QANU Research Review
Earth Sciences

QANU, November 2009

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FOREWORD

This report follows the Standard Evaluation Protocol 2003-2009 for Public Research Organisations (SEP) that was developed by VSNU, KNAW and NWO. The purpose of this report is to present a reliable picture of the research activities submitted for this review and to give feedback on the research management and quality assurance.

The review Committee was supported by QANU (Quality Assurance Netherlands Universities). QANU aims to ensure compliance with the SEP in all aspects and to produce independent assessment reports with peer review Committees of international experts in the academic fields involved.

QANU wishes to thank the chairperson and members of the review Committee for their participation in this assessment and for the dedication with which they carried out this task.

We also thank the staff of the units under review for their carefully prepared documentation and for their co-operation during the assessment.

Quality Assurance Netherlands Universities

Mr. Chris J. Peels
Director

Dr. Jan G.F. Veldhuis
Chairman of the Board

PREFACE

This report describes the quality assessment of the research in Earth Sciences at Delft University of Technology (TUD), Utrecht University (UU) and Vrije Universiteit Amsterdam (VU). The assessment covers the period 2002-2007 and was conducted according to the Standard Evaluation Protocol 2003-2009 for Public Research Organisations (SEP).

The quality assessment was carried out by a review Committee consisting of one chair and six members with expertise in the relevant disciplines.

The Committee is grateful to the Faculties for their time-consuming and successful efforts to prepare their clear and informative self-assessments about the research programmes and activities. The Committee wishes to acknowledge the pleasant receptions and open discussions during the site visits, with the various boards and research coordinators, and with the PhD students.

As chair of the Committee, I greatly appreciate the commitment, the expertise and the excellent cooperation of my colleagues. The Committee would also like to thank all persons involved in the thorough preparation and support of the review, especially the skilful and smooth direction and assistance of our secretary, Mr. Roel Bennink.

Wim Mook
Chairman of the Committee

1. The review Committee and the review procedures

1.1. Scope of the assessment

The review Committee was asked to perform an assessment of the research in four institutes in Earth Sciences at Delft University of Technology (TUD), Utrecht University (UU) and Vrije Universiteit Amsterdam (VUA). The review includes fourteen research programmes and covers the research in the period of 2002-2007.

In accordance with the Standard Evaluation Protocol 2003-2009 for Public Research Organisations (SEP), the Committee's tasks were to assess the quality of the institutes and the research programmes on the basis of the information provided by the institutes and through interviews with the management and research leaders, and to advise how this quality might be improved.

1.2. Composition of the Committee

The composition of the Committee was as follows:

- Prof. dr. Willem G. Mook, emeritus University of Groningen (chairman)
- Prof. dr. Philip L. Gibbard, University of Cambridge
- Prof. dr. William van Impe, Ghent University
- Prof. dr. Jean Poesen, K.U. Leuven
- Prof. dr. Hans Thybo, University of Copenhagen
- Prof. dr. Desmond E. Walling, University of Exeter
- Prof. dr. Bruce Yardley, University of Leeds.

A short curriculum vitae of each of the Committee members is included in Appendix A.

Roel Bennink of the Bureau of QANU (Quality Assurance Netherlands Universities) was appointed as secretary to the Committee.

1.3. Independence

All members of the Committee signed a statement of independence to safeguard that they would assess the quality of the institutes and research programmes in an unbiased and independent manner. Any existing personal or professional relationships between Committee members and institutes under review were reported and discussed. The Committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

1.4. Data provided to the Committee

The Committee has received detailed documentation consisting of the following parts:

- Self-evaluation reports of the institutes under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices;
- Copies of three key publications per research programme.

1.5. Procedures followed by the Committee

The Committee proceeded according to the SEP. Prior to the first Committee meeting; each institute and research programme was assigned to two Committee members for review. A preliminary assessment was independently formulated on the basis of the key publications.

Preceding the interviews, the Committee was briefed by QANU about the research assessment according to SEP. The Committee discussed the preliminary assessments. For each research programme a number of comments and questions were decided upon. The Committee also agreed upon procedural matters and aspects of the assessment. The final assessments are based on the documentation provided by the institutes, the key publications and the interviews with the management and with the leaders of the programmes. The site visits took place on 9-12 March 2009 (see the schedule in Appendix B). After the interviews, the Committee discussed the scores and comments. The texts for the report were finalised through email exchanges. The final version was presented to the institutes for factual corrections and comments. The comments were discussed by the Committee. The final report was presented to the Boards of the participating universities and was printed after their formal acceptance.

The Committee used the rating system of the SEP; the meaning of the scores is described in Appendix C.

