Modulhandbuch

Studiengang Master of Science Water Resources Engineering and Management

Prüfungsordnung: 913-2012

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Universität Stuttgart
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Präambel

Präambel

Die weltweit gestiegenen politischen und gesellschaftlichen Anforderungen bezüglich Lösungen zur Wasserversorgung und umweltbezogenen Investitionen im Wasserbereich steigern den Bedarf an auf diesem Gebiet gut qualifizierten, international ausgerichteten Ingenieurinnen und Ingenieuren. Die Thematik des international orientierten Studiengangs WAREM (Water Resources Engineering and Management) an der Universität Stuttgart ist ausgerichtet auf die Vermeidung und Lösung von Problemen und Fragestellungen in der wasserwirtschaftlichen Planung und im Wassermanagement. Aufgrund dieser Zielrichtung erfolgt die Ausrichtung der Lehrinhalte und Lernziele auf eine internationale Tätigkeit, da z.B. Fragestellungen wie Bewässerungstechniken, die Auslegung großer Stauanlagen oder auch die Bereitstellung von guter Trinkwasserqualität besonders im internationalen Kontext von Bedeutung sind.

Das Studium bei WAREM wird als konsekutiver Studiengang angeboten. Absolventen eines Bachelorstudiums können bei WAREM nach einem viersemestrigen Studium den Abschluss „Master of Science“ erhalten.

Qualifikationsziele

Die im Studiengang Water Resources Engineering and Management (WAREM) ausgebildeten Ingenieurinnen und Ingenieure erwerben alle für die Universität Stuttgart wichtigen und zugrundeliegenden Kompetenzen und Kenntnisse, die als Grundlage für ein erfolgreiches Berufsleben dienen.

Sie

- haben vertiefte Kenntnisse über Wasserwirtschaft, Wasserbau, Grundwasser, Geohydrologie, Siedlungswasserwirtschaft, Wasserqualität und verstehen die dabei grundlegenden natur- und ingenieurwissenschaftlichen Zusammenhänge,
- kennen die Methoden zur Entwicklung von wasserwirtschaftlichen Managementkonzepten, haben aber auch gleichzeitig die Fähigkeiten diese zu planen und durch geeignete technische Maßnahmen und Installationen umzusetzen,
- können die Probleme durch und im Umgang mit Wasser- und Wassersystemen vorhersehen, erkennen und bewerten, sowie analytische, modellhafte und experimentelle Untersuchungen planen und durchführen,
- verfügen über die ingenieurwissenschaftliche Fertigkeit zur Entwicklung, zur Planung und zum Betrieb von Anlagen und kennen dabei auch die nicht-technischen Auswirkungen ihrer Tätigkeit,
- verfügen über die Kompetenzen zur organisatorischen und verwaltungsmäßigen Umsetzung der Wassermanagementaufgaben
- können Aufgaben mit interdisziplinärem und internationalem Charakter vor dem Hintergrund kultureller, wirtschaftlicher und politischer Rahmenbedingungen im Team bearbeiten,
- verfügen über eine hohe wissenschaftliche Qualifikation.

100 Vertiefungsmodule

Zugeordnete Module:	110	Vertiefungsmodule Pflicht
	120	Vertiefungsmodule Wahlpflicht

110 Vertiefungsmodule Pflicht

Zugeordnete Module:

- 19120 Sanitary Engineering
- 50090 Environmental Fluid Mechanics I
- 50110 Requirements of Professional Life and Engineering in Practise
- 50620 Hydraulic Structures

Modul: 19120 Sanitary Engineering

2. Modulkürzel:	021220012	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Klaus Fischer
9. Dozenten:	Klaus Fischer Harald Schönberger
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Pflichtmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	The students have detailed knowledge about waste avoidance procedures in household and industry. Waste avoidance includes the ecology - oriented daily shopping, the substitution of contaminated materials in the industrial production as well as the Zero Emission Society. In the case of unavoidable waste fractions, the students acquire the competence to establish collection and transportation systems for these wastes, within the logistic, economic and legal frame. Main emphasis is given to the collection of recyclables. The students know the relevant factors which influence the waste amount and waste composition in general and in particular within the separate collection of recyclables. The students are acquainted with the state of the art of recycling technologies for separate collected paper, glass, metal and plastic including the pretreatment process. They have knowledge of the aerobic and anaerobic treatment and utilization of separate collected biowaste. Not avoided and recycled waste has to be treated before disposing off e.g. in a landfill site. The students possess a general knowledge of the mechanical and biological treatment technology as well as of the thermal waste treatment. They are able to evaluate the different treatment and recycling processes from an ecological and economic point of view. The students have knowledge about the most important components of the urban drainage and the basic treatment processes of wastewater. Thus they are able to compare different systems in dependence of changing boundary conditions and assess the effectiveness and pros and cons of the systems, e.g. concerning impacts on the environment, economical and operational aspects. They obtain an understanding for system connections between the urban drainage system and

	the wastewater treatment system as well as between the urban water system and the environment.
13. Inhalt:	Solid Waste Management: Waste generation and waste composition National and international regulations for waste Waste avoidance Collection and transport of waste Separate collection of recyclables Sorting of recyclables Recycling technologies for paper, glass, metal, plastic Biological treatment of waste Waste Disposal Ecological indicator systems Waste Water Technology: Basics of urban drainage and municipal wastewater treatment Quantity and Composition of Wastewater Urban drainage systems stormwater treatment mechanical wastewater treatment biological wastewater treatment sludge treatment natural close and ECOSAN systems
14. Literatur:	Lecture Manuscripts Solid Waste Management G. Tchobanoglous et. Al.: Handbook of solid waste management, Biliteski, B. et.al.: Waste Management, Springer 1994 ISBN: 3-540-59210-5 Butler, D., Davies, J.W: .Urban drainage, Spon press London, Henze, M., Harremoes, J., la Coour Jansen, J., Arvin, E: Wastewater treatment. Springer Verlag Berlin
15. Lehrveranstaltungen und -formen:	• 191201 Vorlesung Solid Waste Management • 191202 Vorlesung Waste Water • 191203 Exkursion Sanitary Engineering
16. Abschätzung Arbeitsaufwand:	Time of attendance: I Solid Waste Management, lecture: 2.0 SWS = 28 hours II Waste Water: 2 SWS = 28 hours excursion: 12 hours exam: 2 hours sum of attendance: 70 hours self-study: 110 hours total: 180 hours
17. Prüfungsnummer/n und -name:	• 19121 Solid Waste Management and Waste Water Technology (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich oder Mündlich
18. Grundlage für ... :	Urban Drainage and Design of Wastewater Treatment Plants Industrial Waste Water
19. Medienform:	
20. Angeboten von:	Abfallwirtschaft und Abluft

Modul: 50090 Environmental Fluid Mechanics I

2. Modulkürzel:	021420012	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	apl. Prof. Dr.-Ing. Holger Class
9. Dozenten:	Holger Class Jürgen Braun Sergey Oladyshkin
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester ➞ Compulsory Modules M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester ➞ Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Vertiefungsmodule Pflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Technical Mechanics • Introduction to the statics of rigid bodies • Introduction to elastostatics • Introduction to the mechanics of incompressible fluids Higher Mathematics • Partial differential equations • Vector analysis • Numerical integration Fundamentals of Flow Mechanics • Conservation equations for mass, momentum, energy • Navier-Stokes, Euler, Reynolds, Bernoulli equation
12. Lernziele:	Students have fundamental knowledge of flow in various natural hydrosystems and its application in civil and environmental engineering.
13. Inhalt:	The lecture deals with flow in natural hydrosystems with particular emphasis on groundwater / seepage flow and on flow in surface water / open channels. Groundwater hydraulics includes flow in confined, semi-confined and unconfined groundwater aquifers, wells, pumping tests and other hydraulic investigation methods for exploring groundwater aquifers. In addition, questions concerning regional groundwater management (z.B. recharge, unsaturated

	zone, saltwater intrusion) are discussed. Using the example of groundwater flow, fundamentals of CFD (Computational Fluid Dynamics) are explained, particularly the numerical discretisation techniques finite volume und finite difference. The hydraulics of surface water deals with shallow water equations / Saint Venant equations, unstationary channel flow, turbulence und layered systems. Calculation methods such as the methods of characteisitcs are explained. The contents are: • Potential flow and groundwater flow • Computational Fluid Dynamics • Shallow water equations for surface water • Charakteristikenmethode • Examples from civil and environmental engineering
14. Literatur:	Lecture notes: Hydromechanics, Helmig and Class Lecture notes: Ausbreitungs- und Transportvorgänge in Strömungen, Cirpka White, F.M.: Fluid Mechanics, WCB/McGraw-Hill, New York, 1999 Freeze, R.A. and Cherry J.A.: Groundwater, Prentice Hall, 1979
15. Lehrveranstaltungen und -formen:	• 500901 Lecture and Excercise Environmental Fluid Mechanics I
16. Abschätzung Arbeitsaufwand:	Sum 180 h
17. Prüfungsnummer/n und -name:	• 50091 Environmental Fluid Mechanics I (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich
18. Grundlage für ... :	Environmental Fluid Mechanics II
19. Medienform:	Fundamentals will be developed using the blackboard and presentation tools.
20. Angeboten von:	Hydromechanik und Hydrosystemmodellierung

Modul: 50110 Requirements of Professional Life and Engineering in Practise

2. Modulkürzel:	021410901	5. Moduldauer:	Dreisemestrig
3. Leistungspunkte:	3 LP	6. Turnus:	Wintersemester/ Sommersemester
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Anne Weiß
9. Dozenten:	Anne Weiß, M.A., M.Sc.
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, → Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Pflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	Recent literature on water related topics/ scientific problems
15. Lehrveranstaltungen und -formen:	• 501101 Seminar Requirements of Professional Life and Engineering in Practise • 501102 Excursion Requirements of Professional Life and Engineering in Practise
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	50111 Requirements of Professional Life and Engineering in Practise (USL), Sonstige, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 50620 Hydraulic Structures

2. Modulkürzel:	021410106	5. Moduldauer:	Zweisemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr. Silke Wieprecht
9. Dozenten:	Silke Wieprecht Daniel Stolz Kristina Terheiden
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 2. Semester ➞ Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Vertiefungsmodule Pflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester ➞ Wahlmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	**Advanced Studies in Hydraulic Structures:** The students, • Know about the basic features of hydraulic structures • have an overview what are the main components and know how to arrange them in order to ensure a satisfying operation • are able to dimension all parts of different hydraulic structures • are aware of implicating river works into an overall context of a fluvial system and know how to act and to evaluate in spatial and temporal interrelation • are able to realize the economic and ecologic significance of hydraulic structures as dams, reservoirs and hydro power plants **Case Study in Hydraulic Structures** : The students, • are able to use of the gained theoretical knowledge with the help of a practical example • are aware of the technical relations and their effects on non-technical areas of interest • can give a well-founded argumentation of chosen estimations and are able to present their own results • can give a convincing presentation • are able to assess objectively different planning alternatives
13. Inhalt:	**Advanced Studies in Hydraulic Structures** : The course deals with main structural components of hydraulic engineering schemes such as weirs, dams, hydro power plants, pipelines and ancillary works. The main features as hydraulic and structural dimensioning are treated. The application of structural power

	plants, reservoirs and river development works is discussed. Conventional engineering methods as well as approaches with improved environmental compatibility are taken into consideration. **Case Study in Hydraulic Structures** : The case study uses the content of the lecture "Advanced Studies in Hydraulic Structures". In working groups of 3 to five students a real hydraulic structures will be planned and completely dimensioned. There are hydraulic calculations to be carried out as hydraulic capacity of spillway, dimensioning of stilling basin, hydrological and sedimentological calculations. As well the stabilities of the structures itself has to be checked. Additionally an analysis of the demand of potentially provided electricity, drinking water or irrigation water, resp. is required. The intermediate results will be presented by the groups. Every student has to deliver at least one presentation. Finally a poster for the final presentation and assessment has to be designed. This is the basis for the development of the assessment criteria for the different alternatives.
14. Literatur:	Lecture notes can be downloaded from the internet. Additional detailed information for the case study will be provided during the lectures.
15. Lehrveranstaltungen und -formen:	• 506201 Lecture and Practice Advanced Studies in Hydraulic Structures • 506202 Lecture and Presentation Case Study in Hydraulic Structures,
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50621 Hydraulic Structures (LBP), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

120 Vertiefungsmodule Wahlpflicht

Zugeordnete Module:

15010 Integrated River Management and Engineering
15160 Water and Power Supply
19100 Chemistry and Biology for Environmental Engineers
19310 Urban Drainage and Design of Wastewater Treatment Plants
19360 Water Quality and Treatment
25080 Structural Engineering of Hydraulic Structures
50120 Environmental Informatics
50130 Integrated Watershed Modeling
50140 Modeling of Hydrosystems
50150 Stochastical Modeling and Geostatistics

Modul: 15010 Integrated River Management and Engineering

2. Modulkürzel:	021410102	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Markus Noack
9. Dozenten:	Markus Noack Stefan Haun
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, Sommersemester → Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, Sommersemester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, Sommersemester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, Sommersemester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, Sommersemester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule
11. Empfohlene Voraussetzungen:	none (BAU), advisable LWW_Wabau none (UMW), advisable LWW_Gew Hydraulic Structures (WAREM)
12. Lernziele:	**River Engineering and Sediment Management** The students, • are aware of rivers must be regarded and managed based on an integrated approach • know the basic concept of the European Water Framework Directive (WFD) and the German legal framework for river basin management • are able to analyze and estimate the consequences of the WFD based inventory for future management • are aware of sediment transport processes and of the complexity of the interactions and relations • recognize the possibilities and limitations of sediment managements strategies **Integrated Flood Protection Measures** The students,

	• are aware of the fact that flood protection is an integral process, based on different components (e.g. technical flood protection measures, prevention) • know the basic physical processes: dynamics of flood events, calculation of discharges and water depths, flood wave propagation, functionality of retention and protection structures: reservoirs, dams and dikes • know 1-D and 2-D numerical hydro-dynamic models • are able to apply their knowledge on practical engineering problems related to flood protection
13. Inhalt:	The module consists of two lectures: **River Engineering and Sediment Management** • Basic approaches of river basin management (legal framework) • Systematics and results of basic inventory due to the WFD • Anthropogenic impacts on river basins • Origin of sediments and fundamental principles of transport • Sediment management measures on different scales **Integrated Flood Protection Measures** • Socio-economic aspects of flood damage • Calculation of water depths • Hydro-dynamic flood wave calculation, Saint Venant-equation • Technical flood protection measures • Design and operation of retention basins • Set-up of damage and risk maps, design of overtopping earthen dams and dikes • Probability of failure, reliability calculation, flood risk management
14. Literatur:	Lecture notes and exercise material can be downloaded from the internet. Hints are given for additional literature from the internet as well as libraries.
15. Lehrveranstaltungen und -formen:	• 150101 Vorlesung River Engineering and Sediment Management • 150102 Vorlesung Integrated Flood Protection
16. Abschätzung Arbeitsaufwand:	Time of attendance: 55 h Private study: 125 h
17. Prüfungsnummer/n und -name:	15011 Integrated River Management and Engineering (PL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

Modul: 15160 Water and Power Supply

2. Modulkürzel:	021410105	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sabine-Ulrike Gerbersdorf
9. Dozenten:	Ralf Minke Sabine-Ulrike Gerbersdorf
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Auswahl 1 (6 CP) --> Wahlpflichtmodule
11. Empfohlene Voraussetzungen:	None
12. Lernziele:	**Power Demand, Supply and Distribution:** The students, • know the German, European and worldwide energy markets related to demand, supply and its distribution capabilities • are aware of that non-renewable energy sources are strictly limited and time-scales for conversion of energy markets long • have an idea about the relations between energy, politics, social changes and influences on environment • have a basic knowledge about present energy conversion systems, theoretical limits of efficiencies, and the potential to enhance applied technology • have a basic understanding about where and how energy is provided and distributed • comprehend the balance between load and supply in electrical grids and the resulting necessity for control energy. **Water Demand, Supply and Distribution:** The students,

- know the German and worldwide water systems related to demand, supply and its distribution capabilities
- have an overview on the water supply situation all over the world.
- recognize the different possibilities and levels of water supply
- have an idea of the relations between water, politics, social changes and influences on environment.

