitation is by far the most applied sanitation technology, faecal sludge management is of paramount importance globally.

### Prerequisites

Preceding modules in Sanitary Engineering; an interest in and working knowledge of the business of faecal sludge management help to bring this module to a good end.

### Learning Objectives

- 1 Describe the way how excreta and faecal sludge are characterised.
- 2 Know which technologies can be applied for which type of faecal sludge (settling tanks, planted and unplanted drying beds, etc)
- 3 Name the key stakeholders in FSM.
- 5 Name the challenges in emergency sanitation and know how emergency sanitation can be addressed.
- 6 Be familiar with the latest developments in sustainable (on-site) sanitation solutions that can be applied in high density low income areas.

### Assessments

%	Type	Name
100	Written examination (closed book)	

### Topics

#### 1 Faecal sludge management

Faecal sludge management (FSM) is incredibly important in sanitation. While the focus has been on the provision of toilets mainly in the light of the MDGs, the adequate collection and treatment of the remaining faecal sludge was not always a priority, to say the least. As so many factors play a role in faecal sludge management / climate, hardware, a vast number of stakeholders, willingness to pay, space to store and treat, groundwater pollution, different toilet types / a proper and well-functioning faecal sludge management system is hard to achieve. In this module we will address a holistic approach on FSM. There will be a focus on technology; however, technology cannot be seen separately from planning and management aspects; therefore, non-technical aspects will also be addressed in this module.

## Topics

- 2 Quantification and characterisation
- 3 Collection, Transport, Onsite Sanitation systems
- 4 Treatment Mechanisms
- 5 FS co-treatment with wastewater
- 6 Emergency Sanitation
- 7 Sanitation Planning
- 8 Financial Aspects
- 9 Operation, Maintenance and Monitoring
- 10 Resource Recovery

## Study load

Nr	Topic	Study load								Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Faecal sludge management	0	0	0	0	0	0	0	0	
2	Quantification and characterisation	2	0	0	0	0	0	2	6	M. Ronteltap
3	Collection, Transport, Onsite Sanitation systems	6	0	2	0	0	0	8	20	D.M. Robbins
4	Treatment Mechanisms	4	0	0	0	0	0	4	12	M. Ronteltap
5	FS co-treatment with wastewater	2	0	0	0	0	0	2	6	C.M. Lopez Vazquez
6	Emergency Sanitation	4	0	2	0	0	0	6	14	C.M. Hooijmans
7	Sanitation Planning	4	0	4	0	0	0	8	16	C.E. Luethi
8	Financial Aspects	6	0	0	0	0	0	6	18	V.C.K.A.M. Post
9	Operation, Maintenance and Monitoring	4	0	0	0	0	0	4	12	M. Mulenga
10	Resource Recovery	3	0	3	0	0	0	6	12	C. Furlong
<b>Total</b>		<b>35</b>	<b>0</b>	<b>11</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>46</b>	<b>116</b>	

## Education Material

- Book Faecal Sludge Management Book (IWA; Editors Linda Strande, Mariska Ronteltap, Damir Brdjanovic)
- Handout Handouts.

## Scientific Software

- SWMM
- sobek-RUR

# M3251

## Flood Protection in Lowland Areas

<b>Term</b>	201718T11
<b>Coordinator</b>	J.A. Roelvink
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

### Prerequisites

Basic knowledge of hydraulics, basic knowledge of soil mechanics

### Learning Objectives

- 1 carry out a basic design of dikes, revetments and closure dams
- 2 understand concepts and advances of flood risk management with due consideration of societal aspects, including flooding issues in the floodplain and coastal zone, management of flood risk, planning aspects and a variety of non-structural measures
- 3 understand and apply concepts and advances in tools used for coastal flood modelling and flood forecasting
- 4 understand and apply the principles of flood frequency analysis and risk based approaches to design of hydraulic works
- 5 understand (the practical application of) probabilistic design theory

### Assessments

%	Type	Name
0,4	Written examination (closed book)	Dikes and Revetments
0,2	Written examination (closed book)	Probabilistic Design
0,4	Assignment	Storm Impact Modelling

### Topics

#### 1 Dikes and Revetments

Seadikes in The Netherlands, philosophy of dike design, definition of frequency of failure, risk analysis, design methodology for dikes, hydraulic boundary conditions, wave run-up and overtopping, geometrical design of dikes and revetments, stability for rock, artificial units, design criteria for placed block revetment, other types (bituminous, asphalt.. etc), other design considerations, geotechnical aspects related to dikes, overall stability, design of granular filter, geotextiles, geosystems, improvement and maintenance of dikes and revetments, design of bottom protection, design methodology for closures; sand closures, stone closures, caisson closures.

#### 2 Dikes and Revetments

## Topics

### 3 Probabilistic design

Theoretical background of probability functions, practical application of probabilistic design, various levels of probability, examples of application of probabilistic design, the use of fault trees, exercise in the application of probabilistic design in coastal engineering problems.

### 4 Storm Impact modelling

This course focuses on prediction of flooding from the sea, due to tsunamis and storms. Subjects that are treated are causes, models, effects and warning systems related to tsunamis; storm types and characteristics in different areas in the world; storm surge and extreme wave modeling; storm erosion, overtopping and inundation modeling; predictive modeling vs. (probabilistic) modeling for design purposes. Case studies based on Katrina, Ivan, Sidr and the Indian Ocean tsunami. Hands-on exercises using Delft3D and XBeach.

### 5 Storm Impact modelling

## Study load

Nr	Topic								Lecturers	
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours		SUM: workload hours
1	Dikes and Revetments	8	0	4	0	0	0	12	28	C. Dorst
2	Dikes and Revetments	12	0	0	0	0	0	12	36	J.H. van Dalen
3	Probabilistic design	6	0	6	0	0	0	12	24	M. Kok
4	Storm Impact modelling	6	0	5	0	0	0	11	23	J.A. Roelvink
5	Storm Impact modelling	8	0	5	0	0	0	13	29	M. van Ormondt
<b>Total</b>		<b>40</b>	<b>0</b>	<b>20</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>140</b>	

## Education Material

Handout	Groot, M.: Handouts, Geotechnical Aspects for Dikes, 2003
Handout	Handout: collection of tutorials and papers related to OpenEarth, Delft3D and XBeach applications
Handout	Hassan, R.M.: handouts, Dikes and Revetments, 2002
Lecture notes	Verhagen, H.J. : Design of closure of dams- Lecture notes In0052/02
Lecture notes	Verhagen, H.J.: Revetments, Sea Dikes and River Levees-Lecture notes hh292/99/1
Lecture notes	Vrijling, J.K.: Probabilistic Design, Lecture notes In0217/04/

## Scientific Software

Delft3D  
 Matlab  
 Xbeach

# M3233

## Hydroinformatics for Decision Support

<b>Term</b>	201718T11
<b>Coordinator</b>	A. Jonoski
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Participants from all Master Programmes of IHE Delft.

### Prerequisites

Hydrological and hydraulic modelling concepts; Basic programming skills

### Learning Objectives

- 1 Identify the role of system analysis in water resources planning and management
- 2 Formulate and solve water resources problems as optimisation problems
- 3 Distinguish and properly use different types of decision support methods for water problems
- 4 Build simple software applications that integrate data and models across Internet
- 5 Discuss challenges in integrating weather prediction and water models

### Assessments

%	Type	Name
0,3	Assignment	Exercise report on Decision support systems
0,3	Assignment	Exercise report on Software technologies for integration
0,4	Assignment	Exercise report on Systems analysis in water resources

### Topics

#### 1 Systems analysis in water resources

Definition and role of systems analysis in engineering planning. Basic concepts. Linear and Dynamic programming for water resources problems. Development and use of static and dynamic stochastic simulation models of river systems. Introduction to decision support systems and their use. Exercises in multipurpose integrated river basin (or regional) water resources management modelling.

#### 2 Decision support systems

Introduction to decision making process; objectives and alternatives. Optimisation in decision support (single and multi-objective). Multi-attribute decision methods and tools: formulation of decision matrix, generating and using weights, compensatory and non-compensatory decision methods. Introduction to mDSS4 decision support software; exercises and assignments with case studies implemented in mDSS4.

## Topics

### 3 Software technologies for integration

Introduction to methods and tools for software integration of models and data: Object-oriented integration approaches. Software integration across networks: Client-server programming, Web protocols, Web services. Technologies for integrating distributed resources: web-interfaces technologies; creating web-based and mobile phone applications with assignment exercise.

### 4 Integration of weather prediction and water models

Approaches and methods for integration of weather prediction with hydrological models. Challenges of temporal resolution, spatial scale, and accounting for uncertainty. Exercise in ensemble hydro-meteorological forecasts.

## Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Systems analysis in water resources	12	0	4	4	0	0	20	48	D.P. Loucks
2	Decision support systems	6	0	4	4	0	0	14	30	A. Jonoski, I.I. Popescu
3	Software technologies for integration	4	0	10	10	0	0	24	42	A. Jonoski, G.E. Espinoza Davalos, J.L. Alfonso Segura
4	Integration of weather prediction and water models	4	0	4	0	0	0	8	16	J.L. Alfonso Segura, S.J. van Andel
<b>Total</b>		<b>26</b>	<b>0</b>	<b>22</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>66</b>	<b>136</b>	

## Education Material

Digital files	A. Jonoski, L. Alfonso, G.E. Davalos, J. Craven: Handouts - Software technologies for Integration exercises
Digital files	A. Jonoski: Introduction to Decision Making and Decision Support Systems (PowerPoint Slides)
Digital files	A. Jonoski: Software Technologies for Integration (PowerPoint Slides)
Lecture notes	D.P. Loucks: Lecture Notes on Water Resource Systems Modelling: Its Role in Planning and Management (chapters 2, 3, 4, 10 and 11)
Handout	I. Popescu: Handout DSS exercises with mDSS4
Digital files	S.J van Andel: Integration of weather prediction and water models (PowerPoint Slides)
Digital files	Software for the subject Software technologies for integration: PMWin, Notepad++ text editor, Apache web server with PHP, Openlayers API, Phonegap



## **Scientific Software**

Lingo

mDSS

# M3207

## IWRM as a Tool for Adaptation to Climate Change

<b>Term</b>	201718T11
<b>Coordinator</b>	E.D. de Ruijter van Steveninck
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Students and professionals with an interest in the impacts of climate change on water sectors and how to adapt to uncertain future conditions.

### Prerequisites

BSc or MSc in natural sciences, chemistry, environmental science, agriculture, geography, environmental economics, planning and management or engineering. Good conversational, reading and writing capabilities in the English language. Computer literacy. Professional experience in a relevant area is desirable.

### Learning Objectives

- 1 describe the expected impacts of climate change on water resources and water use sectors in relation to (other) human activities
- 2 identify the consequences of the predicted impacts of climate change and climate variability for integrated water resources management
- 3 integrate climatic change conditions at different time and spatial scales into (risk) management in the water sector
- 4 justify decisions on adaption to the impacts of climate change under uncertainty

### Assessments

%	Type	Name
70	Written examination (closed book)	Adaptation to climate change
0	Assignment	Data search
0	Attendance	Fieldtrip
30	Presentation	Water allocation in Climateland-Group presentation

## Topics

### 1 **IWRM, climate change and the hydrological cycle**

Introduction into the concept of IWRM. The climate system and the causes of climate change and variability. Impacts of climate change on the hydrological cycle. Integrating IWRM and climate change.

### 2 **Climate change: impacts and adaptation**

Impacts of climate change on the environment and on water use sectors. Adaptation measures and economic aspects.

### 3 **Vulnerability and adaptation under uncertainty**

What determines vulnerability to climate change. Adaptation strategies how to adapt under a high level of uncertainty.

### 4 **Institutional aspects and stakeholder participation**

The importance of involving stakeholders in water management and climate change adaptation and strategies on involving stakeholders.

### 5 **Multi sector/multicriteria decision making**

Modelling effects of climate change on water resources using Climateland as a case study.

### 6 **Country presentations**

Presentations by participants covering impacts of climate change and adaptation measures in their countries/ regions.

### 7 **Field trip**

Field trip to Dordrecht and the Biesbosch. Adaptation to climate change in an urban setting and in a polder area.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	IWRM, climate change and the hydrological cycle	6	0	3	0	0	0	9	21	E.D. de Ruijter van Steveninck, R. van Dorland, S. Maskey
2	Climate change: impacts and adaptation	17	0	7	0	0	0	24	58	C.M.S. de Fraiture, E.D. de Ruijter van Steveninck, F. van der Meulen, I.I. Popescu P.D.A. Pathirana, T.Y. Stigter, Y. Jiang
3	Vulnerability and adaptation under uncertainty	4	0	2	0	0	0	6	14	A.H.M. Bresser, E.D. de Ruijter van Steveninck
4	Institutional aspects and stakeholder participation	0	0	6	0	0	0	6	6	J.S. Kemerink - Seyoum
5	Multi sector/multicriteria decision making	0	0	28	0	0	0	28	28	J.W. Wenninger, R.G.W. Venneker
6	Country presentations	1	0	4	0	0	0	5	7	E.D. de Ruijter van Steveninck
7	Field trip	0	0	0	0	6	0	6	6	B. Gersonius, M.F. van Staveren
<b>Total</b>		<b>28</b>	<b>0</b>	<b>50</b>	<b>0</b>	<b>6</b>	<b>0</b>	<b>84</b>	<b>140</b>	

## Education Material

Digital files	Background reading
Handout	Climateland
Digital files	Copies of power point presentations

## Scientific Software

WEAP



**Education Material**

**Scientific Software**

# M3277

## Modelling River Systems and Lakes

<b>Term</b>	201718T11
<b>Coordinator</b>	A. Cattapan
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All participants in the WSE programme

### Prerequisites

Hydrology and Hydraulics & Basic mathematics

### Learning Objectives

- 1 Familiarize participants with structure of equations used to represent water phenomenas, numerical solution techniques and their representation in modelling systems and practical use of these.
- 2 Provide participants practical experience with standard models and develop an understanding of modelling in river and lake systems
- 3 Understanding rainfall run-off processes that will contribute to river flow and applying them to determine flow hydrographs as upstream conditions to a river
- 4 Develop critical assessment in assessing quality of model calibration and validation, verification and uncertainty

### Assessments

%	Type	Name
0,2	Assignment	Assignment on hydrological modelling. (20% of the final mark)
0,2	Assignment	Assignment on modelling lakes. (20% of the final mark)
0,2	Assignment	Assignment on modelling rivers. (20% of the final mark)
0,4	Written examination (closed book)	Written exam on Computational Hydraulics. (40% of the final mark)

## Topics

### 1 Computational Hydraulics

The course aims to introduce numerical aspects of modelling, so that students become aware of the limitations and characteristics of hydrodynamic numerical models. The course starts with a short overview of the differential equations used in hydraulics, principles of discretisation of shallow water equations in 1D and 2D. Further the concept of Courant number, stability and accuracy, will be introduced for both implicit and explicit schemes. Emphasis will be on river and lake applications and short wave propagation.

### 2 Modelling lakes

The objective of this component is for the students to acquire the ability to apply a numerical 3D hydrodynamic model to simulate water flow in lakes.

The software used in this part is MOHID.

"**MOHID** is a three-dimensional water modelling system, developed by [MARETEC](#) (Marine and Environmental Technology Research Center) at [Instituto Superior Técnico \(IST\)](#) which belongs to the [Universidade de Lisboa](#) in Portugal. **MOHID** has been applied to different study cases, as coastal and estuarine areas, as well as oceanic processes and reservoirs, and it has showed its ability to simulate complex features of the flows." [[www.mohid.com](http://www.mohid.com)]

### 3 Hydrological modelling

Students will gain practical experience in working with a hydrological model (HEC HMS) which simulates processes at basin scale and will allow them to integrate the outputs of their simulations with the software they are going to use for modelling rivers (HEC RAS), so to provide them with a complete modelling framework to solve practical problems they might encounter in their professional life.

"The Hydrologic Modeling System (HEC-HMS) is designed to simulate the complete hydrologic processes of dendritic watershed systems. The software includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing. HEC-HMS also includes procedures necessary for continuous simulation including evapo-transpiration, snowmelt, and soil moisture accounting." [<http://www.hec.usace.army.mil/software/hec-hms/>]



## Topics

### 4 Modelling rivers

Students will gain practical experience in working with an hydrodynamic model (HEC RAS). Students will learn how to set up a model using georeferenced data for the definition of the geometry of the system (HEC GeoRAS) and how to model the presence of different types of structures (bridges, in-line and lateral structures, culverts, gates etc.). Depending on time availability they will also learn how to simulate the propagation of floods on floodplains using a combined 1D/2D approach. An introduction to model calibration and validation will also be provided.

"The HEC-RAS system contains several river analysis components for: (1) steady flow water surface profile computations; (2) one- and two-dimensional unsteady flow simulation; (3) movable boundary sediment transport computations; and (4) water quality analysis. A key element is, that all four components use a common geometric data representation and common geometric and hydraulic computation routines. In addition to these river analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed." [<http://www.hec.usace.army.mil/software/hec-ras/features.aspx>]

### Study load

Nr	Topic									Lecturers
		Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	
1	Computational Hydraulics	14	0	0	2	0	0	16	46	I.I. Popescu
2	Modelling lakes	2	0	0	16	0	0	18	38	F.A. Bastos da Cruz Martins
3	Hydrological modelling	2	0	0	10	0	0	12	26	B. Bhattacharya
4	Modelling rivers	0	0	0	16	0	0	16	32	A. Cattapan, I.I. Popescu
<b>Total</b>		<b>18</b>	<b>0</b>	<b>0</b>	<b>44</b>	<b>0</b>	<b>0</b>	<b>62</b>	<b>142</b>	

### Education Material

Handout	Handouts
Book	MOHID - Hydrodynamics user manual, 2009
Lecture notes	Martins, F., 2011: Modelling river and lakes using MOHID. UNESCO-IHE. Lecture notes
Lecture notes	Popescu, I., 2004: Differential Equations and Numerical Methods. UNESCO-IHE Lecture notes.

### Scientific Software

ArcGIS  
 HEC-HMS  
 HEC-RAS  
 Mohid

# M3237

## Remote Sensing for Agricultural Water Management

<b>Term</b>	201718T11
<b>Coordinator</b>	P. Karimi
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All WSE participants and from other programmes with specific interest.

### Prerequisites

General knowledge about remote sensing and GIS.