2. The Earth Science Landscape

2.1. General perspective

The Earth Sciences are directed at understanding the structure of the Earth and the processes that have shaped and continue to shape the Earth. The Earth Sciences are founded on principles and methods of Physics and Chemistry, with respect to material characteristics and the composition of the solid, liquid and gaseous reservoirs of the solid Earth, the waters and the atmosphere, and the processes that operate deep underground, at the surface and in the air. Although the Earth Sciences are concerned with the non-living Earth, while the Life Sciences with the Biosphere, life processes are extremely important in contributing to the processes that shape the Earth, particularly the Earth's surface. On the other hand, the Earth's conditions have an essential control over life.

For doing research in the entire field of the Earth Sciences, the availability and development of technical facilities is a *conditio sine qua non*. These may consist of highly specialised equipment and expensive facilities, such as research vessels and access to Earth observation sources, as well as a wide range of instrumentation for observational and analytical purposes.

The survival of the human race depends on the natural habitat that the Earth offers. A most important contribution that earth scientists make to mankind's well-being is in the exploration and exploitation of natural resources, especially water and energy. Humans have become adapted in varying degrees to the character and the actions of Earth's processes and the changes that these processes bring about over the course of time. What is now recognised and widely accepted by society is the realisation that human activity is capable of causing changes to our natural environment, even on a global scale. These realisations have made the study of all aspects of the Earth Sciences not only of academic and cultural value, but also a matter of socio/economic and possibly even physical survival.

2.2. The Netherlands perspective

2.2.1. Faculties and Research Institutes

In the organisation of the Netherlands universities, the present-day structure consists of Faculties and Research Institutes. The responsibility and budget authority of the different Faculties are in the hands of the Faculty Deans. Apart from small differences in leadership structures, the Institutes are managed by Department Heads, or by Scientific and Managing Directors, and Directors for Education/Teaching. The Institutes are divided into Departments, Sections or Groups headed by one of the full professors. With this, the scientific leaders have become the key players in a research organisation that is, to the satisfaction of the Committee, more transparent than during the preceding decades. It is the observation of the Committee that all Institutes, Departments and Research Groups are being run very efficiently.

2.2.2. Research Schools and Graduate Schools

During the past few decades, the Research Institutes of the Dutch universities have established Research Schools, aimed at providing a broad and coherent education for PhD students (AIO's), generally appointed by the respective universities. In order to achieve this, the Research Schools include groups from a number of participating Institutes, being structured to produce a coherent research programme. Each Research School can only be established with the approval of the KNAW (Royal Netherlands Academy of Arts and Sciences), followed by independent review at six year intervals (re-accreditation). A research school functions as an

independent organisational unit; its level of finance is guaranteed by the university or universities involved for a period of at least four years.