13. Inhalt:

Power Demand, Supply and Distribution:

- Energy demand, energy supply
- Energy generation
  - overview of different types of power plants
  - renewable energy
  - thermal power plants (conventional and nuclear)
- Areas of application of different power plants
- Emission control techniques
- Cooling of thermal power plants
  - methods
  - water resources aspects
- Energy transport and energy storage
- Net techniques
- Energy market
  - trade
  - politics
  - law
- social changes due to energy supply

Water Demand, Supply and Distribution:

- Water supply and water distribution: necessity, basic requirements, elements, hydrological cycle
- Water demand calculation: water consumption, water demand, consumer groups, losses, forecasting, design periods
- Water collection: Selection of source, groundwater withdrawal, springwater tapping, surface water intakes, rainwater harvesting, seawater desalination, recycling of treated sewage, drinking water protection areas
- Water transmission and distribution: necessity, hydraulic basics, dimensioning and calculation of branched and closed loop systems.
- Pumps and pumping stations: necessity, types, hydraulics for pumping design, pumping stations and pressure boosters
- Water storage: necessity, types and functions of tanks and reservoirs
- Case study: planning and design of a water supply system for a small town

14. Literatur:

Lecture notes can be downloaded from the internet.
Hints are given for additional literature from the internet as well as libraries.

15. Lehrveranstaltungen und -formen:

- 151602 Vorlesung Water Demand, Supply and Distribution
- 151601 Vorlesung Energy Demand, Supply and Distribution

16. Abschätzung Arbeitsaufwand:

Time of attendance:	45 h
Private Study:	135 h

17. Prüfungsnummer/n und -name:

15161 Water and Power Supply (PL), Schriftlich, 120 Min., Gewichtung: 1

18. Grundlage für ... :

19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

Modul: 19100 Chemistry and Biology for Environmental Engineers

2. Modulkürzel:	021230502	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	6	7. Sprache:	Weitere Sprachen

8. Modulverantwortlicher:	Univ.-Prof. Dr. Jörg Metzger
9. Dozenten:	Karl Heinrich Engesser Brigitte Schwederski Jörg Metzger Bertram Kuch Daniel Dobslaw
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester → Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester → Elective Modules M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Pflichtmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	**Lecture: Inorganic chem istry** The students • know the fundamental concepts of chemistry (atomic structure, periodic system, chemical formulae, stoichiometry, molecular structures) and are able to use them,

- know the principle types of chemical substances and chemical reactions and can apply their knowledge to synthetic problems,
- know about the most important industrial compounds, their preparation and environmental aspects in their application.

Lecture: Organic chemistry

The students

- can identify important functional groups in organic molecules

- know the main compound classes in organic chemistry and the common rules for their nomenclature

- know the most important representatives thereof and

are able to draw their structural formulae

- know the structure and properties of important bio-molecules such as fats, carbohydrates, proteins, nucleic acids, ATP, lignin and humic acids

- know the most important reactions involved in chemical and microbial degradation of organic matter

- know summary parameters used to characterize water quality

- know the properties of bio-molecules and can explain their general function with respect to cell structures, enzymatic and immune reactions

- knows selected environmental organic contaminants (PAH, dioxins, pesticides etc.) and their properties

Lecture: Biology and ecology of water, soil and air systems

The students

- know about the relation between water, soil and air compartments and many diseases, happening especially in developing countries

- know about the reasons for break out of diseases, the structure and function of prokaryotic and eucaryotic cells as well as the methods for identification and determination of growth conditions and possible growth limitations

- comprehend microbial metabolism, energy production, release and conservation, enzyme syntheses and their regulation.

- know important events and scientists in the history of biology

- know basics in ecology of natural and artificial ('technical') ecosystems as well as selected methods to detect distorted equilibria in technical ecosystems influenced by mankind

Lecture: Technical and medical microbiology for engineers

The students

- know the most important microorganisms being active in plants treating waste water, air and contaminated soil

- know the kind of participation in purification and thus the procedures used to make them feel happy as well as the problems associated with excess biomass

- are aware of a detailed overview of the kind of medically important microorganisms and of the most relevant agents of illness met in these plants, this holds also for the compartments 'drinking water' and 'sewage sludge'.

13. Inhalt:

Lecture: Inorganic chemistry

- atomic structure: stable nuclear particles, atomic nuclei, isotopes and radioactivity, atomic spectra and the hydrogen atom, heavier atoms
- the periodic system of the elements: the sequence of elements, the electronic configuration of some elements, the periodicity of some properties
- chemical bonding: the ionic bond, the metallic bond, the covalent bond, hydrogen bonding, van der Waals forces
- quantitative Relationships and Stoichiometric Equations
- characterizing chemical reactions: the chemical equilibrium, water: the solvent, acid/base reactions, redox reactions
- descriptive part: selected chemical compounds and their preparation and properties

Lecture: Organic chemistry

- functional groups and compound classes
- classification of chemical reactions in organic chemistry
- organic bio-molecules (e.g. proteins, carbohydrates, nucleic acids, fats, humic acids, lignin): structure and function
- chemical and microbial degradation of organic matter in the environment
- summary parameters
- organic environmental contaminants

Lecture: Biology and ecology of water, soil and air systems

The following topics are presented within the lecture:

- Introduction in history of microbiology
- Important waterbased/water related diseases
- Function of microscopy of staining techniques
- Structure and function of prokaryotic cells
- Structure and function of eucaryotic cells

	• Necessity and effects of microbial nutrition • Microbial growth relations and possible limitations • Microbial metabolism: Energy production, conservation and release • Microbial metabolism: Enzymes syntheses and regulation. **Lecture: Technical and medical microbiology for engineers** • Important (sewage) water based /water related diseases/ detection and possible countermeasures • Important soil and air connected diseases • (micro)biological principles in application of engineering techniques • Implication of engineer work on ecosystems /environment protection problems Some test systems for estimation of (bio)degradability of chemicals will be evaluated
14. Literatur:	Lecture notes pdf download of powerpoint slides for lectures Exercises as hand-out or download (pdf)
15. Lehrveranstaltungen und -formen:	• 191001 Lecture Inorganic chemistry • 191002 Lecture Organic chemistry • 191003 Lecture Biology and ecology of water, soil and air systems • 191004 Lecture Technical and medical microbiology for engineers
16. Abschätzung Arbeitsaufwand:	Time of attendance: Inorganic chemistry (Schwederski): Lecture, 1 SWS = 14 hours Organic chemistry (Metzger/Kuch): Lecture, 1 SWS = 14 hours Biology and ecology of water, soil and air systems (Engesser): Lecture, 1 SWS = 14 hours Technical and medical microbiology for engineers (Engesser): Lecture, 1 SWS = 14 hours Exercises for Chemistry and Biology for environmental engineers, 2 SWS = 28 hours Exam: 2 hours Sum of attendance: 86 hours Exercises (group work with presentations): 28 hours Self -study: 94 hours:
17. Prüfungsnummer/n und -name:	19101 Chemistry and Biology for Environmental Engineers (PL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Video projector (powerpoint) presentation explanations on blackboard, group work with presentations
20. Angeboten von:	Hydrochemie und Hydrobiologie in der Siedlungswasserwirtschaft

Modul: 19310 Urban Drainage and Design of Wastewater Treatment Plants

2. Modulkürzel:	021210251	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Ulrich Dittmer
9. Dozenten:	Harald Schönberger Ulrich Dittmer
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Chemistry and Biology for Environmental Engineers Sanitary Engineering
12. Lernziele:	Advanced knowledge of processes and concepts for urban drainage and municipal wastewater treatment systems Basics of construction and dimensioning of different urban drainage systems, stormwater treatment facilities and wastewater treatment plants as a base for dimensioning and discussion of proved and innovative technologies Deeper understanding for system connections as base for a decisions during the planning process
13. Inhalt:	Design of sewer systems and stormwater treatment (Dr.- Ing. Ulrich Dittmer) principles of collection and disposal design of combined and separate sewer systems Sustainable urban drainage systems (SUDS) and low impact design(LID) Application of rainfall runoff models (computer exercise using U.S. EPA Stormwater Management Model) different techniques for treatment and retention

	design of treatment facilities Design of wastewater treatment plants (Prof. Dr.-Ing. Heidrun Steinmetz) Municipal wastewater treatment different techniques for advanced biological wastewater treatment (nitrogen and phosphorous removal) principles of process engineering design of biological wastewater treatment plants and the main important aggregates design of sludge treatment plants Seminar: feasibility studies (Prof. Dr.- Ing. Heidrun Steinmetz and external consultants) special examples for sanitation concepts for world wide application Ecological sanitation and resource orientated systems case studies
14. Literatur:	• Butler, D., Davies, J.W) .Urban drainage, Spon press London, US EPA: SWMM 5.0 users manual • Henze, M., Harremoes, J. la Coour Jansen, J., Arvin, E: Wastewater treatment. Springer Verlag Berlin • Lens, P, Zeeman,G., Lettinga, G.: Decentralised Sanitation and reuse. IWA publishing, London • Different German standards (DWA, Hennef) • Lecture notes
15. Lehrveranstaltungen und -formen:	• 193101 Vorlesung und Übung Design of Sewer System and Stormwater Treatment • 193104 Exkursion • 193102 Vorlesung und Übung Design of Wastewater Treatment Plants • 193103 Seminar Case Study
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 70 hours (including 4*4hours for excursion) 1,5 SWS Private Study: approx. 110 hours Lecture 1 Presence time: 28 hours, self study 30 hours, project 0, Sum: **58 hours** Lecture 2: Presence time: 28 hours, self study 30 hours, project 40, Sum: **58 hours** Case study: Presence time: 14 hours, self study 10 hours, project 0, Sum: **25 hours**
17. Prüfungsnummer/n und -name:	19311 Urban Drainage and Design of Wastewater Treatment Plants (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 19360 Water Quality and Treatment

2. Modulkürzel:	021210051	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Carsten Meyer
9. Dozenten:	Harald Schönberger Carsten Meyer
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Knowledge in Sanitary Engineering, Water Supply and Hydraulics Contents of Water and Power Supply
12. Lernziele:	• The students learn how to characterize and protect water bodies as well as to improve the water quality • Students understand the contribution of wastewater treatment to the preventive protection of receiving waters and they learn the basic methods of water quality management instruments • Students understand the necessity of water treatment as essential element of drinking water supply • Students learn the chemical, physical and biological background of water treatment technologies, their possibilities and boundaries and they are able to develop, design and dimension treatment schemes for different raw water qualities
13. Inhalt:	Water Quality Management: • Terms and introduction: environmental data from Germany • Characterisation and assessment of flowing waters, stagnant waters and groundwater • Water quality parameters, WHO drinking water guidelines, targets for drinking water and sanitation, description of water quality in relation to use • Improvement of water quality, reduction of pollution load, point pollutants and diffuse loads, improving the self-purification capacity of waters, technical helps, assessment of progress

	• Water quality management, the European Union Framework Directive, quality planning and maintenance, monitoring networks Water Treatment: • Water supply and water treatment: basic requirements, drinking water standards • Mechanical treatment: Screening, Sieving, Sedimentation, (Membrane)Filtration, Gas-Exchange, Flotation • Carbondioxide-Carbonate-Balance: relevance, chemical background • Deacidification: mechanical and chemical methods • Removal of iron, manganese and arsenic: methods • Decarbonization: chemical methods • Flocculation • Adsorption • Disinfection: chemical and physical methods
14. Literatur:	Lecture notes and material for exercises will be provided during the lecture. Hints are given for additional literature from the internet as well as libraries, e.g. • American Water Works Assoc.: Water Quality and Treatment, McGraw-Hill Inc., 1999 • David A. Chin: Water-Quality Engineering in Natural Systems, John Wiley und Sons, Inc., 2006 • Degremont: Water Treatment Handbook Vol. 1 und Vol. 2, Lavoisier Publishing 1991 • C. Binnie and M. Kimber: Basic Water Treatment: Fourth Edition, IWA Publishing, 2009 • Nicholas P. Cheremisinoff: Handbook of Water and Wastewater Treatment Technologies, Bitterworth und Heinemann, Boston Oxford Auckland Johannesburg Melbourne New Delhi, 2002 • WHO Guidelines, 2006 • Mutschmann, J, Stimmelmayr, F.: Taschenbuch der Wasserversorgung, Vieweg-Verlag
15. Lehrveranstaltungen und -formen:	• 193601 Lecture Water Treatment • 193602 Lecture Water Quality Management
16. Abschätzung Arbeitsaufwand:	Time of attendance: ca. 42 h Private study: ca. 138 h 1) Lecture: presence time = 34,0, self study = 106,0, Sum = 140,0 2) Exercise: presence time = 8,0, self study = 32,0, Sum = 40,0 Sum Lecture (140) + Sum Exercise (40) = 180,0
17. Prüfungsnummer/n und -name:	19361 Water Quality and Treatment (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 25080 Structural Engineering of Hydraulic Structures

2. Modulkürzel:	LWW_01	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Kristina Terheiden
9. Dozenten:	Kristina Terheiden Hans-Peter Koschitzky
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Basic Knowlegde of Structural Engineering
12. Lernziele:	Students know basics of structural design, restoration and monitoring of hydraulic structures e.g. (reinforced) concrete or block mansonry structures in theory and for practical applications. Furthermore they are able to select and design hydraulic gates and for seveal purposes.
13. Inhalt:	The module contains two parts: **Structural Design, Restoration and Monitoring of Dams** Determination of internal forces of tanks, silos, arched dams using membrane and bending theory FEM for structural hydraulic engineering as large dams (Theory und Practical Application) Damage and failure of dams Monitoring of dams Restoration of dams **Hydraulic Gates** Mechanics and Operation of Hydraulic Gates Design and operating windows Hydraulics and special problems caused by high speed flows Maintanance of hydraulic gates
14. Literatur:	
15. Lehrveranstaltungen und -formen:	• 250802 Übung Talsperrenbemessung, -sanierung, -überwachung • 250803 Vorlesung Stahlwasserbau • 250804 Übung Stahlwasserbau • 250801 Vorlesung Talsperrenbemessung, -sanierung, -überwachung
16. Abschätzung Arbeitsaufwand:	Time of attendance: 55 h Private study: 125 h Total: 180 h

17. Prüfungsnummer/n und -name:	25081	Structural Engineering of Hydraulic Structures (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :		
19. Medienform:		
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft	

Modul: 50120 Environmental Informatics

2. Modulkürzel:	021430002	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Johannes Riegger
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester ➞ Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 3. Semester ➞ Auswahl 1 (6 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester ➞ Compulsory Modules M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Zusatzmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	Skills in Spreadsheet Calculations for Data Processing,Design, Creation, Handling and Application of Relational Database Management Systems for Environmental Issues, Creation and display of Environmental GIS data sets .Use of GIS functionalities to investigate spatial and attribute relationships
13. Inhalt:	**Information Processing und Environmental Data Management** (Excel und Access): Environmental Database Design, Relational Database Management, Data Normalization, Data Security **GIS Tools in Environmental Engineering (ArcGIS):** Basics of GIS, Data implementation, Spatial Structures and Attributes, Display of Environmental Information, Charts und

	Diagrams, Digitization, Spatial and Logical Queries, Data Links, Geo-Referencing, Field Calculations
14. Literatur:	Script: J. Riegger 'Environmental Informatics' User Handbooks for Excel, Access, ArcGIS **Getting to know ArcGIS Desktop ISBN: 9781589482609**
15. Lehrveranstaltungen und -formen:	• 501201 Lecture Environmental Data Management • 501202 Lecture GIS Tools in Environmental Engineering
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 56 hours Private Study: approx. 124 hours during semester Sum: 180h
17. Prüfungsnummer/n und -name:	• 50121 Environmental Informatics (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50130 Integrated Watershed Modeling