### Learning Objectives

- 1 The students will be able to explain RS theory, technology, typical applications, and be able to identify and download relevant RS data and products
- 2 The students will be able to pre-process, extract and analyse common indices, design and collect groundtruth points, and conduct land cover classification
- 3 The students will be able to extract biophysical, infrastructure and management features of agricultural system
- 4 The students will be able to explain the theory and implement pySEBAL model to estimate ET, yield, and WP
- 5 The students will be able to assess the irrigation performance using remote sensing, Interpret them to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements
- 6 The students will be able to produce water accounts for an irrigation system using remote sensing information

### Assessments

%	Type	Name
0,6	Assignment	Irrigation and remote sensing
0,4	Written examination (open book)	RS theory and applications

### Topics

#### 1 Introduction to Remote sensing

The subject will cover basics of RS, common data portals, satellites, and RS products.

## Topics

### **2 Remote Sensing data analysis, groundtruthing, and land cover classification**

Overview of RS data processing flow, common indices, and classification theory; Ground Truthing methods; Hands-on exercises (1) GT collection, (2) Landsat data pre-processing, extracting common indices, categorize them, and (3) Land cover classification and accuracy assessment

### **3 Mapping agricultural systems**

Extracting biophysical, infrastructure and management features of an agricultural system

### **4 Remote sensing for Evapotranspiration, yield and WP assessment (SEBAL)**

Theory and implementation of pySEBAL model to estimate ET, yield, and WP

### **5 Remote sensing for enhancing performance of irrigation systems**

Assessment of the irrigation performance using remote sensing, Interpret WP and other performance indicators results to identify gaps, diagnose water management problems, and attribute to relevant factors for improvements

### **6 Remote Sensing for Irrigation water Accounting**

Producing water accounts for an irrigation system using remote sensing information

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to Remote sensing	6	0	2	0	0	0	8	20	P. Karimi, S. Pareeth, T.M. Hessels
2	Remote Sensing data analysis, groundtruthing, and land cover classification	6	0	4	0	0	0	10	22	S. Pareeth, X Cai
3	Mapping agricultural systems	4	0	2	0	0	0	6	14	X Cai
4	Remote sensing for Evapotranspiration, yield and WP assessment (SEBAL)	6	0	8	0	0	0	14	26	J.D. van Opstal, M.L. Blatchford, S. Pareeth
5	Remote sensing for enhancing performance of irrigation systems	10	0	6	0	0	0	16	36	
6	Remote Sensing for Irrigation water Accounting	6	0	4	0	0	0	10	22	P. Karimi
<b>Total</b>		<b>38</b>	<b>0</b>	<b>26</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>64</b>	<b>140</b>	

## Education Material

Scientific journal	A remote sensing surface energy balance algorithm for land (SEBAL). 1. Formulation
Scientific journal	Diagnosing irrigation performance and water productivity through satellite remote sensing and secondary data in a large irrigation system of Pakistan
Scientific journal	Irrigation performance indicators based on remotely sensed data: a review of literature
Book	Tutorial: Fundamentals of Remote Sensing, <a href="http://www.nrcan.gc.ca/node/9309">http://www.nrcan.gc.ca/node/9309</a> (Open)
Book	Wegmann, M., B. Leutner, and S. Dech. Remote Sensing and GIS for Ecologists: Using Open Source Software. Data in the Wild. Pelagic Publishing, 2016

## Scientific Software

QGIS

# M3270

## Solid Waste Management

<b>Term</b>	201718T11
<b>Coordinator</b>	E.D. van Hullebusch
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Engineers, scientists, academicians, staff from Non-Government Organizations, Community-based Organizations, politicians, health officials, students, teachers, local, regional or national government officials, etc., involved or interested in the management of solid waste.

### Prerequisites

1. involvement in or more than average interested in one or more of the key elements of solid waste management, or
2. having studied the topic in a formal educational setting, or
3. being involved in teaching and/or research related to waste management.

### Learning Objectives

- 1 suggest options for waste reduction at source so as to reduce quantities of waste generated;
- 2 choose from an array of options to turn waste into economic goods;
- 3 suggest treatment/disposal methods for waste from which the value has been taken out and to make basic calculations related to the conceptual design thereof;
- 4 assess the impact of waste and waste management on other environmental compartments;
- 5 roughly assess financial consequences of proposed management aspects in SWM;
- 6 conceptually develop a solid waste management scheme for an urban area.

### Assessments

%	Type	Name
60	Written examination (open book)	MOODLE multiple choice
40	Assignment	All assignments together

### Topics

#### 1 Introduction

what is solid waste? what are the key problems (social, financial, environmental)? who are involved?

## Topics

### 2 Waste collection & stakeholders

How/why is SW generated? how can generation be reduced? what are collection schemes & means, what means waste separation? at what point in the process? what are advantages? how can separation/reuse be stimulated?

### 3 Bioconversion processes

### 4 Composting & anaerobic digestion

### 5 Landfill processes

### 6 Landfill technology

What are main waste management technologies? in more or in less developed countries? design elements, application areas? GHG issues

### 7 Mechanical biological treatment

### 8 Incineration

### 9 Waste prevention & recycling

How much of our daily waste can be prevented or reduced? how would that impact upon the waste composition? What is the role of the waste generator, what is to be done to present 'clean' waste?

What are the options for collecting domestic waste? What systems exist?

What is the role of the public and private sector? What is the role of the informal sector? What are the benefits of waste recycling?

### 10 Finance & planning

### 11 Presentations

### 12 Assignments

### 13 Exam

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction	0	0	4	0	0	0	4	4	C.D.M. Dupont
2	Waste collection & stakeholders	1	0	9	0	0	0	10	12	
3	Bioconversion processes	0	0	6	0	0	0	6	6	
4	Composting & anaerobic digestion	1	0	9	0	4	0	14	16	
5	Landfill processes	0	0	6	0	0	0	6	6	
6	Landfill technology	1	0	7	0	4	0	12	14	
7	Mechanical biological treatment	1	0	5	0	0	0	6	8	
8	Incineration	1	0	7	0	0	0	8	10	
9	Waste prevention & recycling	1	0	5	0	2	0	8	10	
10	Finance & planning	0	0	12	0	0	0	12	12	
11	Presentations	0	0	4	0	0	0	4	4	
12	Assignments	0	24	0	0	0	0	0	24	
13	Exam	0	10	4	0	0	0	4	14	
<b>Total</b>		<b>6</b>	<b>34</b>	<b>78</b>	<b>0</b>	<b>10</b>	<b>0</b>	<b>94</b>	<b>140</b>	

## Education Material

Book	1) PPT's; reviewed paper; BOOK: Waste Technology and Management; BOOK: Vital waste statistics
Book	2) PPT's; reviewed paper; BOOK: From waste to resource; BOOK: Solid Waste Management in World Cities
Book	3) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video: Anaerobic degradation processes
Book	4) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video Bioreactor Landfill; UNEP SWM Landfill chapter
Book	5) PPT's; reviewed paper; BOOK: Waste Technology and Management
Book	6) PPT's; reviewed paper; BOOK: Waste Technology and Management

## Scientific Software

# M3211

## Strategic Planning for River Basins and Deltas

<b>Term</b>	201718T11
<b>Coordinator</b>	J.G. Evers
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Young and mid-career professionals (scientists, decision-makers) with a background in water management, environmental management, and / or watershed management.

### Prerequisites

Affinity with integrated river basin / delta planning and management, spatial planning, hydrology, development economics, agronomy or geography (preferably a relevant environmental or water management / science / engineering related bachelor's degree or equivalent) and preferably experience in river basin management. Good command of English.

### Learning Objectives

- 1 Understand strategic planning concepts and principles
- 2 Describe social-physical relations and interdependencies, in particular among water and environmental systems, and socio-economic development
- 3 Use of the concepts of adaptive and strategic planning and design for developing river basin management and development plans.
- 4 Use Strategic Environmental Assessment (SEA) as a planning tool for developing sustainable river basin management and development plans.

### Assessments

%	Type	Name
50	Assignment	Groupwork: Case study
50	Written examination (closed book)	Written exam (closed book)

### Topics

#### 1 Introduction

In this session the participants are introduced to the modules learning objectives, learning activities, and the assessment (case study group assignment and written exam)



## Topics

### **2 River basins as socio-physical systems**

Human-water systems, driving forces and development dynamics, interdependencies of land use and development and water and environmental systems, complexity, cross-cutting models and modelling approaches, meta modelling.

### **3 Strategic planning and design for river basins and deltas**

Strategic planning versus programming and project planning; tiering; issues of scale; spatial quality and design, land use planning; design methods from plan development to implementation; river basin/delta governance issues.

Strategic impact assessment, including environmental (SEA), economic and social impact assessment

### **4 Dealing with Uncertainties**

Examples of key social, economic and physical uncertainties in river basin systems Concepts and methods for uncertainty identification and assessment, for system and policy design, and governance. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, adaptive policy making and adaptation pathways. Uncertainties in strategic planning, concepts and methods for uncertainty identification and assessment, and for system and policy design. This includes, for example, exploratory analysis, scenario planning, resilience and robustness, and adaptive policy making.