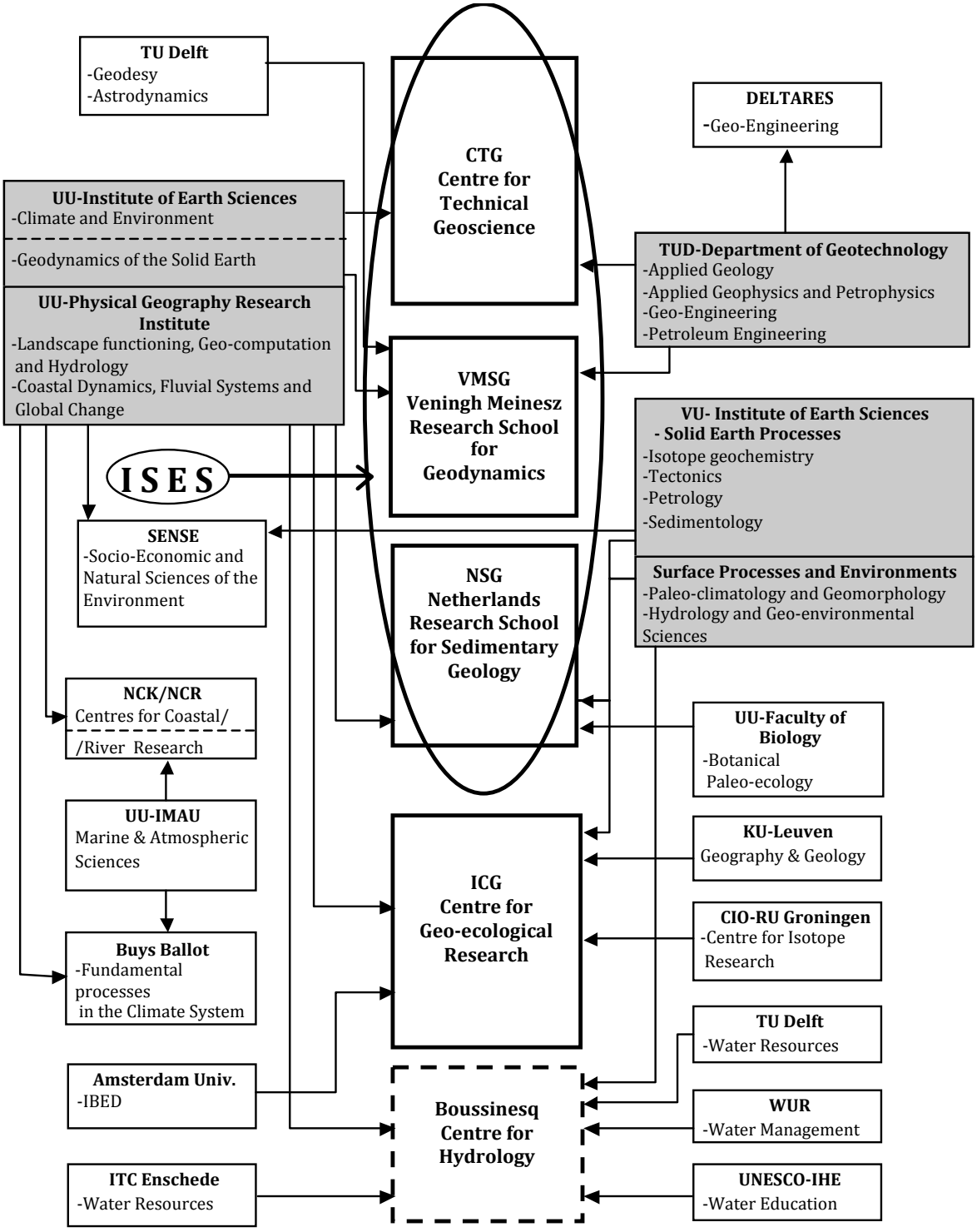

Figure 1: System of Earth Science Research Schools in Netherlands Universities and associated Research Institutes. The research programmes included in this review are printed in bold; the Inter-University Research Schools are indicated by the heavy-lined boxes; three of these are collaborating within the Top Research School ISES, indicated by the ellipse (a list of acronyms is given in the Appendix).

Figure 1 provides a schematic overview of the existing Earth Science Research Schools. The figure gives the situation during the review period.

The picture shows the one Top Research School in the Earth Sciences (oval), the Netherlands Research Centre for Solid Earth Science (ISES), and a collaboration between three Research Schools as indicated. ISES has been selected by the Netherlands Organisation for Scientific Research (NWO) and funded by the Ministry of Education and Science. The other broadly orientated Earth Science Research School, within which several universities cooperate, is the International Centre for Geo-ecology (ICG) in the field of Surface Processes, Physical Geography and Quaternary Environmental Change and Processes. Research Institutes or Groups thereof may (have) participate(d) in more than one Research School, linking the research with other fields.

During recent years a more or less parallel development is taking place, *viz.* the establishment of Graduate Schools, each restricted to one university, for example, in Utrecht the UU Geosciences Graduate School, and at the Vrije Universiteit the Graduate School for Earth, Environment and Ecology (EEE). The three Universities of Technology in the Netherlands, in Delft, Eindhoven and Twente, are considering establishing one 3TU Graduate School. Discussing the academic education in more detail is beyond the scope of this review.

The Committee has the general impression, based upon the documentation provided, the discussions with faculty members, and the discussions with PhD students, that the organisation of the Research Schools and Institutes has been efficient in providing a healthy scientific working climate.

2.3. Disciplines within the Earth Sciences

The Earth Sciences can be subdivided into disciplines which primarily deal with the structures and processes in the various compartments of the Earth:

- the deep solid earth
- the land surface and shallow subsurface
- the oceans
- the atmosphere.

2.3.1. Geophysics, Structural Geology and Tectonics

Solid-Earth geophysics involves studies of the structure, composition and state of materials in the Earth's interior. Diverse techniques are being developed and applied by Dutch geophysicists in their quest to improve our understanding of both deep and shallow Earth processes. Various seismological, paleomagnetic, rock magnetic, electromagnetic and gravity methods are being employed. The solid-Earth geophysics groups in the Netherlands are involved in several well co-ordinated joint programmes, such that the VUA and UU concentrate their efforts on the deep Earth, whereas the primary focus of the TUD is on the shallow Earth with emphasis on resolving problems associated with hydrocarbon exploration and engineering, and environmental issues.

Investigations of the dynamic behaviour and lithology - i.e. the study of the physical character of rock or rock formations - of the solid Earth are the primary concerns of structural or tectonic geology - i.e. the study of forces and movements in the lithosphere. At the UU the programme is concentrated on the crust and mantle, and crust/mantle interactions. In con-

trast, VUA focuses on the deformation of sedimentary basins. In both programmes numerical modelling plays an important role.