2. Modulkürzel:	021430009	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sergey Oladyshkin
9. Dozenten:	Andras Bardossy Sergey Oladyshkin
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: basic knowledge of environmental fluid mechanics, hydrology and geohydrology Prerequisite module: none
12. Lernziele:	**Hydrological Modeling:** Construction of models for each part in the runoff process and how these models are used and integrated in different environment management systems. **Integrated model systems for the groundwater management:** Groundwater and hydrological modelling, Calibration and Validation, Stochastic modelling
13. Inhalt:	**Hydrological Modeling:** What happens to the rain? This is the basic question that needs to be addressed in order to predict the amount of discharge at a certain location in a river system at a given time. Which parts of the fate of rainfall can be determined on a physical basis, and which are still left to empirical searching? Beside the qualitative determination of e.g. the processes of evapotranspiration,

	infiltration, interflow etc. we also need to describe the quantities of these processes to be able to forecast e.g. flood events. Hydrological watershed modelling is fundamental to integrated water management. There are complex interactions between the elements of the environmental continuum. In order to predict future behaviour and to quantify effects of management changes, quantitative mathematical descriptions are needed. A number of advanced hydrological watershed models have been developed in the last 30 years. A few of them will be reviewed in terms of their data needs and there predictive power. The participants are encouraged to form groups and to use their selected models for the same catchment so that the different approaches are compared. **Integrated model systems for the groundwater management:** Water is unique – no other element is so ubiquitous, vital, vulnerable and threatening at the same time. We must secure our access to clean water, shield our civilization from droughts and floods, use water sustainably in food and energy production, and protect water as part of our environment. However our surroundings behave non-trivially in various time and spatial scales. Moreover, many environmental systems such as hydrological systems (precipitation, evaporation, infiltration, groundwater flow, surface flow, etc.) are heterogeneous, non-linear and dominated by real-time influences of external driving forces. Unfortunately, a complete picture of surroundings water systems is not available, because many of these systems cannot be observed directly and only can be derived using sparse measurements. Modeling plays a very important role in reconstructing (as far as possible) the complete and complex picture of the surroundings water systems and offers a unique way to predict behavior of such multifaceted systems. The current course deals with Integrated Watershed Modelling. The main modelling principles are discussed that helps adequately describe the natural system and it's behavior on the basis of the corresponding physical processes. It's imply assumptions about physical concepts, numerical schemes, mathematical formulations, boundary conditions and modelling parameters. The course offers concepts how to incorporate the data into the modelling process, how to calibrate the established model and how to perform validate against the available observation data. The course introduces theoretical concepts and demonstrates how to transfer them into practical applications using hydrological and groundwater modelling. This course is offering insights into the MODFLOW Software that is the USGS's modular hydrologic model. MODFLOW is considered an international standard for simulating and predicting groundwater conditions and groundwater/surface-water interactions. Additionally course is exploring some features of MATLAB software as one of most productive software environment for engineers and scientists.
14. Literatur:	Beven, K.J., 2000. Rainfall-Runoff Modelling: The Primer. Wiley, 360pp. Singh, V.P. (Ed.), 1995. Computer Models of Watershed Hydrology. Water Resource Publications, Littleton, Colorado, USA.
15. Lehrveranstaltungen und -formen:	• 501301 Lecture and excercise Hydrological Modeling • 501302 Lecture and excercise Integrated model systems for the groundwater management
16. Abschätzung Arbeitsaufwand:	

17. Prüfungsnummer/n und -name:	50131 Integrated Watershed Modeling (PL), Schriftlich, 150 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Stochastische Simulation und Sicherheitsforschung für Hydrosysteme

Modul: 50140 Modeling of Hydrosystems

2. Modulkürzel:	021420011	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Rainer Helmig
9. Dozenten:	Bernd Flemisch Rainer Helmig
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Module zum abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Higher Mathematics: • Partial differential equations • Numerical integration Fundamentals of fluid mechanics: • Conservation equations for mass, momentum, energy • Mathematical descr
12. Lernziele:	Students can select suitable numerical methods for solving problems from fluid mechanics and have basic knowledge of implementing a numerical model in C.
13. Inhalt:	Discretisation methods: • Knowledge of the common methods (finite differences, finite elements, finite volume) and the differences between them • Advantages and disadvantages and of the methods and thus of their applicability

	• Derivation of the various methods • Use and choice of the correct boundary conditions for the various methods Time discretisation: • Knowledge of the various possibilities • Assessment of stability, computational effort, precision • Courant number, CFL criterion Transport equation: • Various discretisation possibilities • Physical background • Stabiity criteria of the methods (Peclet number) Clarification of concepts: model, simulation Application of the finite element method to the stationary groundwater equation Setting-up of a simulation programme for modeling groundwater: • Programme requirements • Programming individual routines Fundamentals of programming in C: • Control structures • Functions • Arrays • Debugging Visualisation of the simulation results
14. Literatur:	Lecture notes: Modeling of Hydrosystems, Helmig Helmig, R.: Multiphase Flow and Transport Processes in the Subsurface, Springer Verlag, 1997
15. Lehrveranstaltungen und -formen:	• 501403 Lecture and Excercise Modeling of Hydrosystems 2, Applications • 501401 Lecture and Excercise Modeling of Hydrosystems 1, Fundamentals
16. Abschätzung Arbeitsaufwand:	Sum: 180h
17. Prüfungsnummer/n und -name:	50141 Modeling of Hydrosystems (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Fundamentals will be developed using the blackboard and presentation tools. Group exercises help in understanding the obtained theoretical basis.
20. Angeboten von:	Hydromechanik und Hydrosystemmodellierung

Modul: 50150 Stochastical Modeling and Geostatistics

2. Modulkürzel:	021430003	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Deutsch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Andras Bardossy
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Module zum Abwählen M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester ➞ Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Module zum abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Basic knowledge of statistics Prerequisite module: none
12. Lernziele:	**Concepts of Geostatistics:** Knowledge of the basic geostatistical concepts, difference between Kriging and simulation, advantages and disadvantages of the discussed methods, application of Kriging and simulation **Stochastical Modeling:** The participants have skills in basic statistical methods used in hydrology, like time series analysis, extreme value statistics, parameter estimation methods and statistical tests.
13. Inhalt:	**Concepts of Geostatistics:** Geostatistical procedures for the interpolation of measured values, assessment of model parameters and planning of Measuring networks are dealt with. Contents: • Introduction

- Statistical hypotheses: Basic concepts, Regionalized variables, Second order stationarity, Intrinsic hypothesis, Comparison of the two hypotheses, Selection of the regionalized variable
- The variogram: The experimental variogram, The theoretical variogram, Variogram models, Variogram fitting, Isotropy -, anisotropy
- Ordinary Kriging: Point kriging, Block kriging, Properties of ordinary kr., Kr.as an interpolator, Kr. and the variogram, Practice of kr.,Selection of the neighbourhood, Kr. with a "false" variogram, Cross validation, Kr. with uncertain data, Simple Kr.
- Non stationary methods: Universal kr.,Intrinsic random functions of order k, External-Drift-Kr.
- Indicator Kriging: Indicator Kriging, Applications
- Kriging with arbitrary additional information: Markov-Bayes-Kriging, Simple Updating (SU)
- Time dependent variables
- Simulations: Basic definitions, Monte Carlo, Turning Band, Unconditional simulation, Conditional simulation, Sequential Simulation, Simulation using Markov Chains, The Hastings Algorithm, Simulated annealing, Indicator Simulation, Truncated-Gaussian Simulation, Application of simulations
- Exercises

Stochastical Modeling:
The lecture part stochastic modeling is primarily concerned with the stochastic analysis of temporal and areal arrays, their generation and their use in the hydrological modeling. Calculation and analysis of hydrological data, descriptive statistic and their parameters, possibility analysis, correlation and regression, time series analysis and simulation.
Content:

- Univariate Statistics and multivariate Statistics (e.g. regression analysis)
- theory of probabilities
- random variables and probability functions (e.g. Poission distribution)
- estimation of parameters (e.g. Maximum Likelihood Method)
- statistical tests (e.g. Kolmogorov-Smirnov test)
- extreme value statistics (analysis of the frequency of occurrence of floods)
- time series analysis (e.g.. ARMA Models)
- stochastic simulations (Monte-Carlo Methods)

14. Literatur:

Geostatistics:
Introduction to Geostatistics (Lecture notes, English)
Kitanidis, P. K (1997): Introduction to geostatistics: applications to hydrogeology
Armstrong, Margaret (1998): Basic linear geostatistics
Stochastical Modeling:
Plate, E. 1994. Statistik und angewandte Wahrscheinlichkeitslehre für Bauingenieure. Berlin.
Bras, R. L. and Ignacio Rodriguez-Iturbe. 1993. Random Functions and Hydrology. Dover Publications, Inc. New York.
Hipel, K. W. and McLeod. A. I. 1994. Time Series Modeling of Water Resources and Environmental Systems. Elsevier. Amsterdam.
Chow, V.-E. 1964. Handbook of applied Hydrology. McGraw-Hill Book. Company. New York.

	Maniak, U. 1997. Hydrologie und Wasserwirtschaft: Eine Einführung für Ingenieure. 4. überarb. und erw. Auflage. Springer. Berlin
15. Lehrveranstaltungen und -formen:	• 501501 Lecture Concepts of Geostatistics • 501502 Lecture and Excercise Stochastical Modeling
16. Abschätzung Arbeitsaufwand:	Sum:180h
17. Prüfungsnummer/n und -name:	50151 Stochastical Modeling and Geostatistics (PL), Schriftlich, 90 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

200 Spezialisierungsmodule

Zugeordnete Module:

15010	Integrated River Management and Engineering
15150	Fuzzy Logic and Operation Research
15160	Water and Power Supply
19100	Chemistry and Biology for Environmental Engineers
19310	Urban Drainage and Design of Wastewater Treatment Plants
19330	Industrial Waste Water
19360	Water Quality and Treatment
19390	Sanitary Engineering - Practical Class
25080	Structural Engineering of Hydraulic Structures
34420	Regional and Urban Planning II
36400	Limnic Ecology
36450	Special Aspects of Urban Water Management
50120	Environmental Informatics
50130	Integrated Watershed Modeling
50140	Modeling of Hydrosystems
50150	Stochastical Modeling and Geostatistics
50160	Applied GIS
50170	Environmental Fluid Mechanics II
50180	Flood Control: Evaluation and Case Studies
50190	Geohydrological Modelling I and II
50200	Geohydrological Modelling III
50210	Geohydrology and Geoengineering
50230	Hydrogeological Investigations
50260	Measurements in the Watercycle
50280	Multiphase Modeling in Porous Media
50290	Numerical Methods for Differential Equations
50300	Planning and Design of Water Supply Facilities
50320	Project Preparation, Management and Finance
50330	Regional and Urban Planning I
50340	Regional and Urban Planning III
50350	Water Resources and Irrigation - Planning Methods and Tools
50520	Environmental Aspects
50560	Project Planning and Financing
50580	Methodological Aspects of Infrastructure Planning
55860	Contaminated site remediation and investigation technologies
55950	Hydropower: Environmental Impacts, Mitigation measures and Ecohydraulic Investigations
58100	Constructed wetlands for wastewater treatment
68060	Advanced Methods in Biofilm Research

Modul: 15010 Integrated River Management and Engineering

2. Modulkürzel:	021410102	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Markus Noack
9. Dozenten:	Markus Noack Stefan Haun
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, Sommersemester → Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, Sommersemester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, Sommersemester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, Sommersemester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, Sommersemester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule
11. Empfohlene Voraussetzungen:	none (BAU), advisable LWW_Wabau none (UMW), advisable LWW_Gew Hydraulic Structures (WAREM)
12. Lernziele:	**River Engineering and Sediment Management** The students, • are aware of rivers must be regarded and managed based on an integrated approach • know the basic concept of the European Water Framework Directive (WFD) and the German legal framework for river basin management • are able to analyze and estimate the consequences of the WFD based inventory for future management • are aware of sediment transport processes and of the complexity of the interactions and relations • recognize the possibilities and limitations of sediment managements strategies **Integrated Flood Protection Measures** The students,

	• are aware of the fact that flood protection is an integral process, based on different components (e.g. technical flood protection measures, prevention) • know the basic physical processes: dynamics of flood events, calculation of discharges and water depths, flood wave propagation, functionality of retention and protection structures: reservoirs, dams and dikes • know 1-D and 2-D numerical hydro-dynamic models • are able to apply their knowledge on practical engineering problems related to flood protection
13. Inhalt:	The module consists of two lectures: **River Engineering and Sediment Management** • Basic approaches of river basin management (legal framework) • Systematics and results of basic inventory due to the WFD • Anthropogenic impacts on river basins • Origin of sediments and fundamental principles of transport • Sediment management measures on different scales **Integrated Flood Protection Measures** • Socio-economic aspects of flood damage • Calculation of water depths • Hydro-dynamic flood wave calculation, Saint Venant-equation • Technical flood protection measures • Design and operation of retention basins • Set-up of damage and risk maps, design of overtopping earthen dams and dikes • Probability of failure, reliability calculation, flood risk management
14. Literatur:	Lecture notes and exercise material can be downloaded from the internet. Hints are given for additional literature from the internet as well as libraries.
15. Lehrveranstaltungen und -formen:	• 150101 Vorlesung River Engineering and Sediment Management • 150102 Vorlesung Integrated Flood Protection
16. Abschätzung Arbeitsaufwand:	Time of attendance: 55 h Private study: 125 h
17. Prüfungsnummer/n und -name:	15011 Integrated River Management and Engineering (PL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

Modul: 15150 Fuzzy Logic and Operation Research

2. Modulkürzel:	021430004	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Deutsch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Andras Bardossy
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, ➞ Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 1. Semester ➞ Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester ➞ Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Modul Statistik und Informatik
12. Lernziele:	Die Studierenden sind mit den Grundlagen der Fuzzy-Modellierung wie Fuzzy Zahlen, Fuzzy Regeln, Fuzzy Sets, Membership Funktionen vertraut und können einfache auf Fuzzy-Logik basierende Modelle erstellen. Zudem kennen sie die Anwendungsmöglichkeiten von Fuzzy-Modellen ebenso wie deren Limitierungen. Die Studierenden erkennen die Problematik der Steuerung und Optimierung von komplexen Systemen für verschiedene Zielvorgaben. Sie beherrschen die grundlegenden Methoden der Systemsteuerung und können diese anwenden.
13. Inhalt:	**Fuzzy-Logic:** Um komplexe Prozesse und Zusammenhänge unserer Umwelt zu beschreiben und mögliche Folgen von Eingriffen abschätzen zu können, ist es notwendig, diese in mathematischen Modellen abzubilden. Fuzzy-Logik (oder Unscharfe-Logik) bietet einfache Werkzeuge, um derartige Modelle zu erstellen: Fuzzy-Sets, Membership Funktionen, Fuzzy Zahlen, Fuzzy Regeln **Operation Research:** Die Steuerung von Systemen mit komplexer Mehrfachzielsetzung ist eine Problemstellung wie sie beispielsweise auftritt bei der Steuerung von Wasserreservoirs, die für die Trinkwasserversorgung als auch den Hochwasserschutz eingesetzt werden. Die Optimierung der kombinierten Nutzung eines Wasserspeichers für verschiedene Wasserbereitstellungen mit unterschiedlicher Versorgungssicherheit ist ein weiteres Beispiel. Die Vorlesung gibt eine Einführung in die prinzipiellen Methoden der Systemsteuerung am Beispiel der Wasserwirtschaft.

14. Literatur:	Fuzzy rule based modeling with applications to geophysical, biological and engineering systems / Andras Bardossy, Lucien Duckstein. - Boca Raton [u.a.] : CRC Press, 1995
15. Lehrveranstaltungen und -formen:	• 151501 Vorlesung Fuzzy Logic • 151502 Vorlesung Operation Research
16. Abschätzung Arbeitsaufwand:	Präsenzzeit: 40 h Selbststudium: 140 h Gesamt: 180 h
17. Prüfungsnummer/n und -name:	15151 Fuzzy Logic and Operation Research (PL), Schriftlich, 90 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 15160 Water and Power Supply

2. Modulkürzel:	021410105	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sabine-Ulrike Gerbersdorf
9. Dozenten:	Ralf Minke Sabine-Ulrike Gerbersdorf
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Auswahl 1 (6 CP) --> Wahlpflichtmodule
11. Empfohlene Voraussetzungen:	None
12. Lernziele:	**Power Demand, Supply and Distribution:** The students, • know the German, European and worldwide energy markets related to demand, supply and its distribution capabilities • are aware of that non-renewable energy sources are strictly limited and time-scales for conversion of energy markets long • have an idea about the relations between energy, politics, social changes and influences on environment • have a basic knowledge about present energy conversion systems, theoretical limits of efficiencies, and the potential to enhance applied technology • have a basic understanding about where and how energy is provided and distributed • comprehend the balance between load and supply in electrical grids and the resulting necessity for control energy. **Water Demand, Supply and Distribution:** The students,

- know the German and worldwide water systems related to demand, supply and its distribution capabilities
- have an overview on the water supply situation all over the world.
- recognize the different possibilities and levels of water supply
- have an idea of the relations between water, politics, social changes and influences on environment.