### **5 Case study: groupwork assignment**

During the course, students will work in small groups on integrated application of the concepts, theories and methods introduced in this course on a case. A case will be presented to the students to work and develop a strategic plan for the area. Case options may include deltas and/or basins with different characteristics, such as heavy urbanisation; flooding problems; drought and water scarcity, subsidence, pollution and water quality, etc.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction	0	0	1	0	0	0	1	1	J.G. Evers, Y. Jiang
2	River basins as socio-physical systems	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
3	Strategic planning and design for river basins and deltas	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
4	Dealing with Uncertainties	8	0	4	0	0	0	12	28	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven
5	Case study: groupwork assignment	0	55	0	0	0	0	0	55	A. Mendoza - Sammet, B. Gersonius, C. Zevenbergen, J.G. Evers, W.A.H. Thissen, W.J.A.M. Douven, Y. Jiang
<b>Total</b>		<b>24</b>	<b>55</b>	<b>13</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>37</b>	<b>140</b>	

## Education Material

Scientific journal	Additional reading materials
Lecture notes	Lecture Notes
Digital files	Lecture powerpoint slides

## Scientific Software

# M3261

## Urban Water Governance

<b>Term</b>	201718T11
<b>Coordinator</b>	T. Acevedo Guerrero
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

The module is elective, and therefore open to all students within the WM stream, but it will build on key concepts introduced in the Water Governance core module. Students who have not taken this previous module will be expected to do additional reading to familiarize themselves with necessary terms and concepts. This module is run on the style of a seminar class. Students will be required to do the majority of work (reading, assignments) outside of class. Class time will then be used to discuss and debate what students have learned through self-study.

### Prerequisites

Mandatory: High level of ability to read and discuss academic articles and book chapters in English; willingness to engage in social science theory and new conceptual frameworks; willingness to engage in cross-disciplinary discussions and applications.

Students outside the WM stream might take the module, but they will need to consult (have a short discussion with the coordinator) I am happily open to students registering in it from virtually any discipline. The key thing is that you love southern cities in all their speed and complexity. As AbdouMaliq Simone (in his 2004 epic *For the City Yet to Come*, p. 1) puts it: "African cities are works in progress, at the same time exceedingly creative and extremely stalled. In city after city, one can witness an incessant throbbing produced by the intense proximity of hundreds of activities: cooking, reciting, selling, loading and unloading, fighting, praying, relaxing, pounding, and buying, all side by side on stages too cramped, too deteriorated, too clogged with waste, history, and disparate energy, and sweat to sustain all of them. And yet they persist".

### Learning Objectives

- 1 Identify the significance of the urban transformation for water governance
- 2 Analyze water access and quality in relation to social, economic, and demographic factors
- 3 Analyze water access and quality in relation to biophysical conditions and infrastructures
- 4 Identify/compare conceptual tools to understand urban water justice
- 5 Analyse urban water governance in the light of justice concerns

### Assessments

%	Type	Name
30	Assignment	Daily attendance, rich picture, reading circus & study case (10% x 4) 40%

30	Assignment	Final paper: Critical analysis of urban water policy 30%
40	Assignment	Group work, handout and presentation 30%

## Topics

### 1 Cities, citizenship, and growing inequality

Lecture: What is a city? How/why are cities becoming more unequal?

Rich picture: students organized in groups read news articles on each case study to develop a vision (poster, collage) on different types of urban segregations/inequalities. Then they present it.

Possible case studies Paris, France; Madrid, Spain; Winnipeg, Canada; Detroit, USA; Bogotá, Colombia; Mongolia; Luanda, Angola; Johannesburg, South Africa; Ahmedabad, India; Riyadh, Saudi Arabia

<https://www.theguardian.com/inequality/datablog/2017/apr/26/inequality-index-where-are-the-worlds-most-unequal-countries>

<https://www.theguardian.com/cities/2015/oct/28/which-is-the-worlds-most-segregated-city>

Introduction to the module: learning objectives, rules of the game, assessments, schedule.

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Williams, B. 2001. A River Runs Through Us. *American Anthropologist*, Vol. 103, No. 2 (Jun., 2001), pp. 409-431

## Topics

### 2 Relating urban waters, justice, and governance

Memories of last session

Reflexion: Urban water governance, why urban water governance instead of only water governance?

Lecture: Defining, researching, and struggling for water justice

Margreet Zwarteveen

-

Zwarteveen, M. & R. Boelens (2014) Defining, researching, and struggling for water justice: some conceptual building blocks for research and action, *Water International*, 39(2), 143-158

Reading circus:

– At home: groups of 4 students read 1 article together and must be able to explain this to others (by preparing a hand out)

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Wutich, A 2009, 'Intrahousehold disparities in women and men's experiences of water insecurity and emotional distress in urban Bolivia', *Medical Anthropology Quarterly*, vol. 23, no. 4, pp. 436-454.

Truelove, Y. (2011) (Re-)Conceptualizing water inequality in Delhi, India through a feminist political ecology framework. *Geoforum*, 42(2): 143-152.

Sultana, F 2011, 'Suffering for water, suffering from water: emotional geographies of resource access, control and conflict', *Geoforum*, vol. 42, no. 2, pp.163-172.

## Topics

### 3 Questions of gender in urban water

Memories of last session

Lecture – Questions of gender in water storage: the case of zika in Latin America and the Caribbean

Reading circus:

– In class: groups are split into 4 teaching groups (each teaching group having one representative of the expert groups): each member explains the particular reading to the others

Presenting a study case:

– At home: 3 groups of students explore 1 study case together and must be able to explain this to others (by preparing a short presentation)

*Study Case: Flint, USA*

Ranganathan, M 2016, 'Thinking with Flint: Racial liberalism and the roots of an American water tragedy', *Capitalism Nature Socialism*, vol. 27, no. 3, pp. 17-33.

Lin, J, J. Rutter & H. Park, 2016, 'Events that Led to Flint's Water Crisis' *The New York Times*, [http://www.nytimes.com/interactive/2016/01/21/us/flint-lead-water-timeline.html?\\_r=0](http://www.nytimes.com/interactive/2016/01/21/us/flint-lead-water-timeline.html?_r=0) (last visited Mar 15, 2016).

*Case Study: Accra, Ghana*

Mahama, AM, Anaman KA & Osei-Akoto I 2014, 'Factors influencing householders' access to improved water in low income areas in Accra, Ghana', *Water and Health*, vol. 12, no. 2, pp. 318 - 331.

*Case Study: Khayelitsha, South Africa*

Rodina, L & L. M. Harris (2016). Water Services, Lived Citizenship, and Notions of the State in Marginalised Urban Spaces: The case of Khayelitsha, South Africa. *Water Alternatives* 9(2): 336-355.

## Topics

### **4 Income, race, and other intersectional factors reflected in/reinforced through urban water flows**

Memories of last session

Lecture: Income, race and other intersectional factors

Presenting a study case:

– In class: Presentations

### **5 Biophysical conditions and other material considerations**

Memories of last session

Lecture: Flooding, droughts, climate change, and other material considerations

Lecture: The case of post-colonial infrastructure

Michelle Kooy

-

Kooy, M, & Bakker, K 2008, 'Splintered networks: The colonial and contemporary waters of Jakarta', *Geoforum*, vol. 39, no. 6, pp. 1843–1858.

## Topics

### 6 Intellectual traditions to understand water justice

Memories of last session

Lecture: Urban Political Ecology & hydro-politics

Video: Maria Kaika – What is UPE?

<https://www.youtube.com/watch?v=Z5PRfxNUBao>

<https://vimeo.com/180669461>

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Swyngedouw, E. 1997. "Power, nature, and the city: The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador, 1880-1990". *Environment and Planning A*, 29 (2): 311-332.

### 7 Tutorial

Tutorial for group work: water security, hydro-social cycle, & the human right to water

### 8 Conceptual tools to understand water justice

**Conceptual tools to understand water justice**

GROPUWORK

### 9 Water security, hydro-social cycle, & the human right to water

Lecture: Recapitulating concepts - water security, hydro-social cycle, & the human right to water

Lecture: Tutorial on final essay



## Topics

### 10 Shifting water governance in light of justice concerns

Lecture. Water privatization in Metro Manila; assessing the state of equitable water provision

Phil Torio

Waste Land - documentary

Located just outside Rio de Janeiro, Jardim Gramacho, Brazil, is the world's largest garbage landfill. Modern artist Vik Muniz works with the so-called catadores, the men and women who pick through the refuse, to create art out of recycled materials. Muniz selects six of the garbage pickers to pose as subjects in a series of photographs mimicking famous paintings. In his desire to assist the catadores and change their lives, Muniz finds himself changed as well.

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Bakker, K. 2007. "Trickle Down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia". *Geoforum*, 38 (5): 855-868.

### 11 The right to the city

Memories of last session

Lecture. Reading David Harvey

Lecture. Sanitation Alternatives for a just city.. yet to come

Claire Furlong

-

Harvey, D. 2008. The Right to the City. *New Left Review* 53: Available at: <http://newleftreview.org/II/53/david-harvey-the-right-to-the-city>

## Topics

### 12 Thinking with water

Fieldtrip: Exhibition Water ZomerExpo 2017 - Museum de Fundatie, Zwolle and the Castle Nijenhuis, Heino-Wijhe (Overijssel).

### 13 Recapitulating concepts: hydro-social cycle

Thinking with water: short fieldtrip discussion

Memories of last session - Recapitulating concepts: hydro-social cycle

Round table: Hydro-politics and the hydrosocial cycle

Jessica Budds

University of East Anglia

## Topics

### 14 Alternatives amongst the “crisis of imagination”

Visiting Lecturer: Araceli Rojas, Universiteit Leiden

Ancient water technology of streams, springs and runoffs

Closing reflection: Alternatives amongst the “crisis of imagination”

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Walker, B. (2010) Toxic archipelago: a history of industrial disease in Japan. Seattle: University of Washington Press, 2010. (conclusion)

Draft + Bibliography for final essay

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Cities, citizenship, and growing inequality	1	0	0	0	0	0	1	3	T. Acevedo Guerrero
2	Relating urban waters, justice, and governance	1	0	0	0	0	0	1	3	M.Z. Zwarteveen, T. Acevedo Guerrero
3	Questions of gender in urban water	2	0	0	0	0	0	2	6	T. Acevedo Guerrero
4	Income, race, and other intersectional factors reflected in/reinforced through urban water flows	2	0	0	0	0	0	2	6	T. Acevedo Guerrero
5	Biophysical conditions and other material considerations	2	0	0	0	0	0	2	6	M.E. Kooy
6	Intellectual traditions to understand water justice	2	0	0	0	0	0	2	6	T. Acevedo Guerrero
7	Tutorial	3	0	0	0	0	0	3	9	M.E. Kooy, T. Acevedo Guerrero
8	Conceptual tools to understand water justice	3	0	0	0	0	0	3	9	T. Acevedo Guerrero
9	Water security, hydro-social cycle, & the human right to water	2	0	0	0	0	0	2	6	M.E. Kooy, T. Acevedo Guerrero
10	Shifting water governance in light of justice concerns	2	0	0	0	0	0	2	6	
11	The right to the city	0	1	0	0	0	0	0	1	C. Furlong, T. Acevedo Guerrero
12	Thinking with water	0	48	0	0	0	0	0	48	M.E. Kooy, T. Acevedo Guerrero
13	Recapitulating concepts: hydro-social cycle	0	30	0	0	0	0	0	30	T. Acevedo Guerrero
14	Alternatives amongst the "crisis of imagination"	0	0	0	0	0	0	0	0	M.E. Kooy, T. Acevedo Guerrero
<b>Total</b>		<b>20</b>	<b>79</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>20</b>	<b>139</b>	

## Education Material

Handout                      Students are provided a Handout on Urban Water Governance

## Scientific Software

# M3048

## Water Sensitive Cities

<b>Term</b>	201718T11
<b>Coordinator</b>	P.D.A. Pathirana
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

All participants and external professionals dealing with urban water and flood risk management working for municipalities, water management organisation, consulting firms, educational institutions and NGOs.

### Prerequisites

BSc degree in Engineering or Social Sciences background; basic knowledge of urban water and flood risk management; good command of English.

### Learning Objectives

- 1 Describe the historical transition of cities from the viewpoint of water management. List salient features of that transition (both positive and negative). (ILO1:History)
- 2 Argue that the three main components of the urban water cycle (UWC) management are interdependent. Describe the interactions with other important aspects of UWC like groundwater, urban atmosphere, etc., and how they affect each. (ILO2:Integration)
- 3 Identify interactions between water system components, while following 'thematic' topics (e.g. urban hydrology, water transport and distribution). Describe how to exploit such interactions to enhance livability, sustainability and resilience of cities.
- 4 Argue that considering multiple aspects of the water systems could provide opportunities to add extra value and create substantial additional benefits related to water management projects. Estimate such benefits using toolkits. (ILO4:MultipleValues)
- 5 Illustrate the importance of 'mainstreaming' water sensitive elements to general urban development process. Describe concrete examples (real-world and hypothetical) of such mainstreaming. (ILO5: Mainstreaming)
- 6 Analyse the stakeholder involvement in the management of water in city. Argue that for effective embedding of water-sensitive features to urban development, stakeholders should also include traditionally 'non-water' domains. (ILO6:Stakeholders)
- 7 Reflect on the relationship of WSC principals and practice to existing cities and their sub-components (e.g. neighbourhoods). Propose (conceptual) next steps in moving towards a more water-sensitive state for a given concrete case-study. (ILO7:Vision)

### Assessments

%	Type	Name
50	Assignment	Case study reflection reports
25	Oral examination	
25	Presentation	

## **Topics**

### **T1 Introduction to water sensitive cities**

This module's structure is quite different from the 'traditional model' of teaching modules here at IHE. The Learning objectives are realized via a series of 'Case Studies' (between 10 and 14) each taking a half a day or full day. Each case study has a hands-on, workshop type part as well.

This section which precedes those case studies describe:

1. What is a water sensitive city? Why it is important? How cities can strive to arrive at more water sensitive states?
2. The components of the urban water cycle (Water supply, Surface/storm water system, Wastewater system + groundwater), each as a brief introduction and how they interact with each other and the broader urban processes that are outside the domain of water.

### **T2 Case studies (change every year)**

List of case studies. Each case study has

1. Lecture/discussion part
2. Workshop - hands-on part.

Since the number and content of the case studies change every year this section represents the 'collection' of the case studies.

### **T3 Field trip**

In most years, the module has a one day field trip.

### **T4 Final presentations**

Here students present their own impressions about the concept of WSC, its implementation, challenges, suitability, etc. They do peer-assessment.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
T1	Introduction to water sensitive cities	8	0	0	0	0	0	8	24	P.D.A. Pathirana
T2	Case studies (change every year)	28	12	28	0	0	0	56	124	
T3	Field trip	0	0	0	0	8	0	8	8	P.D.A. Pathirana, W. Veerbeek
T4	Final presentations	0	0	4	0	0	0	4	4	M. Radhakrishnan, P.D.A. Pathirana
<b>Total</b>		<b>36</b>	<b>12</b>	<b>32</b>	<b>0</b>	<b>8</b>	<b>0</b>	<b>76</b>	<b>160</b>	

## Education Material

Lecture notes

Every year a set of scientific papers, reports and book chapters will be provided in addition to the slides used in the class.

## Scientific Software

# M3214

## Wetlands for Livelihoods and Conservation

<b>Term</b>	201718T11
<b>Coordinator</b>	E.M.A. Hes
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

Programme target group

### Prerequisites

Programme prerequisites

### Learning Objectives

- 1 understand the framework of ecosystem functions and services, and means of assessing it
- 2 develop adaptive management for wetlands in response to change
- 3 analyse the socioecological system by applying DPSIR and Agency Network Analysis
- 4 assess the state of the wetland ecosystem on the basis of HydroGeoMorphological units and applying WETHealth
- 5 develop and carry out stakeholder interviews and surveys
- 6 conduct and communicate a research project.

### Assessments

%	Type	Name
10	Presentation	Group presentation
10	Attendance	Individual performance during fieldweek
80	Assignment	Individual research assignment (report)

### Topics

- 1 **Ecosystem services framework**
- 2 **Wetland Assessment**
- 3 **Driver Pressure State Impact Response**
- 4 **Agency Network Analysis**
- 5 **Stakeholder Analysis and Participatory Approaches**
- 6 **Research Assignment**
- 7 **Group Presentation**



## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Ecosystem services framework	8	0	4	0	0	0	12	28	A.A. van Dam, E.M.A. Hes, K.A. Irvine
2	Wetland Assessment	4	0	2	0	8	0	14	22	A.A. van Dam, E.M.A. Hes
3	Driver Pressure State Impact Response	2	0	2	0	4	0	8	12	E.M.A. Hes
4	Agency Network Analysis	4	0	4	0	6	0	14	22	L.E. Charli Joseph
5	Stakeholder Analysis and Participatory Approaches	4	0	2	0	6	0	12	20	G.J.M. Gevers
6	Research Assignment	0	24	0	0	6	0	6	30	E.M.A. Hes, G.J.M. Gevers, L.E. Charli Joseph
7	Group Presentation	0	0	0	0	6	0	6	6	E.M.A. Hes, G.J.M. Gevers, L.E. Charli Joseph
<b>Total</b>		<b>22</b>	<b>24</b>	<b>14</b>	<b>0</b>	<b>36</b>	<b>0</b>	<b>72</b>	<b>140</b>	

## Education Material

## Scientific Software

# M3322

## Summer Course - Nature Based Solutions in Water Management

<b>Term</b>	201718T12
<b>Coordinator</b>	C. Zevenbergen
<b>Credit points</b>	1.000000000
<b>Specialization</b>	

### Target Group

This course offers a multidisciplinary program with short introductions from the different Water Management fields such as coastal management, urban flood management, land & water management, sanitation and wetland management.

Hence, the target group is broad.

### Prerequisites

This course is a general introduction to the topic of NBS.

### Learning Objectives

- 1 Define the basic design and operation principles of Nature Based Solutions
- 2 Describe and explain how these principles work in in the fields of water engineering, water management, water supply and sanitation in practice for a number of case studies across the world
- 3 Get acquainted with bad and best practices of NBS (c.q. practical experiences)
- 4 Apply these principles in a concrete context (e.g. related to his/her home country)

### Assessments

%	Type	Name
1	Presentation	Groupwork (poster session) and Group Presentations

## Topics

### 1 Course Introduction

Nature Based Solutions (NBS) is an emerging concept. It covers a range of approaches and technologies, which use natural processes to address societal challenges. Of particular relevance are applications in the field of water management, such as in coastal/river flood protection, water resources management, stormwater management, water supply, wastewater treatment and pollution prevention.