13. Inhalt:

Power Demand, Supply and Distribution:

- Energy demand, energy supply
- Energy generation
  - overview of different types of power plants
  - renewable energy
  - thermal power plants (conventional and nuclear)
- Areas of application of different power plants
- Emission control techniques
- Cooling of thermal power plants
  - methods
  - water resources aspects
- Energy transport and energy storage
- Net techniques
- Energy market
  - trade
  - politics
  - law
- social changes due to energy supply

Water Demand, Supply and Distribution:

- Water supply and water distribution: necessity, basic requirements, elements, hydrological cycle
- Water demand calculation: water consumption, water demand, consumer groups, losses, forecasting, design periods
- Water collection: Selection of source, groundwater withdrawal, springwater tapping, surface water intakes, rainwater harvesting, seawater desalination, recycling of treated sewage, drinking water protection areas
- Water transmission and distribution: necessity, hydraulic basics, dimensioning and calculation of branched and closed loop systems.
- Pumps and pumping stations: necessity, types, hydraulics for pumping design, pumping stations and pressure boosters
- Water storage: necessity, types and functions of tanks and reservoirs
- Case study: planning and design of a water supply system for a small town

14. Literatur:

Lecture notes can be downloaded from the internet.
Hints are given for additional literature from the internet as well as libraries.

15. Lehrveranstaltungen und -formen:

- 151602 Vorlesung Water Demand, Supply and Distribution
- 151601 Vorlesung Energy Demand, Supply and Distribution

16. Abschätzung Arbeitsaufwand:

Time of attendance:	45 h
Private Study:	135 h

17. Prüfungsnummer/n und -name:

15161 Water and Power Supply (PL), Schriftlich, 120 Min., Gewichtung: 1

18. Grundlage für ... :

19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

Modul: 19100 Chemistry and Biology for Environmental Engineers

2. Modulkürzel:	021230502	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	6	7. Sprache:	Weitere Sprachen

8. Modulverantwortlicher:	Univ.-Prof. Dr. Jörg Metzger
9. Dozenten:	Karl Heinrich Engesser Brigitte Schwederski Jörg Metzger Bertram Kuch Daniel Dobslaw
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester → Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester → Elective Modules M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Pflichtmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	**Lecture: Inorganic chem istry** The students • know the fundamental concepts of chemistry (atomic structure, periodic system, chemical formulae, stoichiometry, molecular structures) and are able to use them,

- know the principle types of chemical substances and chemical reactions and can apply their knowledge to synthetic problems,
- know about the most important industrial compounds, their preparation and environmental aspects in their application.

Lecture: Organic chemistry

The students

- can identify important functional groups in organic molecules

- know the main compound classes in organic chemistry and the common rules for their nomenclature

- know the most important representatives thereof and

are able to draw their structural formulae

- know the structure and properties of important bio-molecules such as fats, carbohydrates, proteins, nucleic acids, ATP, lignin and humic acids

- know the most important reactions involved in chemical and microbial degradation of organic matter

- know summary parameters used to characterize water quality

- know the properties of bio-molecules and can explain their general function with respect to cell structures, enzymatic and immune reactions

- knows selected environmental organic contaminants (PAH, dioxins, pesticides etc.) and their properties

Lecture: Biology and ecology of water, soil and air systems

The students

- know about the relation between water, soil and air compartments and many diseases, happening especially in developing countries

- know about the reasons for break out of diseases, the structure and function of prokaryotic and eucaryotic cells as well as the methods for identification and determination of growth conditions and possible growth limitations

- comprehend microbial metabolism, energy production, release and conservation, enzyme syntheses and their regulation.

- know important events and scientists in the history of biology

- know basics in ecology of natural and artificial ('technical') ecosystems as well as selected methods to detect distorted equilibria in technical ecosystems influenced by mankind

Lecture: Technical and medical microbiology for engineers

The students

- know the most important microorganisms being active in plants treating waste water, air and contaminated soil

- know the kind of participation in purification and thus the procedures used to make them feel happy as well as the problems associated with excess biomass

- are aware of a detailed overview of the kind of medically important microorganisms and of the most relevant agents of illness met in these plants, this holds also for the compartments 'drinking water' and 'sewage sludge'.

13. Inhalt:

Lecture: Inorganic chemistry

- atomic structure: stable nuclear particles, atomic nuclei, isotopes and radioactivity, atomic spectra and the hydrogen atom, heavier atoms
- the periodic system of the elements: the sequence of elements, the electronic configuration of some elements, the periodicity of some properties
- chemical bonding: the ionic bond, the metallic bond, the covalent bond, hydrogen bonding, van der Waals forces
- quantitative Relationships and Stoichiometric Equations
- characterizing chemical reactions: the chemical equilibrium, water: the solvent, acid/base reactions, redox reactions
- descriptive part: selected chemical compounds and their preparation and properties

Lecture: Organic chemistry

- functional groups and compound classes
- classification of chemical reactions in organic chemistry
- organic bio-molecules (e.g. proteins, carbohydrates, nucleic acids, fats, humic acids, lignin): structure and function
- chemical and microbial degradation of organic matter in the environment
- summary parameters
- organic environmental contaminants

Lecture: Biology and ecology of water, soil and air systems

The following topics are presented within the lecture:

- Introduction in history of microbiology
- Important waterbased/water related diseases
- Function of microscopy of staining techniques
- Structure and function of prokaryotic cells
- Structure and function of eucaryotic cells

	• Necessity and effects of microbial nutrition • Microbial growth relations and possible limitations • Microbial metabolism: Energy production, conservation and release • Microbial metabolism: Enzymes syntheses and regulation. **Lecture: Technical and medical microbiology for engineers** • Important (sewage) water based /water related diseases/ detection and possible countermeasures • Important soil and air connected diseases • (micro)biological principles in application of engineering techniques • Implication of engineer work on ecosystems /environment protection problems Some test systems for estimation of (bio)degradability of chemicals will be evaluated
14. Literatur:	Lecture notes pdf download of powerpoint slides for lectures Exercises as hand-out or download (pdf)
15. Lehrveranstaltungen und -formen:	• 191001 Lecture Inorganic chemistry • 191002 Lecture Organic chemistry • 191003 Lecture Biology and ecology of water, soil and air systems • 191004 Lecture Technical and medical microbiology for engineers
16. Abschätzung Arbeitsaufwand:	Time of attendance: Inorganic chemistry (Schwederski): Lecture, 1 SWS = 14 hours Organic chemistry (Metzger/Kuch): Lecture, 1 SWS = 14 hours Biology and ecology of water, soil and air systems (Engesser): Lecture, 1 SWS = 14 hours Technical and medical microbiology for engineers (Engesser): Lecture, 1 SWS = 14 hours Exercises for Chemistry and Biology for environmental engineers, 2 SWS = 28 hours Exam: 2 hours Sum of attendance: 86 hours Exercises (group work with presentations): 28 hours Self -study: 94 hours:
17. Prüfungsnummer/n und -name:	19101 Chemistry and Biology for Environmental Engineers (PL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Video projector (powerpoint) presentation explanations on blackboard, group work with presentations
20. Angeboten von:	Hydrochemie und Hydrobiologie in der Siedlungswasserwirtschaft

Modul: 19310 Urban Drainage and Design of Wastewater Treatment Plants

2. Modulkürzel:	021210251	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Ulrich Dittmer
9. Dozenten:	Harald Schönberger Ulrich Dittmer
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester ➞ Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Chemistry and Biology for Environmental Engineers Sanitary Engineering
12. Lernziele:	Advanced knowledge of processes and concepts for urban drainage and municipal wastewater treatment systems Basics of construction and dimensioning of different urban drainage systems, stormwater treatment facilities and wastewater treatment plants as a base for dimensioning and discussion of proved and innovative technologies Deeper understanding for system connections as base for a decisions during the planning process
13. Inhalt:	Design of sewer systems and stormwater treatment (Dr.- Ing. Ulrich Dittmer) principles of collection and disposal design of combined and separate sewer systems Sustainable urban drainage systems (SUDS) and low impact design(LID) Application of rainfall runoff models (computer exercise using U.S. EPA Stormwater Management Model) different techniques for treatment and retention

	design of treatment facilities Design of wastewater treatment plants (Prof. Dr.-Ing. Heidrun Steinmetz) Municipal wastewater treatment different techniques for advanced biological wastewater treatment (nitrogen and phosphorous removal) principles of process engineering design of biological wastewater treatment plants and the main important aggregates design of sludge treatment plants Seminar: feasibility studies (Prof. Dr.- Ing. Heidrun Steinmetz and external consultants) special examples for sanitation concepts for world wide application Ecological sanitation and resource orientated systems case studies
14. Literatur:	• Butler, D., Davies, J.W) .Urban drainage, Spon press London, US EPA: SWMM 5.0 users manual • Henze, M., Harremoes, J. la Coour Jansen, J., Arvin, E: Wastewater treatment. Springer Verlag Berlin • Lens, P, Zeeman,G., Lettinga, G.: Decentralised Sanitation and reuse. IWA publishing, London • Different German standards (DWA, Hennef) • Lecture notes
15. Lehrveranstaltungen und -formen:	• 193101 Vorlesung und Übung Design of Sewer System and Stormwater Treatment • 193104 Exkursion • 193102 Vorlesung und Übung Design of Wastewater Treatment Plants • 193103 Seminar Case Study
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 70 hours (including 4*4hours for excursion) 1,5 SWS Private Study: approx. 110 hours Lecture 1 Presence time: 28 hours, self study 30 hours, project 0, Sum: **58 hours** Lecture 2: Presence time: 28 hours, self study 30 hours, project 40, Sum: **58 hours** Case study: Presence time: 14 hours, self study 10 hours, project 0, Sum: **25 hours**
17. Prüfungsnummer/n und -name:	19311 Urban Drainage and Design of Wastewater Treatment Plants (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 19330 Industrial Waste Water

2. Modulkürzel:	021210151	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Prof.Uni.Reg.de Blumenau Uwe Menzel
9. Dozenten:	Michael Koch Uwe Menzel
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester → Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester → Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	Students have: • a basic understanding for the problems and requirements of industrial waste water treatment • an overview of measures for production integrated environmental protection, relevant treatment methods for process water and its characterization • an overview of water analysis including sampling, the main principles of different analytical techniques and the ways to assure the quality of chemical analysis
13. Inhalt:	Fundamentals of industrial waste water treatment Determiniation of current situation possible process integrated measures, arrangements for reuse and recirculation of water mass and concentration balance Basic elements and examples for applications of advanced purification processes Biological waste water treatment Sampling and analytical techniques using on-site measurements, oxidation - reduction, acids and bases, sum parameters, photometry, spectrometry and chromatography Analytical quality assurance
14. Literatur:	• lecture notes (approx. 400 pages)

	• exercises • Lehr- und Handbuch der Abwassertechnik, 4. revised edition, volume I. GFA-Verlag St. Augustin 1994. • ATV V: Lehr- und Handbuch der Abwassertechnik, volume v: Organisch verschmutzte Abwässer der Lebensmittelindustrie, Wilhelm Ernst und Sohn Verlag, Berlin. • ATV VII: Lehr- und Handbuch der Abwassertechnik, volume VII: Industrieabwässer mit anorganischen Inhaltsstoffen, Wilhelm Ernst und Sohn Verlag, Berlin. • Deutsche Einheitsverfahren zur Wasser-, Abwasser und Schlammuntersuchung -Standard Methods for the Examination of Water and Wastewater • Wenclawiak, Koch, Hajicostas: Quality Assurance in Analytical Chemistry. Springerverlag 2003
15. Lehrveranstaltungen und -formen:	• 193301 Lecture Treatment of Industrial Waste Water • 193302 Lecture Water Analysis and Analytical Quality Control
16. Abschätzung Arbeitsaufwand:	Time of attendance: I Treatment of Industrial Waste Water: 2 SWS = 24 hours II Water Analysis and Analytical Quality Control: 2 SWS = 24 hours Exam: 2 hours sum of attendance: 50 hours self-study: 130 hours **total: 180 hours**
17. Prüfungsnummer/n und -name:	19331 Industrial Waste Water (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	power-point-presentation, blackboard and over-head projector
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 19360 Water Quality and Treatment

2. Modulkürzel:	021210051	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Carsten Meyer
9. Dozenten:	Harald Schönberger Carsten Meyer
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Knowledge in Sanitary Engineering, Water Supply and Hydraulics Contents of Water and Power Supply
12. Lernziele:	• The students learn how to characterize and protect water bodies as well as to improve the water quality • Students understand the contribution of wastewater treatment to the preventive protection of receiving waters and they learn the basic methods of water quality management instruments • Students understand the necessity of water treatment as essential element of drinking water supply • Students learn the chemical, physical and biological background of water treatment technologies, their possibilities and boundaries and they are able to develop, design and dimension treatment schemes for different raw water qualities
13. Inhalt:	Water Quality Management: • Terms and introduction: environmental data from Germany • Characterisation and assessment of flowing waters, stagnant waters and groundwater • Water quality parameters, WHO drinking water guidelines, targets for drinking water and sanitation, description of water quality in relation to use • Improvement of water quality, reduction of pollution load, point pollutants and diffuse loads, improving the self-purification capacity of waters, technical helps, assessment of progress

	• Water quality management, the European Union Framework Directive, quality planning and maintenance, monitoring networks Water Treatment: • Water supply and water treatment: basic requirements, drinking water standards • Mechanical treatment: Screening, Sieving, Sedimentation, (Membrane)Filtration, Gas-Exchange, Flotation • Carbondioxide-Carbonate-Balance: relevance, chemical background • Deacidification: mechanical and chemical methods • Removal of iron, manganese and arsenic: methods • Decarbonization: chemical methods • Flocculation • Adsorption • Disinfection: chemical and physical methods
14. Literatur:	Lecture notes and material for exercises will be provided during the lecture. Hints are given for additional literature from the internet as well as libraries, e.g. • American Water Works Assoc.: Water Quality and Treatment, McGraw-Hill Inc., 1999 • David A. Chin: Water-Quality Engineering in Natural Systems, John Wiley und Sons, Inc., 2006 • Degremont: Water Treatment Handbook Vol. 1 und Vol. 2, Lavoisier Publishing 1991 • C. Binnie and M. Kimber: Basic Water Treatment: Fourth Edition, IWA Publishing, 2009 • Nicholas P. Cheremisinoff: Handbook of Water and Wastewater Treatment Technologies, Bitterworth und Heinemann, Boston Oxford Auckland Johannesburg Melbourne New Delhi, 2002 • WHO Guidelines, 2006 • Mutschmann, J, Stimmelmayr, F.: Taschenbuch der Wasserversorgung, Vieweg-Verlag
15. Lehrveranstaltungen und -formen:	• 193601 Lecture Water Treatment • 193602 Lecture Water Quality Management
16. Abschätzung Arbeitsaufwand:	Time of attendance: ca. 42 h Private study: ca. 138 h 1) Lecture: presence time = 34,0, self study = 106,0, Sum = 140,0 2) Exercise: presence time = 8,0, self study = 32,0, Sum = 40,0 Sum Lecture (140) + Sum Exercise (40) = 180,0
17. Prüfungsnummer/n und -name:	19361 Water Quality and Treatment (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 19390 Sanitary Engineering - Practical Class

2. Modulkürzel:	021230501	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Bertram Kuch
9. Dozenten:	Bertram Kuch Ralf Minke Matthias Rapf Detlef Clauß
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	Prerequisite Modules : Sanitary Engineering Urban drainage and design of Wastewater treatment plants Chemistry and Biology for Environmental Engineers
12. Lernziele:	The student knows and understands in theory and practice - the most important parameters to characterize water and waste water and the analytical methods to determine them (e.g. pH, nitrate, ammonium, phosphorus, alkalinity, acidity, permanganate index, conductivity, oxygen, loss of ignition, filterable matter). - important techniques for removal of water contaminants (e.g. ion exchange, precipitation, coagulation, sorption, neutralization, aerobic, anoxic and anaerobic degradation) - how to take representative samples out of the different waste streams and the relevant sampling errors The student is aware of the most important microbiological tools to detect, handle and use microorganisms in environmental engineering systems The student - is capable of interpreting and evaluating analytical data and based on these data to draw conclusions in order to evaluate the quality of water and the efficiency of processes for treatment of water and solid waste. - is able to apply the relevant laboratory test procedures to analyze compost within the quality assurance system and to interpret the results. - has the competence to develop a sampling procedure for household waste and to determine the waste composition by a sorting analyses - is able to apply selected test procedures in the field of hazardous waste and the analyses of odor samples

13. Inhalt:	This course serves to the intensification of the theoretical knowledge in sanitary engineering by practical work in the laboratory and an accompanying student seminar. The experiments offered belong thematically to the three main areas: - water and waste water - solid waste - chemistry and microbiology The experiments are mainly performed directly by the students in groups of 3 to max. 6 or offered as demonstration experiments.
14. Literatur:	Description of Experiments (available as download, pdf) Handouts for seminar work
15. Lehrveranstaltungen und -formen:	• 193901 Praktikum Sanitary Engineering - Practical Class • 193903 Practical Work and Seminar Solid Waste
16. Abschätzung Arbeitsaufwand:	Time of attendance (incl. seminar work): 90 h Preparation time (before/ after practical work): 90 h Total: 180 hours
17. Prüfungsnummer/n und -name:	19391 Sanitary Engineering - Practical Class (PL), Schriftlich, 90 Min., Gewichtung: 1 written records of practical experiments
18. Grundlage für ... :	
19. Medienform:	• Explanation of experiments and presentation of the results of the practical work by the students (flip chart, blackboard) • Practical Work in chemical and microbiological laboratories
20. Angeboten von:	Hydrochemie und Hydrobiologie in der Siedlungswasserwirtschaft

Modul: 25080 Structural Engineering of Hydraulic Structures

2. Modulkürzel:	LWW_01	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Kristina Terheiden
9. Dozenten:	Kristina Terheiden Hans-Peter Koschitzky
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Basic Knowlegde of Structural Engineering
12. Lernziele:	Students know basics of structural design, restoration and monitoring of hydraulic structures e.g. (reinforced) concrete or block mansonry structures in theory and for practical applications. Furthermore they are able to select and design hydraulic gates and for seveal purposes.
13. Inhalt:	The module contains two parts: **Structural Design, Restoration and Monitoring of Dams** Determination of internal forces of tanks, silos, arched dams using membrane and bending theory FEM for structural hydraulic engineering as large dams (Theory und Practical Application) Damage and failure of dams Monitoring of dams Restoration of dams **Hydraulic Gates** Mechanics and Operation of Hydraulic Gates Design and operating windows Hydraulics and special problems caused by high speed flows Maintanance of hydraulic gates
14. Literatur:	
15. Lehrveranstaltungen und -formen:	• 250802 Übung Talsperrenbemessung, -sanierung, -überwachung • 250803 Vorlesung Stahlwasserbau • 250804 Übung Stahlwasserbau • 250801 Vorlesung Talsperrenbemessung, -sanierung, -überwachung
16. Abschätzung Arbeitsaufwand:	Time of attendance: 55 h Private study: 125 h Total: 180 h

17. Prüfungsnummer/n und -name:	25081	Structural Engineering of Hydraulic Structures (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :		
19. Medienform:		
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft	

Modul: 34420 Regional and Urban Planning II

2. Modulkürzel:	-	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Jörn Birkmann
9. Dozenten:	Astrid Ley Jörn Birkmann
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, → Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Wahlmodule
11. Empfohlene Voraussetzungen:	prerequisite modules: Regional and Urban Planning I
12. Lernziele:	The students are acquainted with basic methods of analysis and assessment in spatial planning. The students are able to cope with function, prerequisites and methodical problems of the methods present-ed.The lectures demonstrate the usage of planning instruments and methods based on planning cases from Germanyand other countries.
13. Inhalt:	The course Regional Planning II deals with the following planning methods: • Indicator-based monitoring and evaluation methods • Multi-criteria decision analysis (e.g. cost-benefit analysis, utility value analyis, analytic hierarchy process) • Methods of impact assessment • Techniques of demand forecast and land suitability analysis • Hazard and vulnerability analysis (climate change adaptation) The course Urban Planning II gives an overview on: • Levels of spatial planning in urban areas • Urban development planning • Urban analysis • Urban renewal • Urban planning instruments • Land use planning and implementation planning • Legal framework

14. Literatur:	Skript Regional and Urban Planning II
15. Lehrveranstaltungen und -formen:	• 344201 Vorlesung Regional Planning II • 344202 Vorlesung Urban Planning II
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx.45hours Private Study: approx. 120 hours
17. Prüfungsnummer/n und -name:	• 34421 Regional Planning II (LBP), , Gewichtung: 1 • 34422 Urban Planning II (LBP), , Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Optional
20. Angeboten von:	Raumentwicklungs- und Umweltplanung

Modul: 36400 Limnic Ecology

2. Modulkürzel:	021410205	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	0	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sabine-Ulrike Gerbersdorf
9. Dozenten:	Sabine-Ulrike Gerbersdorf
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule
11. Empfohlene Voraussetzungen:	Biologie Grundkenntnisse / basic knowledge in biology
12. Lernziele:	Knowledge on Limnology, Hydrobiology and Limnic Ecology is essential for solving problems concerned with water protection. Lecture Limnic Ecology The student knows about abiotic factors (e.g. light, nutrients, flow regime) to impact biocoenosis and thus to structure habitats/ biotopes. He/She understands the organisms and their metabolic activities in detail, ranging from primary producers (microalgae, macrophytes) to secondary producers and consumers up to trophic relationships (from microbial loop to higher food webs). The student is familiar with challenges for health and safety of water bodies / drinking water as well as self-purification within aquatic systems with regard to eutrophication, human impacts in a wider sense as well as natural toxic algae blooms. The student knows about the important question on the ecological balance of water bodies and strategies of biomanipulation, decontamination up to restoration in order to support the natural regeneration potential of aquatic systems. He/She understands both habitats, water column and sediment, as both compartments are strongly linked to each other and determine the overall health status. Seminar Selected topics in Limnic Ecology The student knows how to present research to an audience by practising and improving important presentation skills (soft skills) in response to appropriate feedback. At the same time he/she deepened his/her knowledge in selected topics by choosing a topic of his/her special interest from Limnic Ecology. The students learned about external lecturer and their special fields of interest and how to participate in a lively discussion.
13. Inhalt:	Lecture "Limnic Ecology

	This lecture gives insights into morphology and ecological principles of different water bodies (natural / artificial, groundwater, streams, lakes, drinking reservoirs etc). • Basic definitions and classifications schemes for a range of aquatic habitats, differences in lotic and stagnant water bodies • Abiotic factors and their impact on organisms and habitat: light, temperature, flow regime/turbulence, wind, water level, chemical factors, pH, conductivity, oxygen and nutrients • Biotic factors such as competition, prey-predator relations, biological engineering as well as primary and secondary production and decomposition • Ecosystem functions such as nutrient recycling, food webs or engineering / sediment stabilisation • Challenges for health and safety of water bodies: natural (toxic algae) to human (eutrophication) impacts • Strategies to re-establish or support ecological balance, is there an ecological balance? • Important methods investigating single abiotic (e.g. oxygen, nutrients) and biotic (e.g. chlorophyll) factors as well as complex interactions on ecological level (e.g. community composition) with implications for water purity will be presented Seminar Selected topics in Limnic Ecology A range of possible topics (front of research or actual/political interest) will serve as a choice, but also the students can come up with own ideas
14. Literatur:	Skript, Books: "Limnische Ökologie Lothar Kalbe, "Limnoecology Winfried Lampert, Ulrich Sommer, Internet sources
15. Lehrveranstaltungen und -formen:	• 364001 Lecture Limnic Ecology • 364002 Seminar Limnic Ecology
16. Abschätzung Arbeitsaufwand:	Lecture: Präsenzzeit/Presence: ca. 22,5 h Selbststudium/post-preparation: ca. 67,5 h Seminar: Präsenzzeit/Presence: ca. 22,5 h Selbststudium/post-preparation: ca. 67,5 h
17. Prüfungsnummer/n und -name:	36401 Limnic Ecology (PL), Schriftlich oder Mündlich, 90 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Powerpoint, Tafel
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 36450 Special Aspects of Urban Water Management

2. Modulkürzel:	021210006	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Ralf Minke
9. Dozenten:	Ralf Minke Ulrich Dittmer Klaus Werner König
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester → Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Inhaltlich: Grundlegende Kenntnisse der Gesamt,zusammenhänge der Siedlungswasser- und Wasserwirtschaft. Vertiefte Kenntnisse der Abwassertechnik, der Wassergütewirtschaft, der Wasserversorgung oder des allgemeinen Managements von Wasserressourcen. Formal: Wasserversorgungstechnik I oder Abwassertechnik I oder Waste Water Technology oder Water Quality and Treatment
12. Lernziele:	Fachlich: Die Studierenden entwickeln ein Verständnis für Zusammenhänge über ihre Teildisziplin hinaus. Sie können bei Entscheidungen und Planungen zwischen konkurrierenden Belangen der Siedlungswasserwirtschaft, Wasserwirtschaft und anderer Infrastrukturbereiche fachlich fundiert abwägen. Methodisch: Die Studierenden können selbständig mit internationaler wissenschaftlicher Literatur zu ihrem jeweiligen Fachgebiet umgehen, Ergebnisse kritisch bewerten und so ein eigenes Bild des Standes der Wissenschaft erarbeiten und präsentieren.
13. Inhalt:	- Wechselwirkungen zwischen Teilbereichen der Siedlungswasserwirtschaft am Beispiel des Umgangs mit Regenwasser - Jährlich wechselnde Spezialthemen entsprechend dem wissenschaftlichen und technischen Fortschritt

14. Literatur:	Gujer, W. Siedlungswasserwirtschaft, Springer Verlag GmbH Mutschmann, J, Stimmelmayr, F.: Taschenbuch der Wasserversorgung, Vieweg-Verlag Jeweils die aktuellen Auflagen Nationale und internationale Fachzeitschriften, z.B. GWF-Wasser/Abwasser, KA Abwasser, Abfall, Hrsg. und Verlag GFA, W.Sci.Tech., Wat. Res., Wasser und Abfall Diverse Merk- und Arbeitsblätter des DVGW und der DWA
15. Lehrveranstaltungen und -formen:	• 364503 Excursions • 364501 Scientific Seminar • 364502 Lecture Rainwater Harvesting and Management
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	36451 Special Aspects of Urban Water Management (Seminar presentation) (LBP), Schriftlich oder Mündlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 50120 Environmental Informatics

2. Modulkürzel:	021430002	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Johannes Riegger
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, 3. Semester ➞ Semi-Compulsory Modules M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 3. Semester ➞ Auswahl 1 (6 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, 3. Semester ➞ Compulsory Modules M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester ➞ Zusatzmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	Skills in Spreadsheet Calculations for Data Processing,Design, Creation, Handling and Application of Relational Database Management Systems for Environmental Issues, Creation and display of Environmental GIS data sets .Use of GIS functionalities to investigate spatial and attribute relationships
13. Inhalt:	**Information Processing und Environmental Data Management** (Excel und Access): Environmental Database Design, Relational Database Management, Data Normalization, Data Security **GIS Tools in Environmental Engineering (ArcGIS):** Basics of GIS, Data implementation, Spatial Structures and Attributes, Display of Environmental Information, Charts und

	Diagrams, Digitization, Spatial and Logical Queries, Data Links, Geo-Referencing, Field Calculations
14. Literatur:	Script: J. Riegger 'Environmental Informatics' User Handbooks for Excel, Access, ArcGIS **Getting to know ArcGIS Desktop ISBN: 9781589482609**
15. Lehrveranstaltungen und -formen:	• 501201 Lecture Environmental Data Management • 501202 Lecture GIS Tools in Environmental Engineering
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 56 hours Private Study: approx. 124 hours during semester Sum: 180h
17. Prüfungsnummer/n und -name:	• 50121 Environmental Informatics (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50130 Integrated Watershed Modeling

2. Modulkürzel:	021430009	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sergey Oladyshkin
9. Dozenten:	Andras Bardossy Sergey Oladyshkin
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: basic knowledge of environmental fluid mechanics, hydrology and geohydrology Prerequisite module: none
12. Lernziele:	**Hydrological Modeling:** Construction of models for each part in the runoff process and how these models are used and integrated in different environment management systems. **Integrated model systems for the groundwater management:** Groundwater and hydrological modelling, Calibration and Validation, Stochastic modelling
13. Inhalt:	**Hydrological Modeling:** What happens to the rain? This is the basic question that needs to be addressed in order to predict the amount of discharge at a certain location in a river system at a given time. Which parts of the fate of rainfall can be determined on a physical basis, and which are still left to empirical searching? Beside the qualitative determination of e.g. the processes of evapotranspiration,

	infiltration, interflow etc. we also need to describe the quantities of these processes to be able to forecast e.g. flood events. Hydrological watershed modelling is fundamental to integrated water management. There are complex interactions between the elements of the environmental continuum. In order to predict future behaviour and to quantify effects of management changes, quantitative mathematical descriptions are needed. A number of advanced hydrological watershed models have been developed in the last 30 years. A few of them will be reviewed in terms of their data needs and there predictive power. The participants are encouraged to form groups and to use their selected models for the same catchment so that the different approaches are compared. **Integrated model systems for the groundwater management:** Water is unique – no other element is so ubiquitous, vital, vulnerable and threatening at the same time. We must secure our access to clean water, shield our civilization from droughts and floods, use water sustainably in food and energy production, and protect water as part of our environment. However our surroundings behave non-trivially in various time and spatial scales. Moreover, many environmental systems such as hydrological systems (precipitation, evaporation, infiltration, groundwater flow, surface flow, etc.) are heterogeneous, non-linear and dominated by real-time influences of external driving forces. Unfortunately, a complete picture of surroundings water systems is not available, because many of these systems cannot be observed directly and only can be derived using sparse measurements. Modeling plays a very important role in reconstructing (as far as possible) the complete and complex picture of the surroundings water systems and offers a unique way to predict behavior of such multifaceted systems. The current course deals with Integrated Watershed Modelling. The main modelling principles are discussed that helps adequately describe the natural system and it's behavior on the basis of the corresponding physical processes. It's imply assumptions about physical concepts, numerical schemes, mathematical formulations, boundary conditions and modelling parameters. The course offers concepts how to incorporate the data into the modelling process, how to calibrate the established model and how to perform validate against the available observation data. The course introduces theoretical concepts and demonstrates how to transfer them into practical applications using hydrological and groundwater modelling. This course is offering insights into the MODFLOW Software that is the USGS's modular hydrologic model. MODFLOW is considered an international standard for simulating and predicting groundwater conditions and groundwater/surface-water interactions. Additionally course is exploring some features of MATLAB software as one of most productive software environment for engineers and scientists.
14. Literatur:	Beven, K.J., 2000. Rainfall-Runoff Modelling: The Primer. Wiley, 360pp. Singh, V.P. (Ed.), 1995. Computer Models of Watershed Hydrology. Water Resource Publications, Littleton, Colorado, USA.
15. Lehrveranstaltungen und -formen:	• 501301 Lecture and excercise Hydrological Modeling • 501302 Lecture and excercise Integrated model systems for the groundwater management
16. Abschätzung Arbeitsaufwand:	

17. Prüfungsnummer/n und -name:	50131 Integrated Watershed Modeling (PL), Schriftlich, 150 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Stochastische Simulation und Sicherheitsforschung für Hydrosysteme

Modul: 50140 Modeling of Hydrosystems

2. Modulkürzel:	021420011	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Rainer Helmig
9. Dozenten:	Bernd Flemisch Rainer Helmig
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Module zum abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Higher Mathematics: • Partial differential equations • Numerical integration Fundamentals of fluid mechanics: • Conservation equations for mass, momentum, energy • Mathematical descr
12. Lernziele:	Students can select suitable numerical methods for solving problems from fluid mechanics and have basic knowledge of implementing a numerical model in C.
13. Inhalt:	Discretisation methods: • Knowledge of the common methods (finite differences, finite elements, finite volume) and the differences between them • Advantages and disadvantages and of the methods and thus of their applicability