Their success is related to good performance on primary objectives, co-benefits for other objectives and (in many cases) low operation and maintenance costs. Nature Based Solutions, when well designed, will result in multiple benefits for the environment, society and economy. They can also promote a green and circular economy, because they close the loop of water management and make connections between healthy ecosystems and social/economic development challenges.

On the first day of the course the concept of Nature Based Solutions is introduced, along with its basic design and operation principles. During the next three days (morning sessions) the application of these principles is demonstrated for the different fields of water management. In parallel (in the afternoon sessions), the participants will work in teams on a design of an application in a concrete context. In this “learning by design” exercise, the participants are challenged to apply the NBS principles through poster design and presentation. On the last course day, the participants will present and discuss their design and underlying motivation and application of these principles.

#### Learning Objectives

Upon completion, the participant should be able to:

- **Define** the basic design and operation principles of Nature Based Solutions
- **Describe and explain** how these principles work in the fields of water engineering, water management, water supply and sanitation in practice for a number of case studies across the world
- **Get acquainted** with bad and best practices of NBS (c.q. practical experiences)
- **Apply** these principles in a concrete context (e.g. related to a particular area)

## Topics

### 2 Poster design & Presentation

All participants in the summer courses of 30 July to 3 August 2018 will have to form a team of 3 to 5 members each and design a poster for the course assessment. The design and presentation will be held on the last day of the courses. For this purpose, each team will be provided poster paper(s) in rolls, poster board as well as necessary materials for making the poster. The objectives of the presentations are as follows:

1.  
to learn to create and present your poster in the most effective way for a broad audience;
2.  
to place your own ideas in a broader context;
3.  
to show the rich diversity of research topics within the summer course, and;
4.  
to assess your knowledge gained through the course.

Each team will have 10 minutes to present the poster and 10 minutes for questions, comments and discussion. The poster and presentation will be evaluated by other teams. All the posters will also be showcased on the IHE Delft website.

### 3 Land & Water

Land & Water

Nature based solutions: an ecosystems approach to agriculture

**Dr. Charlotte Fraiture** will talk about how nature based solutions can be applied to agriculture. Agriculture has a large environmental footprint. It covers some 40% of the global land surface and is linked to some 20-30% of greenhouse gasses. More than 70% of water withdrawals are for agricultural purposes. With a growing demand for food in the coming decades, a business-as-usual approach is not sustainable. This sessions explores the concept of nature based solutions in agriculture. Several examples will illustrate how improved management of land and water for food production can not only reduce the adverse impacts on the environment but can contribute to a range of ecosystem services.

## Topics

### 4 Stormwater Infrastructure

**Dr. Berry Gersonius** will be discussing the multiple benefits of blue-green stormwater infrastructure.

Sustainable drainage systems (SuDS) is a term used to refer to drainage systems that are not primarily buried pipes below ground; although many SuDS utilize pipes for interconnecting measures. Traditional piped drainage systems and many below ground SuDS deal with the quantity and to some extent the quality aspects of stormwater runoff, but provide no added benefits. SuDS that use Nature Based Solutions (NBS) can bring a wide range of benefits beyond simply dealing with stormwater. There are a number of tools and procedures for assessing these benefits, some of which provide a monetized bottom-line. A UK project led by CIRIA has reviewed the available knowledge and techniques for valuing multiple benefits, and from this developed a new freely available SuDS valuation tool, known as BeST (Benefits of SuDS Tool). This lesson provides information about how to determine the value of the benefits brought from SuDS by using BeST or equivalent software.

He will also be taking the case study of the city of Dordrecht

### 5 Water Resource Management

**Dr. Janez Susnik** will deliver a lecture on nature based solutions and sustainable (urban) water supply.

Supplying fresh water to an increasing urban population is a major global concern. In many cases, traditional water supplies are being overexploited, or are being brought into a basin through interbasin transfers, which only moves the problem elsewhere. This is true for surface and groundwater resources. Recently, there has been a growing interest in how to use alternative water sources to close supply-demand gaps, to reduce the pressure on existing water sources and to enhance the resilience of urban water systems. This talk presents a background of urban water supply and demand, and gives an introduction to the many different ways that alternative systems can contribute. Case studies and recent research are used to highlight possibilities.

He will be undertaking the case studies of work done in Lilongwe (Malawi) and Sharm El-Sheikh (Egypt).

### 6 Coastal Systems

**Dr. Dano Roelvink** will be talking about Coastal erosion and coastal safety against flooding and the role of nature based solutions in both.

He will discuss different coastal types and the important coastal processes leading to long-term and short-term coastal erosion and risk of inundation. Hard and soft solutions will be discussed and examples from practice in West-Africa, Vietnam and the Netherlands will be compared. Central question to discuss will be why it is often so difficult to 'sell' soft solutions in developing countries.

## Topics

### 7 Resource Recovery

**Dr. Eldon Raj** will give a lecture on Natural treatment systems for water and wastewater treatment and resource recovery.

He will also be presenting a case study on permeable reactive barriers.

### 8 Aquatic Ecology

**Dr. Ken Irvine** will be talking about aquatic ecology with the help of case study of Florida Everglades. His topic is 'From Cityscape to Florida Everglades. Why plan with Nature?'

Green infrastructure is increasingly used and advocated as an important component of sustainable development. While frequently focused on water management, it also used to find solutions for many other environmental and engineering problems. These varied applications are reflected in the definitions of green infrastructure that can range from e.g. "cost-effective, resilient approach to managing wet weather impacts that provides many community benefits" to the very encompassing "ingredients for solving urban and climatic challenges by building with nature." To try and better connect the concept with application he proposes a more mechanistic definition as "The use of natural and semi-natural (including constructed) plant communities to support local environmental management for societal benefit" and four connected postulates that can form the basis of a more structured formulation of the concept:

1. Vegetation roughness dissipates energy and slows down water flow and power;
2. The natural accumulation of biomass provides habitat heterogeneity, adaptability and increased resistance and resilience to disturbance;
3. Maintenance of floodplains provide natural spillways, also essential for traditional agriculture and ecosystem services; and
4. Green infrastructure is cost-effective in providing multiple benefits for humans and nature.

The session explores these concepts using number of case studies and examples and how these ideas can be incorporated into spatial planning and policy. This links to questions about public health and economic benefits of green infrastructure. At the end of the session it is expected that participants will be able to: be exposed to examples of how natural habitats can reduce flood and pollution risk; explore the underlying principles of how green infrastructure can support local environmental management for societal benefit; and discuss and evaluate the socio-economic benefits and challenges to the use of green infrastructure.

### 9 Field trip

This field trip is aimed to give a real example of the application of Nature-based Solutions. The participant will visit an institution that has experiences in implementing NBS in The Netherlands.

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Course Introduction	4	0	0	0	0	0	4	12	B. Gersonius, C. Zevenbergen, E.R. Raj
2	Poster design & Presentation	0	0	10	0	0	0	10	10	B. Gersonius, C. Zevenbergen, E.R. Raj
3	Land & Water	2	0	0	0	0	0	2	6	C.M.S. de Fraiture
4	Stormwater Infrastructure	2	0	0	0	0	0	2	6	B. Gersonius
5	Water Resource Management	2	0	0	0	0	0	2	6	J. Susnik
6	Coastal Systems	3	0	0	0	0	0	3	9	J.A. Roelvink
7	Resource Recovery	2	0	0	0	0	0	2	6	E.R. Raj
8	Aquatic Ecology	2	0	0	0	0	0	2	6	K.A. Irvine
9	Field trip	0	0	0	0	4	0	4	4	B. Gersonius, C. Zevenbergen
<b>Total</b>		<b>17</b>	<b>0</b>	<b>10</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>31</b>	<b>65</b>	

## Education Material

Digital files           Lecture and assignment material  
 Digital files           Reader for NBS Summer Courses 2018

## Scientific Software

# M3062

## World History of Water Management

<b>Term</b>	201718T12
<b>Coordinator</b>	L.G. Hayde
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

### Prerequisites

### Learning Objectives

### Assessments

%	Type	Name
1	Attendance	

### Topics

### Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

### Education Material

### Scientific Software



# M1284

## Groupwork WSE

<b>Term</b>	201718T13
<b>Coordinator</b>	W. Veerbeek
<b>Credit points</b>	5.000000000
<b>Specialization</b>	Core Program

### Target Group

### Prerequisites

All previous modules

### Learning Objectives

- 1 elaborate (a first outline of) an Integrated Coastal Area and River Basin Management (ICARM) Plan
- 2 provide a detailed and fully integrated (interlinked) diagnosis of the main problems and threats in the area for which the ICARM Plan has to be developed, with regard to water resources, coastal zone, river basin developer and environment
- 3 perform specialized studies (using an engineering approach) in their own discipline to support the implementation of measures and assess their impacts and efficiency
- 4 present a programme of measures to address, in an integrated and interdisciplinary manner, the problems/threats and achieve the objectives/opportunities identified for the different disciplines
- 5 develop inter- and multi-disciplinary project activities in integrated teams

### Assessments

%	Type	Name
25	Presentation	Group mark Phase 1 determined by report and presentation
25	Presentation	Group mark Phase 2 determined by report and presentation
50	Presentation	Individual mark Phase 2 determined by report and feedback sessions

## Topics

### 1 Groupwork

The groupwork simulates the elaboration of (a first outline of) an Integrated Coastal Area and River Basin Management (ICARM) Plan for a specific area by multidisciplinary consulting firms. Such an ICARM Plan starts with a thorough characterization of the area with regard to the natural system and human activities, and a detailed diagnosis of the current situation (problems, threats) with regard to the different disciplines linked to WSE. These include river basin, coastal zone, land and water development and water resources exploitation and management. During the diagnosis the interlinkages between the different problems and threats need to be clearly addressed. The plan

continues with defining the main opportunities and objectives with regard to each of the disciplines (including environmental objectives) and then goes on to suggest the main (structural and/or non-structural) measures that need to be implemented during a certain time frame (for instance five years), to address the problems/threats and achieve the objectives/opportunities identified for the different disciplines. A fundamental step towards the proposition of measures to be implemented in an area is the performance of specialized studies that support the implementation of these measures and assess their impacts and efficiency, as well as their interrelations (positive or negative) with other measures that are being proposed.

### Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Groupwork	0	0	140	0	0	0	140	140	
Total		0	0	140	0	0	0	140	140	

### Education Material

Handout                      Handouts group work, information and data

### Scientific Software

# M3360

## Environmental modelling using PCRaster

<b>Term</b>	201718T14
<b>Coordinator</b>	J. van der Kwast
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

The course is designed for professionals (engineers and scientists) active in the water sector, especially those involved in using simulation models for water management.

### Prerequisites

It is expected that participants have good computer skills and basic knowledge of GIS.

### Learning Objectives

- 1 Use scripting for GIS data processing
- 2 Apply Map Algebra using PCRaster Python
- 3 Use the PCRaster Python framework for environmental modelling

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 1 **DOS and GDAL**
- 2 **Python**
- 3 **PCRaster Python library**

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	DOS and GDAL	0	0	0	0	0	0	0	0	
2	Python	0	0	0	0	0	0	0	0	
3	PCRaster Python library	0	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	0	0	

## Education Material

## Scientific Software

# M3362

## Hydraulic modelling using HEC-RAS

<b>Term</b>	201718T14
<b>Coordinator</b>	I.I. Popescu
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

Students of Water Science and Engineering taught course

Professionals who work in River flow analysis and river flood related aspects.

### Prerequisites

Knowledge of hydraulics of open channel flow

### Learning Objectives

- 1 Learn how to solve by numerical approximation equations of open channel flow
- 2 Understand basic principles of modelling 1D and 1D/2D river flow
- 3 Ability to build a river model using HEC-RAS
- 4 Ability to interpret results of a river flow model

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 01 Modelling open channel flow
- 02 Steady flow modelling
- 03 Modelling 1D, 1D+SA and structures on the river
- 04 Modelling 1D/2D and 2D river flow
- 05 Example of case studies in projects
- 06 Building a model of an existing river

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
01	Modelling open channel flow	4	0	2	0	0	0	6	14	I.I. Popescu
02	Steady flow modelling	0	0	4	0	0	0	4	4	T. Herman Assumpção
03	Modelling 1D, 1D+SA and structures on the river	0	0	6	0	0	0	6	6	I.I. Popescu, T. Herman Assumpção
04	Modelling 1D/2D and 2D river flow	0	0	4	0	0	0	4	4	I.I. Popescu, T. Herman Assumpção
05	Example of case studies in projects	4	0	0	0	0	0	4	12	B. Bhattacharya
06	Building a model of an existing river	0	4	2	0	0	2	4	12	I.I. Popescu, T. Herman Assumpção
<b>Total</b>		<b>8</b>	<b>4</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>28</b>	<b>52</b>	

## Education Material

Handout                      Step by step model building with HEC-RAS  
 Handout                      Theory of river flow

## Scientific Software

HEC-RAS

# M3231

## MSc research, thesis and defence

<b>Term</b>	201718T14
<b>Coordinator</b>	E.A. de Jong
<b>Credit points</b>	30.000000000
<b>Specialization</b>	Core Program

### Target Group

for GroundwatCH and Flood Risk Management (30 ECTS)

### Prerequisites

### Learning Objectives

- 1 Explore the background of the research problem by critically reviewing scientific literature; Evaluate relevant theories and applying these theories to a relevant scientific problem; Assure adequate delineation and definition of the research topic
- 2 Formulate research questions and hypotheses
- 3 Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.
- 4 Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results.
- 5 Demonstrate academic attitude and learning skills (incl thinking in multidisciplinary dimensions & distinguishing main issues from minor ones), to enhance & keep up-to-date the acquired knowledge and application skills in a largely independent manner.
- 6 Communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rationale underpinning of these in oral and written presentations to a variety of audiences.

### Assessments

%	Type	Name
100	Presentation	Defence

### Topics

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

## Education Material

## Scientific Software



# M3355

## Open Source Software for Preprocessing GIS data for Hydrological Models

<b>Term</b>	201718T14
<b>Coordinator</b>	J. van der Kwast
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

The course is designed for professionals (engineers and scientists) active in the water sector, especially those involved in using simulation models for water management and GIS analysts.

### Prerequisites

It is expected that participants have good computer skills.

### Learning Objectives

- 1 Convert tables to GIS data
- 2 Join attribute tables
- 3 Calculate new attributes
- 4 Convert between different GIS formats and projections
- 5 Georeference a scanned map
- 6 Digitize vector layers from scanned maps
- 7 Delineate catchments and streams

### Assessments

%	Type	Name
1	Attendance	

### Topics

- 1 Introduction to Open Source software for GIS and hydrological modelling
- 2 Spatial Data Infrastructures for Open Access Water Data
- 3 Using QGIS to digitize vector layers from a scanned map
- 4 Using QGIS for importing tabular data into GIS, data correction and interpolation
- 5 Using QGIS for catchment and stream delineation

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction to Open Source software for GIS and hydrological modelling	0	0	0	0	0	0	0	0	
2	Spatial Data Infrastructures for Open Access Water Data	0	0	0	0	0	0	0	0	
3	Using QGIS to digitize vector layers from a scanned map	0	0	0	0	0	0	0	0	
4	Using QGIS for importing tabular data into GIS, data correction and interpolation	0	0	0	0	0	0	0	0	
5	Using QGIS for catchment and stream delineation	0	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	0	0	

## Education Material

Digital files <https://ocw.un-ihe.org/course/view.php?id=11>

## Scientific Software

QGis

# M3361

## River Basin Modelling Using SWAT

<b>Term</b>	201718T14
<b>Coordinator</b>	I. Masih
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

### Prerequisites

### Learning Objectives

### Assessments

%	Type	Name
1	Attendance	

### Topics

### Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

### Education Material

### Scientific Software

# M1810

## Small Hydropower Development

<b>Term</b>	201718T14
<b>Coordinator</b>	M. Marence
<b>Credit points</b>	0.000000000
<b>Specialization</b>	

### Target Group

The course is designed for scientists, engineers and water managers involved in hydropower development and water resources management, or interested in these topics

### Prerequisites

Basic knowledge of hydraulics, geotechnics and structural engineering

### Learning Objectives

- 1 To address the various stages of a small hydropower project cycle
- 2 To be familiar with the main components required for the development of a small hydropower scheme

### Assessments

%	Type	Name
1	Attendance	

### Topics

#### 1 Introduction

Introduction in hydropower and small hydropower. Characteristics of small hydropower and main layouts.

#### 2 Civil Design of SHPP

Structural design of the small hydropower structures, including weirs, intakes power channels, penstocks and powerhouses.

## Topics

### **3 Mechanical components**

Design of the mechanical components and turbines for SHPP

### **4 Electrical design of SHPP**

Design of the electrical components of the small hydropower with connection in the grid.

### **5 Hydraulic design of SHPP**

Hydraulic design of the components of the SHPP, as intakes, open channels and flow in pipes

### **6 Hydrology**

Basics of the hydrology needed for SHPP design with special consideration on the flow duration curves

### **7 GIS tools for site analysis**

Use of GIS tools and open source software in development of the basic information for the SHPP site selection

### **8 Impact of SHPP on morphology**

### **9 Environmental impact**

### **10 Hydropower assesment, minimal flow and cost analysis**

### **11 Small hydropower development**

Development of the small hydropower in the developing world

### **12 Marine energy**

### **13 Field trip**

### **14 Small hydropower - Examples**

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Introduction	2	0	0	0	0	0	2	6	M. Marence
2	Civil Design of SHPP	4	0	0	0	0	0	4	12	M. Marence
3	Mechanical components	4	0	0	0	0	0	4	12	M. Marence
4	Electrical design of SHPP	6	0	0	0	0	0	6	18	A.J. Hartinger
5	Hydraulic design of SHPP	6	0	0	0	0	0	6	18	A. Cattapan
6	Hydrology	6	0	0	0	0	0	6	18	S. Maskey
7	GIS tools for site analysis	4	0	0	0	0	0	4	12	P. Paron
8	Impact of SHPP on morphology	4	0	0	0	0	0	4	12	A. Crosato
9	Environmental impact	4	0	0	0	0	0	4	12	A. Mendoza - Sammet
10	Hydropower assesment, minimal flow and cost analysis	10	0	0	0	0	0	10	30	M.A. Peviani
11	Small hydropower development	4	0	0	0	0	0	4	12	R.P. Singh
12	Marine energy	2	0	0	0	0	0	2	6	M.A. Peviani
13	Field trip	0	0	0	0	4	0	4	4	P.L.A. Buijs
14	Small hydropower - Examples	4	0	0	0	0	0	4	12	P. Mazzoli
<b>Total</b>		<b>60</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>64</b>	<b>184</b>	