	• Derivation of the various methods • Use and choice of the correct boundary conditions for the various methods Time discretisation: • Knowledge of the various possibilities • Assessment of stability, computational effort, precision • Courant number, CFL criterion Transport equation: • Various discretisation possibilities • Physical background • Stabiity criteria of the methods (Peclet number) Clarification of concepts: model, simulation Application of the finite element method to the stationary groundwater equation Setting-up of a simulation programme for modeling groundwater: • Programme requirements • Programming individual routines Fundamentals of programming in C: • Control structures • Functions • Arrays • Debugging Visualisation of the simulation results
14. Literatur:	Lecture notes: Modeling of Hydrosystems, Helmig Helmig, R.: Multiphase Flow and Transport Processes in the Subsurface, Springer Verlag, 1997
15. Lehrveranstaltungen und -formen:	• 501403 Lecture and Excercise Modeling of Hydrosystems 2, Applications • 501401 Lecture and Excercise Modeling of Hydrosystems 1, Fundamentals
16. Abschätzung Arbeitsaufwand:	Sum: 180h
17. Prüfungsnummer/n und -name:	50141 Modeling of Hydrosystems (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Fundamentals will be developed using the blackboard and presentation tools. Group exercises help in understanding the obtained theoretical basis.
20. Angeboten von:	Hydromechanik und Hydrosystemmodellierung

Modul: 50150 Stochastical Modeling and Geostatistics

2. Modulkürzel:	021430003	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Deutsch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Andras Bardossy
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Module zum Abwählen M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester ➞ Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Module zum abwählen M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Vertiefungsmodule Wahlpflicht --> Vertiefungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Basic knowledge of statistics Prerequisite module: none
12. Lernziele:	**Concepts of Geostatistics:** Knowledge of the basic geostatistical concepts, difference between Kriging and simulation, advantages and disadvantages of the discussed methods, application of Kriging and simulation **Stochastical Modeling:** The participants have skills in basic statistical methods used in hydrology, like time series analysis, extreme value statistics, parameter estimation methods and statistical tests.
13. Inhalt:	**Concepts of Geostatistics:** Geostatistical procedures for the interpolation of measured values, assessment of model parameters and planning of Measuring networks are dealt with. Contents: • Introduction

- Statistical hypotheses: Basic concepts, Regionalized variables, Second order stationarity, Intrinsic hypothesis, Comparison of the two hypotheses, Selection of the regionalized variable
- The variogram: The experimental variogram, The theoretical variogram, Variogram models, Variogram fitting, Isotropy -, anisotropy
- Ordinary Kriging: Point kriging, Block kriging, Properties of ordinary kr., Kr.as an interpolator, Kr. and the variogram, Practice of kr.,Selection of the neighbourhood, Kr. with a "false" variogram, Cross validation, Kr. with uncertain data, Simple Kr.
- Non stationary methods: Universal kr.,Intrinsic random functions of order k, External-Drift-Kr.
- Indicator Kriging: Indicator Kriging, Applications
- Kriging with arbitrary additional information: Markov-Bayes-Kriging, Simple Updating (SU)
- Time dependent variables
- Simulations: Basic definitions, Monte Carlo, Turning Band, Unconditional simulation, Conditional simulation, Sequential Simulation, Simulation using Markov Chains, The Hastings Algorithm, Simulated annealing, Indicator Simulation, Truncated-Gaussian Simulation, Application of simulations
- Exercises

Stochastical Modeling:
The lecture part stochastic modeling is primarily concerned with the stochastic analysis of temporal and areal arrays, their generation and their use in the hydrological modeling. Calculation and analysis of hydrological data, descriptive statistic and their parameters, possibility analysis, correlation and regression, time series analysis and simulation.
Content:

- Univariate Statistics and multivariate Statistics (e.g. regression analysis)
- theory of probabilities
- random variables and probability functions (e.g. Poission distribution)
- estimation of parameters (e.g. Maximum Likelihood Method)
- statistical tests (e.g. Kolmogorov-Smirnov test)
- extreme value statistics (analysis of the frequency of occurrence of floods)
- time series analysis (e.g.. ARMA Models)
- stochastic simulations (Monte-Carlo Methods)

14. Literatur:

Geostatistics:
Introduction to Geostatistics (Lecture notes, English)
Kitanidis, P. K (1997): Introduction to geostatistics: applications to hydrogeology
Armstrong, Margaret (1998): Basic linear geostatistics
Stochastical Modeling:
Plate, E. 1994. Statistik und angewandte Wahrscheinlichkeitslehre für Bauingenieure. Berlin.
Bras, R. L. and Ignacio Rodriguez-Iturbe. 1993. Random Functions and Hydrology. Dover Publications, Inc. New York.
Hipel, K. W. and McLeod. A. I. 1994. Time Series Modeling of Water Resources and Environmental Systems. Elsevier. Amsterdam.
Chow, V.-E. 1964. Handbook of applied Hydrology. McGraw-Hill Book. Company. New York.

	Maniak, U. 1997. Hydrologie und Wasserwirtschaft: Eine Einführung für Ingenieure. 4. überarb. und erw. Auflage. Springer. Berlin
15. Lehrveranstaltungen und -formen:	• 501501 Lecture Concepts of Geostatistics • 501502 Lecture and Excercise Stochastical Modeling
16. Abschätzung Arbeitsaufwand:	Sum:180h
17. Prüfungsnummer/n und -name:	50151 Stochastical Modeling and Geostatistics (PL), Schriftlich, 90 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50160 Applied GIS

2. Modulkürzel:	062300071	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Li Zhang
9. Dozenten:	Daniel Feldmeyer Li Zhang Hans-Georg Schwarz-von Raumer Annette Schmitt
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Modul "Statistics and GIS"
12. Lernziele:	The students are able to evaluate different data sources, to carry through basic data acquisition and integrate different data into field and office GIS. They are able to apply spatial analysis techniques to real world GIS problems in environmental and regional planning (GIS-based modeling, network-, raster- and 3D-analysis). The students have the expertise and ability to manage small-scale GIS projects (data mining, analysis design, output delivery) within the planning workflow, from project definition to product delivery.
13. Inhalt:	GIS-based Data Acquisition Lecture: • introduction • GIS hard- and software for primary data acquisition • coordinate systems, geodetic datum and projections • coordinate transformations and conversions • terrestrial positioning and laser scanning • satellite-based positioning (GNSS) • overview of other acquisition methods • additional topics of mapping • data import from various sources (e.g. Web) • Web-GIS (e.g. Open Street Map)integration of data into GIS Exercices : • terrestrial and satellite-based data acquisition (field project) • integration of measured data into GIS (computer lab) • integration of web-data into GIS (computer lab) GIS in Environmental and Regional Planning Application cases: • land suitability analysis for urban development • accessibility of infrastructure facilities

	• Evaluation of soil functions • Urban Heat Island modelling • Biotope Networks and animal movement • Flood risk • Development capacity studies • Site analysis for wind power • GIS-based E-government and community participation Tools and methods: • Model builder • Spatial Analyst • Network Analyst • Map Algebra • Neighbourhod Analysis • Regression Modelling • Multi Criteria Evaluation • analysis design • project management Workflow: • Geoprocessing, • remote sensing data integration, • advanced visual communication
14. Literatur:	GIS-based Data Acquisition : ILIAS - Elearning Modules, Chen, Y., Lee, Y.: Geographical Data Acquisition, Springer, Wien - New York, 2001. GIS in Environmental and Regional Planning: ILIAS-Material, Exercise sheets, onlins-tutorial
15. Lehrveranstaltungen und -formen:	• 501604 Practical Training GIS in Environmental and Regional Planning • 501601 Lecture GIS-based Data Acquisition • 501602 Laboratory and Practical Training GIS-based Data Acquisition • 501603 Lecture GIS in Environmental and Regional Planning
16. Abschätzung Arbeitsaufwand:	Summe: 180 h
17. Prüfungsnummer/n und -name:	50161 Applied GIS (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Ingenieurgeodäsie und Geodätische Messtechnik

Modul: 50170 Environmental Fluid Mechanics II

2. Modulkürzel:	021420013	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Rainer Helmig
9. Dozenten:	Wolfgang Nowak Rainer Helmig
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, ➞ Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Mechanics of incompressible and compressible fluids, fundamentals of numerical methods in fluid mechanics, fundamentals of exchange and transport processes in technical and natural systems (e.g. groundwater and surface water, pipelines). Contents of Environmental Fluid Mechanics I
12. Lernziele:	Students have the necessary grasp of hydrodynamic, physical and chemical processes and systems to be able to answer environmentally relevant questions concerning water and air quality in natural and technical systems.
13. Inhalt:	The lecture deals with the heat and mass budget of natural and technical systems. This includes transport processes in lakes, rivers and groundwater, heat and mass transfer processes between compartments as well as between various phases (sorption, dissolution), conversion of matter in aquatic systems and the quantitative description of these processes. In addition to classical single fluid phase systems, multiphase flow and transport processes in porous media will be considered. On the basis of a comparison of single- and multiphase flow systems, the various model concepts will be discussed and assessed. In the accompanying exercises, example problems present applications, extend the lecture material and help prepare for the exam. Computer exercises improve the grasp of the problems and give insight into the practical application of what has been learned.
14. Literatur:	Lecture notes: Fluidmechanics II, Helmig Helmig, R.: Multiphase Flow and Transport Processes in the Subsurface. Springer, 1997

15. Lehrveranstaltungen und -formen:	• 501701 Lecture and Excercise Environmental Fluid Mechanics II
16. Abschätzung Arbeitsaufwand:	Sum: 180h
17. Prüfungsnummer/n und -name:	50171 Environmental Fluid Mechanics II (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Fundamentals will be developed using the blackboard and presentation tools. Process understanding will be improved using movies and experiments. Small exercises will help to to deepen the knowledge.
20. Angeboten von:	Hydromechanik und Hydrosystemmodellierung

Modul: 50180 Flood Control: Evaluation and Case Studies

2. Modulkürzel:	021410901	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	3 LP	6. Turnus:	Unregelmäßig
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Anne Weiß
9. Dozenten:	Prof. Dr. Sahol Hamid Abu Bakar, Guest lecturer from UiTM, MARA, Shah Alam, Malaysia
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	Lecture notes and exercise material can be downloaded from the internet. Hints are given for additional literature from the internet as well as libraries. Tucci, Carlos E. M.: Urban Flood Management, Peter Van Oosterom, Siyka Zlatanova, Elfriede M. Fendel: Geo-Information for Disaster Management
15. Lehrveranstaltungen und -formen:	• 501801 Lecture Flood Control: Evaluation and Case Studies
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	• 50181 Flood Control: Evaluation and Case Studies (BSL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Bau- und Umweltingenieurwissenschaften

Modul: 50190 Geohydrological Modelling I and II

2. Modulkürzel:	021430007	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Johannes Riegger
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 2. Semester ➞ Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester ➞ Auswahl 2 (12 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester ➞ Module zum Abwählen
11. Empfohlene Voraussetzungen:	Contents of Geohydrology and Geoengineering
12. Lernziele:	• Setup of a Geohydrological Model • Spatial and temporal Discretization (Stability Criteria) • Adequate Transfer of Nature into a Model • Simplification of complex Geohydrological Systems • Choice of adequate Numerical Scheme • Unique Calibration of Flow and Transport • Assessment of Geohydrological Model Approaches and Model Realizations
13. Inhalt:	Geohydrological Modelling 1: Groundwater Flow, Conceptual Model, Numerical Model, Modelling of Natural Systems, Calibration Process, Sensitivity Analysis, Model Verification and Validation. Geohydrological Modelling 2: Complex und Transient Systems, 3D-Flow, Fractured Systems, Double Porosity, Advective and Dispersive Transport, Numerical Methods for Transport, Stability Criteria, Chemical Reactions, Measurement of Transport Parameters, Transport Calibration
14. Literatur:	Script: J. Riegger 'Geohydrological Modelling' Anderson und Woessner 'Applied Groundwater Modelling' Spitz und Moreno : 'A Practical Guide to Groundwater and Solute Transport Modeling'

	Freeze und Cherry: 'Groundwater'
15. Lehrveranstaltungen und -formen:	• 501901 Lecture Geohydrological Modelling 1 • 501902 Lecture Geohydrological Modelling 2
16. Abschätzung Arbeitsaufwand:	Sum: 180h
17. Prüfungsnummer/n und -name:	50191 Geohydrological Modelling I and II (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50200 Geohydrological Modelling III

2. Modulkürzel:	021430021	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	3 LP	6. Turnus:	Sommersemester
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Johannes Riegger
9. Dozenten:	Johannes Riegger
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	recommended background knowledge: Contents of Geohydrological Modelling I+II
12. Lernziele:	Setup of Geohydrological Models for the purpose of heat transport Specific properties of heat transport parameters Pure Heat conductance (modflow) Heat transport with the fluid in porous media (mt3d) Equilibrium Approach and effective parameters Nonequilibrium Approach with Dual Porosity Boundaries and Initial Conditions Spatial and temporal Discretization (Stability Criteria)
13. Inhalt:	Geohydrological Modelling III: Theory of heat conductance and advective heat transport in porous media in thermal non- / equilibrium, Dual porosity approach, Adaption of heat parameters for calculation with modflow and mt3d, Calculation of non equilibrium heat conductance and transport with dual porosity approach, Application examples: ground heat collector, geothermal energy probes, geothermal tests, hydrothermal configurations (monopol, dipole, multipol) and their application for heat extraction or storage
14. Literatur:	Script: J. Riegger 'Geohydrological Modelling III'
15. Lehrveranstaltungen und -formen:	• 502001 Lecture Geohydrological Modelling 3
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 21 hours Private Study: approx. 69 hours during semester
17. Prüfungsnummer/n und -name:	50201 Geohydrological Modelling III (BSL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50210 Geohydrology and Geoengineering

2. Modulkürzel:	021430004	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Christian Moormann
9. Dozenten:	Christian Moormann
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Auswahl 1 (6 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Geoengineering: Basic knowledge of mechanics and groundwater flow Geohydrology: Basic knowledge of groundwater hydraulics Prerequisite module: none
12. Lernziele:	**Geoengineering:** The students have the required skills to treat fundamental soil mechanics problems such as: groundwater flow, consolidation, slope stability, settlement and soil strength calculations. **Geohydrology:** The students have a strong foundation in the applied skills required to locate, analyse, assess, develop, and protect groundwater resources.
13. Inhalt:	**Geoengineering:** This course includes information about the origin of soils and soil classification methods. It also includes the basics of groundwater flow as used in soil mechanics. Common geotechnical problems such as slope stability and soil consolidation are discussed and clarified. The stresses in soil, stiffness of soils and strength of soils are explained in details. **Geohydrology:** Covers the most important concepts of geology and hydrogeology, the interpretation of hydrogeological information from maps, aerial photographs, geophysical measurements and field data, the principles of groundwater development and the understanding of hydrogeological systems through case studies. A brief overview is given on the analysis of hydrochemical data and isotopes.

14. Literatur:	Geoengineering Lecture notes can be downloaded from the Internet, PowerPoint presentations Lancellotta, R. (1998): "Geotechnical Engineering", A.A. Balkema, Rotterdam,NetherlandDas, B.M. (1999): "Principles of Geotechnical Engineering", PSW, Internat Thomson Public., Boston, USASutton, B.H.C. (1994): "Solving problems in Soil Mechanics", McGraw-Hill Book Company, London, UKScott, C.R. (1994): "An introduction to Soil Mechanics and Foundation", E und FN Spon, London, UK Geohydrology: Lecture notes can be downloaded from the Internet via the ILIAS system, PowerPoint presentations Fetter, C.W. (2001): Applied Hydrogeology, 4th edition. Prentice Hall, 598 pages Wichtig: mindestens ein konkreter Titel (Monographie, Artikel o.ä.) ist anzugeben
15. Lehrveranstaltungen und -formen:	• 502102 Lecture Geohydrology • 502101 Lecture Geoengineering
16. Abschätzung Arbeitsaufwand:	Geoengineering: 84h Geohydrology: 54h
17. Prüfungsnummer/n und -name:	50211 Geohydrology and Geoengineering (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Geotechnik

Modul: 50230 Hydrogeological Investigations

2. Modulkürzel:	021430008	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Deutsch

8. Modulverantwortlicher:	Dr. Jochen Seidel
9. Dozenten:	Johannes Riegger Jochen Seidel
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 2. Semester → Auswahl 2 (12 CP) --> Wahlpflichtmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Hydrology, Hydrogeology, Fluid Mechanics
12. Lernziele:	**Field Course Hydrogeology:** The students know the most common field investigations used in groundwater. This includes the relevant theoretical basics on groundwater hydraulics, hydrogeology and field methods. When applying theoretical knowledge on practical problems, the participants are able to recognise critical points and develop appropriate solutions. **Pumping Test Analysis** The participants know the basic theories to analyse pumping tests and are able to use computer based methods like Spreadsheet Calculations for Analysis like Theis, Cooper-Jacob, Diagnostic Plots, Inverse Normalized Diagnostics, Recognition of Inner / Outer Boundaries, Heterogeneity, Well Effects and Handling of noise and trends.
13. Inhalt:	**Field Course Hydrogeology:** In the field: • Soil Sampling / Drilling • Surveying / Levelling • Piezometric Heads / Potentiometric Surfaces • Pumping Test - Recovery Test • Piezometer test / Slug test • Tracer Test • Geophysical Borehole measurements / Natural groundwater velocity

	• Groundwater Chemistry • Hydrogeological Site Assessment In the lab: • Column Experiments to Determine the Hydrodynamic Dispersion Coefficient and the Hydraulic Conductivity • Particle-Size Distribution and Soil Characterisation • Rocks: Definitions, Characterisation, Classification, Genesis, Hydraulic Properties In the classroom: • Theoretical background of the methods applied in the field and in the laboratory (see above) **Pumping Test Analysis** : Basic theory and computer exercises to evaluate and analyse the pumping tests. Analytical techniques, Diagnostic Plots, stationary / transient conditions, interior / outer boundary conditions, step-drawdown tests and Well Performance Tests, spatial distribution of parameters, regional parameters, effective parameters
14. Literatur:	**Field Course Hydrogeology:** Marsily: Quantitative Hydrogeology. Groundwater Hydrology for Engineers. Lecture Notes: Barthel/Seidel Field Course Hydrogeology **Pumping Test Analysis** Script: J. Riegger 'Pumping Test Analysis' Kruseman und de Ridder: 'Analysis and Evaluation of Pumping Test Data'
15. Lehrveranstaltungen und -formen:	• 502301 Lecture Field Course Hydrology • 502302 Lecture Pumping Test Analysis
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50231 Hydrogeological Investigations (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrologie und Geohydrologie

Modul: 50260 Measurements in the Watercycle

2. Modulkürzel:	040401001	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr. Johan Alexander Huisman
9. Dozenten:	Jochen Seidel Johan Alexander Huisman Rudolf Widmer-Schnidrig
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 2. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Module zum Abwählen M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	Recommended background knowledge: (I) Basic knowledge in Hydromechanics/Hydraulics corresponding to a lecture with approx. 6-8 ECTS (II) Basic physics of electricity and wave propagation
12. Lernziele:	The relevant principles of key measurement methodologies used to characterize the water cycle will be introduced and discussed so that the students can assess the advantages and disadvantages of the available measurements methodologies. In addition, the students will be sensitized for potential sources of error and uncertainty of measurements.
13. Inhalt:	**(I) Measuring surface hydrological fluxes** • Precipitation measurements • Evaporation and evapotranspiration measurements • Discharge measurements • Water quality measurements **(II) Measuring subsurface hydrological fluxes** • Infiltration measurements • Water potential measurements • Physical principles of water content measurements • Electromagnetic methods (TDR, GPR, Remote sensing) • Electrical methods (ERT, SP, SIP)
14. Literatur:	R. Herschey, Streamflow Measurement, Taylor und Francis, 3rd edition, 2009.

	S. Emais, Measurements Methods in Atomspheric Sciences, Boerntraeger, 2010. P. V. Sharma, Environmental and engineering geophysics, Cambridge Univ. Press, 1997.
15. Lehrveranstaltungen und -formen:	• 502601 Lecture Hydrometry and Remote Sensing • 502602 Lecture Hydrogeophysics
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50261 Measurements in the Watercycle (BSL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrogeophysik

Modul: 50280 Multiphase Modeling in Porous Media

2. Modulkürzel:	021420014	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	5	7. Sprache:	Englisch

8. Modulverantwortlicher:	apl. Prof. Dr.-Ing. Holger Class
9. Dozenten:	Holger Class Rainer Helmig
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule
11. Empfohlene Voraussetzungen:	Theory of multiphase systems in porous media: • Phases / components • Capillary pressure • Relative permeability Contents of Environmental Fluid Mechanics I
12. Lernziele:	Students have the basic theoretical and numerical knowledge to model multiphase systems in porous media. Furthermore, they have basic skills to practically work with numerical software, programming languages, etc.
13. Inhalt:	Using complex models in engineering practice requires well-founded knowledge of the characteristics of discretisation techniques as well as of the capabilities and limitations of numerical models, taking into account the respective concepts implemented and the underlying model assumptions. The contents are: Theory of multiphase flow in porous media • Derivation of the differential equations • constitutive relations Numerical solution of the multiphase flow equation • Box method • Linearisation • Time discretisation Multicomponent systems • Thermodynamic fundamentals and non-isothermal processes Application examples: • Thermal remediation techniques • CO2 storage in geological formations • Water / oxygen transport in gas diffusion layers of fuel cells • Freshwater / saltwater interaction

14. Literatur:	Lecture notes: Multiphase Modeling, Class Helmig, R.: Multiphase Flow and Transport Processes in the Subsurface. Springer, 1997 Class, H.: Models for Non-Isothermal Compositional Gas-Liquid Flow and Transport in Porous Media, Habilitation, Universität Stuttgart, 2008
15. Lehrveranstaltungen und -formen:	• 502801 Lecture Multiphase Modeling in Porous Media • 502802 Excercise Multiphase Modeling in Porous Media
16. Abschätzung Arbeitsaufwand:	Lectures: 55 h Self-study: 125 h Total: 180 h
17. Prüfungsnummer/n und -name:	50281 Multiphase Modeling in Porous Media (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Fundamentals will be developed using the blackboard and presentation tools. Group exercises help in understanding the obtained theoretical basis. Practical computer exercises for different problems are carried out with the help of an interactive multi-media system.
20. Angeboten von:	Hydromechanik und Hydrosystemmodellierung

Modul: 50290 Numerical Methods for Differential Equations

2. Modulkürzel:	080310506	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	3	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr. Kunibert Gregor Siebert
9. Dozenten:	Claus-Justus Heine
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	• basic knowledge about the theory of ordinary and/or partial differential equations • overview about numerical solution methods for these problems • ability to link a given problem and the appropriate method • ability to program solution methods in MATLAB
13. Inhalt:	In the first part of the semester, we will discuss algorithms for the numerical integration of ordinary differential equations (ODEs). In the second part, an introduction to partial differential equations (PDEs) and its solution by the use of the Finite Element (FE) method will be given. While the lecture focuses on the treatment of the required mathematical theory, the tutorial will place emphasis on the implementation of the developed schemes within the Matlab programming environment.
14. Literatur:	Stoer, Bulirsch: Introduction to numerical Analysis
15. Lehrveranstaltungen und -formen:	• 502901 Lecture Numerical Methods for Differential Equations • 502902 Tutorial Numerical Methods for Differential Equations
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 33=21(L)+12(T) hours Private Study: approx. 70 hours Preparation of exercises: 33 hours Coding: approx 40 hours
17. Prüfungsnummer/n und -name:	50291 Numerical Methods for Differential Equations (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Angewandte Mathematik/Numerik für Höchstleistungsrechner

Modul: 50300 Planning and Design of Water Supply Facilities

2. Modulkürzel:	021210052	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Ralf Minke
9. Dozenten:	Ralf Minke
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester ➞ Zusatzmodule
11. Empfohlene Voraussetzungen:	Knowledge in Sanitary Engineering, Water Supply and Hydraulics Contents ofWater and Power Supply
12. Lernziele:	The students, • Are able to plan and design centralised water supply systems as a part of rural and urban infrastructure. • Are able to calculate dimensions of all elements of centralised water supply systems. • Are able to calculate costs of all elements of centralised water supply systems. • have an idea of the relations between water, politics, social changes and influences on environment and on planning process. • Are able to design in detail all elements of centralised water supply systems.
13. Inhalt:	• Planning process as function of topografical, economical, social, environmental boundaries. • Water demand calculation: water consumption, water demand, consumer groups, losses, forecasting, design periods. • Water collection: Selection of source, groundwater withdrawal, springwater tapping, surface water intakes, rainwater harvesting, seawater desalination, recycling of treated sewage, drinking water protection areas, details of planning and design. • Water transmission and distribution: necessity, hydraulic basics, dimensioning and calculation of branched and closed loop systems, details of planning and design. • Pumps and pumping stations: necessity, types, hydraulics for pumping design, pumping stations and pressure boosters, details of planning and design. • Water storage: necessity, types and functions of tanks, water towers and reservoirs, details of planning and design. • Cost calculation: Cost functions for different facilities, Calculation process, calculation of water tariff.

14. Literatur:	Lecture notes can be downloaded from the internet. Karamouz, Mohammad et al.: Urban Water Engineering and Management. Boca Raton: CRC Press, 2010. ISBN 978-1-4398-1310-2 Mutschmann, J, Stimmelmayr, F.: Taschenbuch der Wasserversorgung, Vieweg-Verlag Hints are given for additional literature from the internet as well as libraries.
15. Lehrveranstaltungen und -formen:	• 503001 Lecture Planning and design of water supply facilities • 503003 Excursion to planning area and water supply company • 503002 Case Study Planning and design of water supply facilities
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50301 Planning and Design of Water Supply Facilities (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Siedlungswasserbau und Wassergütewirtschaft

Modul: 50320 Project Preparation, Management and Finance

2. Modulkürzel:	021410801	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Anne Weiß
9. Dozenten:	Dr.-Ing. Andreas Hutarew
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester ➞ Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	Script, e-learning Programs
15. Lehrveranstaltungen und -formen:	• 503201 Lecture PPaM • 503202 Lecture VAwS • 503203 Excursion
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	50321 Project Preparation, Management and Finance (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 50330 Regional and Urban Planning I

2. Modulkürzel:	021100010	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Jörn Birkmann
9. Dozenten:	Jörn Birkmann Astrid Ley
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Wahlmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Auswahl 1 (6 CP) --> Wahlpflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	The students understand the major challenges, objectives, strategies and instruments in spatial planning and urban development in Europe as well as in developing and countries in transition. The students are acquainted with the legal framework of comprehensive and sector planning and know the capabilities and limits of public planning as "positive" and "negative" planning.
13. Inhalt:	The course Regional Planning I covers the following topics: • International Planning studies • Overview on current planning issues • Basic Terms of Spatial Planning • Strategies in Spatial Planning • Instruments of Spatial Planning • Performance of Plans, Assessing Plans The course Urban Planning I provides an overview on the origin of planned urban development, starting in Greece and the Roman Empire, passing through all important periods up to the 21st century. The second part introduces urbanisation processes in third world countries, planned and unplanned urban conglomerations, including Mega Cities and Global Cities.
14. Literatur:	Berke, P.R. et al. (2006): Urban Land Use Planning. Urbana/ Chicago: University of Illinois Press

	Birkmann et al. (2010): Adaptive urban governance: nes challenges for the second generation of urban adaptation studies to climate change In: Sustanability science 5 Hall, P. (2002): Urban and Regional Planning. New York: Routledge
15. Lehrveranstaltungen und -formen:	• 503301 Lecture Regional Planning I • 503302 Lecture Urban Planning I
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 45 hours Private Study: approx.135 hours
17. Prüfungsnummer/n und -name:	50331 Regional and Urban Planning I (LBP), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Raumentwicklungs- und Umweltplanung

Modul: 50340 Regional and Urban Planning III

2. Modulkürzel:	021100012	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr.-Ing. Jörn Birkmann
9. Dozenten:	Anette Gangler Katharina Mohr
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	The students are able to analyze and present the development situation and problems or some specific topics related to the development of their own countries in a systematic way and to discuss development situations and problems or specific topics of other countries. They receive experience in analyzing, summarizing and presenting the aspects mentioned above in English language. The students are able to investigate housing standards and typologies and the housing demand and supply.
13. Inhalt:	*The course "Development Policy and Planning: A Seminar Conference" will be conducted as a series of (a) lectures, (b) consultations and (c) seminar meetings.* *a) Lectures provide an overview of development history and current issues concerning development policy and planning. Students will choose a topic of interest within this context and propose an agenda and outline for the self-study of this topic.* *b) Additional lectures on academic writing and presentation techniques as well as consultation hours will provide assistance for the preparation of a scientific paper on this topic.* *c) A conference program for seminar meetings will be set up for authors to present their work in smaller groups (plenary sessions). Students participating in a plenary session peer-review papers of presenters and participate in the discussion.* *The first part of the seminar Housing introduces housing typologies in Europe and Middle East. In the second part, participants portray the housing situation of their home countries with respect to typology, supply and demand, self-help models and spontaneous settlement patterns*
14. Literatur:	OECD: Perspectives of global development, Paris, 2010

	Northey, M. and Jewinsky,J: Making sense: A student's guide to research and writing. Bon Mills, Ontario, 2007
15. Lehrveranstaltungen und -formen:	• 503402 Seminar Housing • 503401 Lecture Development Policy and Planning
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50341 Regional and Urban Planning III (PL), Schriftlich und Mündlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Raumentwicklungs- und Umweltplanung

Modul: 50350 Water Resources and Irrigation - Planning Methods and Tools

2. Modulkürzel:	021410204	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	6	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Kristina Terheiden
9. Dozenten:	Kristina Terheiden Jochen Seidel
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	Students know about crop water demand and supply, conservation of soil quality and, in this context, about decision making as well as planning and design processes. **Irrigation Issues (Terheiden):** Students have theoretical and practical back ground knowledge of irrigation and soil conservation issues. **Computer Applications in Water Engineering (Terheiden):** Students know how to apply computer programs related to irrigation- and river basin-management. **Multi Objective Decision Making in Water Resources Management** **(Seidel):** Students are able to apply various decision making methods and are able to use them for the appraisal of large projects such as irrigation schemes and/or river training works
13. Inhalt:	**Water Management and Irrigation Facilities:** • Water demand, scarcity and availability • Assessment of crop water demand • Irrigation facilities • Health hazards of irrigation facilities • Soil erosion and salinization **Computer Applications in Water Engineering:** Theory and application of computer programs such as • SimResSedim: Water and sediment balance of reservoirs • Sahel: Interaction between socio-economic human activities and water- and land-resources of the used area • Wasim: Water and salt balance in soils • Wepp: Water Erosion of crop- and natural land

	• Cropwat: Crop water requirements and irrigation scheduling • Hec-Ras, Mike11, Hydro_As 2D: One- and two-dimensional hydrodynamic modeling of river systems **Multi Objective Decision Making in Water Resources Management:** The use of evaluation and decision making methods in order to determine long term effects on planed actions will be addressed. Registration, quantification and evaluation of project alternatives using different methods and techniques are focused: • Cost comparison method • Linear Programming • Multi ObjectiveDecision Making methods, e.g. Composite Programming, ELECTRE, MCQA • Case study using Composite Programming • Introduction to Game Theory and Conflict Analysis
14. Literatur:	Lecture notes to • 'Irrigation Issues' authored by W.Marx • 'Multi Objective Decision Making in Water Resources Management', authored by A. Bardossy, J. Seidel will be provided on the e-learning Ilias-platform for downloading. Specific material will be distributed during lectures/exercises
15. Lehrveranstaltungen und -formen:	• 503501 Lecture Water Management and Irrigation Facilities • 503502 Lecture Computer Applications in Water Engineering • 503503 Lecture Multi Objective Decision Making in Water Resources Management
16. Abschätzung Arbeitsaufwand:	Sum 180h
17. Prüfungsnummer/n und -name:	50351 Water Resources and Irrigation - Planning Methods and Tools (PL), Schriftlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft

Modul: 50520 Environmental Aspects

2. Modulkürzel:	011000801	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	6	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Hans-Georg Schwarz-von Raumer
9. Dozenten:	Hans-Georg Schwarz-von Raumer Lydia Seitz Manuel Krauß
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Module zum abwählen
11. Empfohlene Voraussetzungen:	
12. Lernziele:	The students have basic knowledge about basic environmental aspects in infrastructure planning concerning soils, species and biotopes, air quality and hydro systems. They know how to include environmental aspects in spatial planning and to assess environmental impacts of strategies and projects. They are aware and have gained skills in • ecological evaluation methods (e.g. land suitability) and • Environmental Impact Assessment The students have first experiences in project exercises.
13. Inhalt:	A: Lecture "Ecological aspects of infrastructure planning" Introduction to the environment factors and goods: geological ressources, species and biotopes, ecosystem functioning, Air quality, hydrosystems,impact of land use systems (especially agriculture and urbanisation, ecological landscape design. B: Seminar "Environmental impact assessment" In the seminar students have the task to prepare a presentation and a paper about: • Structuring and evaluation of environmental impacts of strategies and projects • Legislative aspects • Modelling and evaluation methods • Tools for impact modelling • Case study examples

	Alternatively the students work on case study exercises covering strategic regional and urban planning as well as road, housing, industrial, water, sports, tourism and other infrastructure projects
14. Literatur:	Information will be provided during the lectures Additional material can be downloaded from ILIAS
15. Lehrveranstaltungen und -formen:	• 505201 Vorlesung Ecological aspects of infrastructure planning • 505202 Seminar Environmental impact assessment
16. Abschätzung Arbeitsaufwand:	Sum 204 h
17. Prüfungsnummer/n und -name:	• 50521 Environmental Aspects (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Landschaftsplanung und Ökologie

Modul: 50560 Project Planning and Financing

2. Modulkürzel:	240903002	5. Moduldauer:	Zweisemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Elke Schneider
9. Dozenten:	Klaus-Peter Pischke
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012, → Semi-Compulsory Modules
11. Empfohlene Voraussetzungen:	
12. Lernziele:	Students know critical phases of a typical project cycle, they know how to plan, appraise, and evaluate infrastructure projects from the economic and financial point of view, they know different measures to calculate the return of a project in order to evaluate its worth, they know pros and cons of different ways to finance and operate infrastructure projects, solving problems based on real world case studies enhances their ability to evaluate projects themselves or to assess project proposals (e.g. feasibility studies) prepared by consultants.
13. Inhalt:	A: Project Planning and Appraisal (SS) • Comprehensive introduction into planning and appraisal of infrastructure projects • Subject description • the project cycle: major aspects of the different phases • project planning • LogFrame analysis as a project planning tool • project appraisal (financial and economic analysis) • evaluation of project alternatives • case studies B: Project Financing, Implementation and Advanced Issues of Economic Analysis (WS) • Comprehensive introduction into financing, implementation, monitoring and ex-post evaluation of infrastructure projects selected issues of advanced economic analysis of projects • Subject Description: • external and internal sources of financing • private sector participation for project financing and operation (BOT models)

	• selected issues in project implementation (implementation consultant, terms of reference, bidding procedures, contract of goods and services) project supervision, monitoring and ex-post evaluation • advanced issues of economic analysis of projects including case studies
14. Literatur:	• Script, • Damodaran, Aswath: Corporate Finance -Theory and Practice
15. Lehrveranstaltungen und -formen:	• 505601 Lecture A: Project Planning and Appraisal • 505602 Lecture B: Project Financing, Implementation and Final Evaluation
16. Abschätzung Arbeitsaufwand:	Sum 180h Time of attendance: 56 h Private Study: 124 h Pos unit presence time self study project Sum 1 Lecture A 28,0 62,0 0,0 90,0 2 Lecture B 28,0 62,0 0,0 90,0 Sum: 180,0
17. Prüfungsnummer/n und -name:	50561 Project Planning and Financing (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Power Point Presentations, Black Board, Case Studies, Group Discussions
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 50580 Methodological Aspects of Infrastructure Planning

2. Modulkürzel:	021100013	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr.-Ing. Richard Junesch
9. Dozenten:	Marion Aschmann Richard Junesch
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 2. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 2. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	Basic notions of infrastructure planning
12. Lernziele:	The students understand techniques for dealing with complex decision situations and gain insights in the decision-analysis process for both public and private decision-making with all related steps. Social aspects that may influence planning process or outcome will also be discussed. The students are acquainted with fundamental notions of demography as far as urban and regional planning is concerned. The students are able to apply basic methods of demographic analysis and forecasting.
13. Inhalt:	The module consists of two courses: The lecture "Decision Analysis" will cover the following subjects: • Elements of Decision Problems • Structuring Decisions • Generating Objectives and Hierarchies • Generating Alternatives • Decision Making with Multiple Objectives • Risk and Uncertainty in Decision Situations • Collective Decision Making • Application to Infrastructure Planning The course Demographic Analysis and Forecasting will provide an overview of the most frequently appearing issues of demographic analysis and forecasting. It will consist of three main parts: Fundamental notions of (applied) demography and some of the methodical/conceptual problems linked with these notions. Selected fundamental approaches to analysing and forecasting natural growth (or decline) of population, will be presented and discussed critically. Examples of such analyses and forecasts will be calculated. Migration, as the most critical and most important aspectof population development under regional aspects, will constitute the main topic of the third part. Basic methods of analysing and forecasting migration will be presented and discussed with regard to their application on concrete cases.

14. Literatur:	Lecture notes, see http://www.ivr.uni-tuttgart.de/vwl/ studium_und_lehre/ sommer/Decision_Analysis.html as well as the literature listed (see website) • Rowland, Donald (2003): Demographic Methods and Concepts. Oxford, New York, Oxford University Press • Davis, H. Craig (1994): Demographic projection techniques for regions and smaller areas, Vancouver, University of British Columbia Press
15. Lehrveranstaltungen und -formen:	• 505801 Lecture Decision Analysis • 505802 Lecture Demographic Analysis and Forecasting • 505803 Exercise Demographic Analysis and Forecasting
16. Abschätzung Arbeitsaufwand:	Time of attendance: approx. 45 hours Private Study: approx.135 hours
17. Prüfungsnummer/n und -name:	50581 Methodological Aspects of Infrastructure Planning (PL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	Presentations, Exercises with spreadshed calculations
20. Angeboten von:	Raumentwicklungs- und Umweltplanung

Modul: 55860 Contaminated site remediation and investigation technologies

2. Modulkürzel:	021410903	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Wintersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr. Johan Alexander Huisman
9. Dozenten:	Johan Alexander Huisman Jürgen Braun
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Module zum Abwählen
11. Empfohlene Voraussetzungen:	Recommended background knowledge: Basic knowledge in Hydromechanics/Hydraulics/Multiphase flow corresponding to a lecture with approx. 6-8 ECTS Recommended module: Measurements in the water cycle
12. Lernziele:	The relevant physical principles of subsurface remediation will be reviewed and key remediation technologies will be introduced and discussed. Non-invasive technologies for characterization and monitoring of contaminated sites will also be introduced and discussed. The overall aim is that students will be able to assess the advantages and disadvantages of the available remediation and measurement technologies.
13. Inhalt:	**(I) Contaminated site remediation technologies** • Multi-phase flow considerations • On/off site treatment • Remediation technologies **(II) Non-invasive contaminated site investigations** • Introduction to site investigation • Electromagnetic methods (TDR, GPR) • Electrical methods (ERT, EMI, SIP) • Direct-push methods • Time-lapse monitoring with geophysics
14. Literatur:	(I) Selection of learning material for a range of remediation technologies (will be provided). (II) Selection of learning material for a range of site investigation methods (will be provided). P. V. Sharma, Environmental and engineering geophysics, Cambridge Univ. Press, 1997.
15. Lehrveranstaltungen und -formen:	• 558601 Contaminated site remediation technologies, Lecture

	• 558602 Non-invasive contaminated site investigations, Lecture
16. Abschätzung Arbeitsaufwand:	Lecture (I) 24,0 Lecture (II) 24,0 Seminar 8,0
17. Prüfungsnummer/n und -name:	• 55861 Contaminated site remediation and investigation technologies (PL), Schriftlich, 120 Min., Gewichtung: 1 • V Vorleistung (USL-V), Schriftlich und Mündlich
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Hydrogeophysik

Modul: 55950 Hydropower: Environmental Impacts, Mitigation measures and Ecohydraulic Investigations

2. Modulkürzel:	021410902	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	3 LP	6. Turnus:	Wintersemester
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Anne Weiß
9. Dozenten:	Dr.-Ing. Martin Schletterer Dr.-Ing. Matthias Schneider
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	Allan J.D.: Stream Ecology - Structure and function of running waters The Volga River: review on research history and synthesis of current knowledge, River Systems 19 Paul Kemp, Atle Harby, Ian Maddock, Paul J. Wood. Ecohydraulics: An Integrated Approach CASiMiR-Fish Handook CASiMiR-Benthos Handbook
15. Lehrveranstaltungen und -formen:	• 559501 Hydropower: Environmental Impacts, Mitigation measures and Ecohydraulic Investigations: lecture, exercises, seminar, excursion
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	55951 Hydropower: Environmental Impacts, Mitigation measures and Ecohydraulic Investigations (BSL), Schriftlich oder Mündlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 58100 Constructed wetlands for wastewater treatment

2. Modulkürzel:	-	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	3 LP	6. Turnus:	Unregelmäßig
4. SWS:	2	7. Sprache:	Englisch

8. Modulverantwortlicher:	Anne Weiß
9. Dozenten:	Dr.- Ing.Christos Akratos
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 3. Semester → Zusatzmodule M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 3. Semester → Pflichtmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	Stefanakis, A.I., Akratos, C.S., Tsihrintzis, V.A. Vertical flow constructed wetlands: Eco-engineering systems for wastewater and sludge treatment, first ed. Elsevier, Burlington, USA. Kadlec,R.H., Wallace, S. Treatment wetlands, send ed. CRC Press Lecture notes
15. Lehrveranstaltungen und -formen:	• 581001 Vorlesung Design of constructed wetlands
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	58101 Constructed wetlands for wastewater treatment (BSL), Schriftlich, 120 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

Modul: 68060 Advanced Methods in Biofilm Research

2. Modulkürzel:	021410206	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Sommersemester
4. SWS:	4	7. Sprache:	Englisch

8. Modulverantwortlicher:	Dr. Sabine-Ulrike Gerbersdorf
9. Dozenten:	Sabine-Ulrike Gerbersdorf
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, ➞ Spezialisierungsmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Zusatzmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, ➞ Spezialisierungsmodule
11. Empfohlene Voraussetzungen:	• Basic experience in laboratory work as well as basic knowledge in ecology, microbiology, chemistry and physics • Basic knowledge in microscopy would be desirable
12. Lernziele:	• The students acquire fundamental knowledge of biofilms (composition, main species, requirements, occurrence, functionality and ecosystem services) • The students deepen their ability to work analytical in the laboratory on the micro- and macroscale • The students broaden their portfolio of applied methods ranging from autoclaving to photometry • The students apply microbiological techniques in freshwater ecology • The students learn about the most common biological and chemical parameters concerning biofilm research but also beyond • The students are familiar with light microscopy and get first hands-on experience with electron microscopy • The students know techniques to determine biofilm topography • He/she can measure biofilm adhesion with electromagnets
13. Inhalt:	• Growth of a monocultural biofilm (bacterial origin) (cultures, nutrient broth, autoclaving) • Growth of a natural highly diverse biofilm (preparing substrates, circultating freshwater from river in mini-flumes) • Monitoring of biomass/cell numbers and growth (bacteria: Ultrasound, Staining, Flow Cytometry, Microalgae: Chlorophyll a Extraction, Photometer) • Extracellular polymeric substancen (EPS) : Extraction, Determination of sugar - and proteincontent in the matrix • Microscopy: Ligth-Microscopy to determine the most prominent species as well as address biofilm topography. Electron-Microscope to visualize various biofilm structures • Structure from Motion: Visualisation of three dimensional biofilm structures

	• Functionality of biofilm: Biostabilisation of sediments, measurements of the biofilm adhesion via MagPI (Magnetic Particle Induction) • Excursion to collect and observe biofilms in their natural habitat
14. Literatur:	Book: Biofilm Highlights (H.-C. Flemming, J. Wingender, SU. Szewzyk, Springer Verlag) More milestone publications (e.g. Reviews) will be recommended
15. Lehrveranstaltungen und -formen:	• 680601 Vorlesung Fortgeschrittene Methoden in der Biofilm Forschung • 680602 Übung Fortgeschrittene Methoden in der Biofilm Forschung
16. Abschätzung Arbeitsaufwand:	Lecture: Präsenzzeit/Presence: 14h Selbststudium/post-preparation: ca. 28h Summe: 42h Laboratory course: Präsenzzeit/Presence: 42h Selbststudium/post-preparation: ca. 96h Summe: 138 h
17. Prüfungsnummer/n und -name:	68061 Fortgeschrittene Methoden in der Biofilm Forschung (PL), Schriftlich, 90 Min., Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasser- und Umweltsystemmodellierung

400 Deutschkurse

Zugeordnete Module:
19150 German as a Foreign Language
401 Deutschkenntnisse ausreichend

Modul: 19150 German as a Foreign Language

2. Modulkürzel:	SZ	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	6 LP	6. Turnus:	Unregelmäßig
4. SWS:	8	7. Sprache:	Weitere Sprachen

8. Modulverantwortlicher:	John Nixon
9. Dozenten:	
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2012, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2017, 1. Semester → Deutschkurse M.Sc. Water Resources Engineering and Management Mara Outgoing Double Degree, PO 913MaO2016, 1. Semester → Pflichtmodule M.Sc. Water Resources Engineering and Management, PO 913-2012, 1. Semester → Deutschkurse M.Sc. Water Resources Engineering and Management Chalmers Outgoing Double Degree, PO 913ChO2012, 1. Semester → Pflichtmodule
11. Empfohlene Voraussetzungen:	
12. Lernziele:	
13. Inhalt:	
14. Literatur:	
15. Lehrveranstaltungen und -formen:	• 191501 Seminar German as a Foreign Language I • 191502 Seminar German as a Foreign Language II
16. Abschätzung Arbeitsaufwand:	
17. Prüfungsnummer/n und -name:	• 19151 German as a Foreign Language I (BSL), Schriftlich oder Mündlich, Gewichtung: 1 • 19152 German as a Foreign Language II (BSL), Schriftlich oder Mündlich, Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	II/3 Interkultureller Unterricht

401 Deutschkenntnisse ausreichend

Modul: 80990 Master's Thesis WAREM

2. Modulkürzel:	-	5. Moduldauer:	Einsemestrig
3. Leistungspunkte:	30 LP	6. Turnus:	Wintersemester/ Sommersemester
4. SWS:	20	7. Sprache:	Englisch

8. Modulverantwortlicher:	Univ.-Prof. Dr. Silke Wieprecht
9. Dozenten:	Depending on the topic. The first examiner has to be a full professor of the University of Stuttgart or a member of the senior academic staff who is an authorized examiner according to the legal statutes.
10. Zuordnung zum Curriculum in diesem Studiengang:	M.Sc. Water Resources Engineering and Management, PO 913-2017, M.Sc. Water Resources Engineering and Management, PO 913-2012, M.Sc. Water Resources Engineering and Management Mara Incoming Double Degree, PO 913MaI2012, M.Sc. Water Resources Engineering and Management Chalmers Incoming Double Degree, PO 913ChI2012,
11. Empfohlene Voraussetzungen:	The topic of the Master Thesis can be handed out only the moment at least 72 ECTS have been acquired already by the candidate.
12. Lernziele:	Capability to implement an independently composed project schedule for the treatment of a recent scientific problem in an international research environment. Effective scientific work in a team, enforcement of strategies internally and particularly externally. Acquire the necessary stamina to not be discouraged by unexpected problems and throwbacks in scientific projects and to finally be successful by the formulation of alternative methods of resolution. Multidisciplinarity through contacts with representatives of other fields like Chemistry, Mathematics, Informatics, etc. Obtaining the capability to discuss the own results of research in the environment of the recent international research comprehensively and to represent them in written (Master's Thesis) and oral (talk) form.
13. Inhalt:	Treatment of a recent scientific problem in an international research environment. The successful treatment of the scientific problem requires the specialisation in the related field of research and the acquisition of the necessary knowledge.
14. Literatur:	Recent literature on the topic of the scientific problem
15. Lehrveranstaltungen und -formen:	
16. Abschätzung Arbeitsaufwand:	900 h (Contact time: 900 h)
17. Prüfungsnummer/n und -name:	80991 Master's Thesis WAREM (PL), , Gewichtung: 1
18. Grundlage für ... :	
19. Medienform:	
20. Angeboten von:	Wasserbau und Wassermengenwirtschaft