## Education Material

## Scientific Software

# M3284

## Thesis Research Proposal Development for WSE

<b>Term</b>	201718T14
<b>Coordinator</b>	G.A. Corzo Perez
<b>Credit points</b>	9.000000000
<b>Specialization</b>	Core Program

### Target Group

All students of the Water Science and Engineering programme

### Prerequisites

### Learning Objectives

- 1 concisely define the intended research topic, state precise aims and objectives, describe the research methodology, argue expected relevance and justification, and identify boundary conditions and self- or externally imposed limitations
- 2 list available literature and replicate main arguments expounded in the literature on the specified research topic
- 3 demonstrate analytical problem-analysis skills and the ability to distil the strategic issues to be addressed in the research phase
- 4 plan, using the project management approach, the research process in weekly time-steps and indicate essential milestones, targets and indicators, required human, financial and other resources, deliverables and perceived threats and constraints at each
- 5 develop and formulate the research proposal in a clearly written, well argued and convincing report, submitted within a set deadline
- 6 successfully present and defend individual work, cross-reference it to and critically evaluate it in light of contemporary thinking in a specific field of study

### Assessments

%	Type	Name
100	Assignment	Research proposal

### Topics

#### 1 Selection of research topic

The initial research topic of study will be selected in a consultative process with a mentor, the MSc coordinator and a professor.

## Topics

### 2 Proposal drafting

Research is likely to be based primarily on a review of selected literature, to a limited extent other methods of data gathering and analysis may also be applied (e.g. interviews, laboratory and field work, computer modelling, expert consultations, etc). One hour weekly meetings with the tutor form the main stay of the proposal development process. It is however expected that the MSc candidate will be self-motivated and pro-active, taking all necessary initiatives to reach the set target in a timely fashion.

### 3 Proposal presentation

The resulting proposal will be presented in written form and orally defended before an audience of critical peers and a panel of staff members

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	Selection of research topic	0	0	0	0	0	0	0	0	
2	Proposal drafting	0	188	0	0	0	0	0	188	
3	Proposal presentation	0	0	0	4	0	0	4	8	
Total		0	188	0	4	0	0	4	196	

## Education Material

## Scientific Software



# M2927

## MSc research, thesis and defence

<b>Term</b>	201718T15
<b>Coordinator</b>	E.A. de Jong
<b>Credit points</b>	36.000000000
<b>Specialization</b>	Core Program

### Target Group

All students of the MSc programmes

### Prerequisites

### Learning Objectives

- 1 Explore the background of the research problem by critically reviewing scientific literature; Evaluate relevant theories and applying these theories to a relevant scientific problem; Assure adequate delineation and definition of the research topic
- 2 Formulate research questions and hypotheses
- 3 Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.
- 4 Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results.
- 5 Demonstrate academic attitude and learning skills (incl thinking in multidisciplinary dimensions & distinguishing main issues from minor ones), to enhance & keep up-to-date the acquired knowledge and application skills in a largely independent manner.
- 6 Communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences.

### Assessments

%	Type	Name
100	Presentation	Defence

### Topics

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
	Total	0	0	0	0	0	0	0	0	

## Education Material

## Scientific Software



**Education Material**

**Scientific Software**

Delft3D

# M3272

## Online Course on Decision Support Systems in River Basin Management

### Term

### Coordinator

A. Jonoski

### Credit points

0.000000000

### Specialization

### Target Group

Young and mid-level professionals who are involved in decision making processes in river basins at different levels;

Professionals who are developing modelling and information systems support for managing water resources in river basins.

### Prerequisites

Basic knowledge of hydrology and water resources.

### Learning Objectives

- 1 Identify the key challenges in River Basin Management and understand the need for decision support tools
- 2 Translate RBM problems into structured decision making problems using systems analysis approaches through formulation of alternatives and objectives
- 3 Set-up and execute moderately complex river basin simulation models
- 4 Formulate several typical water resources problems as optimisation problems and solve them using optimisation software packages
- 5 Formulate given river basin management problem as an MCA problem and analyse it using specialized software
- 6 Outline the generic structure of a computer-based DSSs used in RBM and distinguish different types of DSSs

### Assessments

%	Type	Name
1	Assignment	Assignment project planning and analysis
1	Assignment	Assignment Multi Criteria Analysis
1	Assignment	Assignment basic optimization
1	Assignment	Assignment optimization in systems analysis
1	Assignment	Assignment simulation modelling

## Topics

### **1 River Basin Management**

Introduction to the concept of RBM; Guiding principles in RBM; relations between the natural, socioeconomic and administrative systems; functions and users; Challenges: integration across functions, upstream-downstream integration, trade-offs; Nature of RBM complexity requiring decision support

### **2 Decision support: structuring decision making problems and solution techniques**

Introduction to decision making processes; Formulation of objectives and alternatives; Hierarchical structuring of objectives; Formulation of alternatives in terms of control (decision) variables; Introduction to simulation, optimisation and multi-criteria analyses as techniques used in decision support

### **3 Simulation modelling as tool for decision support in RBM**

Modelling paradigms: physically-based modelling, data-driven modelling-agent-based modelling; Types of modelling used for RBM: river basin modelling; catchment modelling; river and flood Modelling; water quality and ecological modelling; socioeconomic modelling; Special focus on River Basin Modelling; Computer exercises with River Basin Modelling Software

### **4 Optimisation techniques for decision support in RBM**

Introduction to optimisation; Classical optimisation (calculus-based); Single-objective and multi-objective optimisation; Linear Programming; Dynamic Programming; Formulation of typical water resources problems as optimisation problems; Exercises with optimisation software packages

### **5 Multi-Criteria Analyses (MCA) techniques and their role in decision support for RBM**

The need for MCA; Definition of MCA problems; Solution methods –compensatory and non-compensatory; Decision matrix and its use; Multiple Attributes Decision Methods (MADM); Computer exercises with DSS software that implements MCA

### **6 Structure and types of DSSs for RBM**

Introduction to DSS as computer-based tools; Structure of a generic DSS; Types of DSSs; Examples of developed DSSs and case studies

## Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1	River Basin Management	0	0	0	0	0	0	0	0	A. Jonoski, E. van Beek
2	Decision support: structuring decision making problems and solution techniques	0	0	0	0	0	0	0	0	A. Jonoski
3	Simulation modelling as tool for decision support in RBM	0	0	0	0	0	0	0	0	I.I. Popescu
4	Optimisation techniques for decision support in RBM	0	0	0	0	0	0	0	0	A. Jonoski, D. Solomatine, D.P. Loucks
5	Multi-Criteria Analyses (MCA) techniques and their role in decision support for RBM	0	0	0	0	0	0	0	0	A. Jonoski, I.I. Popescu
6	Structure and types of DSSs for RBM	0	0	0	0	0	0	0	0	A. Jonoski, S.J. van Andel
<b>Total</b>		<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	

## Education Material

Digital files	Audio lectures Multi Criteria analysis (with slides)
Digital files	Audio lectures decision support concepts and methods (with slides)
Digital files	Audio lectures on decision support systems (with slides)
Digital files	Audio lectures simulation modeling (with slides)
Digital files	Audio tutorials - RIBASIM software (with lecture notes)
Digital files	Tutorial on using LINGO software
Digital files	Tutorials on using mDSS software
Digital files	Video lectures river basin management (with slides)

## Scientific Software

Ribasim  
mDSS

# M3274

## Online Course on Flood Modelling for Management

### Term

### Coordinator

I.I. Popescu

### Credit points

0.000000000

### Specialization

### Target Group

### Prerequisites

### Learning Objectives

- 1 Identify the causes of river floods
- 2 Identify the type of a flood
- 3 Model and simulate river floods
- 4 Interpret and evaluate the impacts of floods
- 5 Prepare and advise/communicate on possible flood prevention and mitigation actions, including technical and ethical considerations

### Assessments

%	Type	Name
0,5	Attendance	
0,5	Assignment	Several assignments on modelling

### Topics

1. Context and causes of floods

The course will explain the context in which floods are happening and what is the cause for it. The focus is on river basins and river floods.

- 2 **Analyse and mathematically describe flood flow processes**

Analyse and mathematically describe flood flow processes



### Topics

3. Model and simulate floods

Model and simulate floods. The focus was the topic is on 1D simulation of river floods. Course uses HEC-HMS for catchment modelling and Mike 11 for river flow.

4. Evaluate impact of river floods

Evaluate impact of river floods

### Study load

Nr	Topic	Lecture	Assignment	Exercise	Lab session and report	Fieldtrip	Design Exercise	SUM: contact hours	SUM: workload hours	Lecturers
1.	Context and causes of floods	0	0	0	0	0	0	0	0	
2	Analyse and mathematically describe flood flow processes	0	0	0	0	0	0	0	0	
3.	Model and simulate floods	0	0	0	0	0	0	0	0	
4.	Evaluate impact of river floods	0	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	0	0	

### Education Material

Handout                      Exercise hand-outs (HEC-HMS and Mike11)  
Lecture notes              Lecture notes on flood propagation

### Scientific Software

HEC-HMS  
Mike 11