2.3.2. Geochemistry and Geochronology

Geochemistry is the study of chemical processes on Earth governed by and governing geological processes, and of chemical characteristics of Earth materials. An important part of it is the study of the natural abundance and behaviour of stable and radioactive isotopes, or rather isotopic substances. These contribute to studying the origin and pathways of solids, fluids and gases, and if the isotopic materials are radioactive, to determining their ages. Geochronology, dealing with the age measurement of Earth materials and processes, is a key part of many of the geological programmes.

Earth Science research in the Netherlands has an excellent geochemical infrastructure. Geochemistry forms a strong theme at the UU and VUA institutes. Isotopic studies of the light elements are performed at Groningen University (CIO-Centre for Isotope Research), not included in this Review, and at UU and VUA.

2.3.3. Petrology

Petrology is one of the basic sub disciplines of the Earth Sciences and addresses the description, classification and occurrences of rocks and of theories related to their origin. Petrology includes the physical, chemical and mineralogical study of rock materials, and also the study of the fluid and gas inclusions. It focuses on the formation and evolution of (i) crystalline, including metamorphic (i.e. recrystallized by high temperature and pressure) rock, transported from the Earth's surface to the deep by orogenetic processes and returned to the surface by tectonic processes and erosion; (ii) magmatic or igneous rock formed at deeper levels and brought to the surface by a variety of processes. Applying a series of advanced analytical techniques, the effects of temperature and pressure can be studied, contributing to thereconstruction of the geological processes involved. At UU experimental methods are employed to study the deformation and transformations by high pressures and elevated temperatures. The VUA formerly focused on fluid inclusions in the rock material, but is now moving into new areas including planetary geology. TUD is less concerned with crystalline rocks but studies the occurrence and the technical introduction of underground fractures in petroleum- or water-bearing rocks.

2.3.4. Quaternary Geology, Stratigraphy and Geomorphology

Quaternary Geology, the study of the Quaternary – i.e. the past two to three million years - is concerned with the response of Earth systems to rapid changes in energy levels, manifested as frequent, rapid and extreme climate changes and responses of the Earth's interior to these changes. Stratigraphy studies the succession of the resulting sedimentary strata, differing in composition and age. Typical studies within Quaternary Geology include changing patterns of glaciation, sea-level, atmospheric dust flux, plant cover and animal distributions.

Geomorphology is the study of surface processes that shape the surface of the Earth. It is concerned, for instance, with the ways that rivers, glaciers, wind and coastal waves and currents erode landforms and deposit sediment. It is also concerned with the results of internal processes such as volcanism, tectonics and mountain building, which control the disposition of relief upon which the surface processes operate. The two subjects are linked together because of their concern with processes and materials close to and at the Earth's surface, and because they are concerned with activities that have recently or are taking place today. Both subjects have strong traditions within the Netherlands, because so much of this country was formed

within the Quaternary period by geomorphological processes that are taking place today or during the Glacial periods of the Quaternary. Both subjects are closely linked with processes within the biosphere. Therefore, there are close links with research groups in Life Sciences. Several projects fall within the Darwin Center programme.

In recent years Quaternary Geology and Geomorphology have attained high social relevance. Within the Netherlands research is concerned particularly with erosion processes and landscape modelling, cold climate Quaternary science and geomorphology, long- and short-term river dynamics, coastal dynamics and changes, aeolian processes, and the investigation and modelling of Quaternary climate change. These activities are concentrated at the VUA and UU, where modelling of coastal and fluvial systems is combined with laboratory observations of water and sediment transport.

2.3.5. Marine Geology and Sedimentology

The composition and structure of sub-aquatic sediments can be related to actual sedimentary processes and conditions prevailing in shallow marine basins, in lakes or in rivers and estuaries (VUA and UU), or to past (paleo-) processes, where geochronological dating methods and paleontology - the study of fossils - play an important role. Studies in the Netherlands are particularly concerned with: (i) large-scale processes such as the evolution and deformation of sedimentary basins and the timing of paleomagnetic, paleontological and (bio)geochemical events (Earth Science Departments/Faculties of the VUA and UU), and (ii) marine geological studies of sea-bed processes, for instance, paleoclimatic reconstruction (VUA, UU), patterns and rates of sea-level change (VUA), and the occurrence of hydrocarbons in mud dome structures on the seafloor (VUA and UU). The TUD specialises in clastic sediments – such as clay and sand – while carbonate sediments and sedimentation continue to be the interest of the VUA.

2.3.6. Soil Science

Soil Science is the study of the upper few meters of the Earth's surface. Soils are of critical importance for plant, human and animal life, and represent the zone in which the influence of light, heat or cold, atmospheric gases, water, physical disturbance by micro-organisms, plant roots and animal life all operate. It is the most managed part of the Earth and is critical for the future management of food resources and recreational/environmental activities. Within the Netherlands, Wageningen University (WUR) has a long and well-defined tradition in the soil sciences, reflecting the main agricultural background of the University. Contrary to the previous review, WUR has now chosen a different review platform. The Physical Geography Departments of UU and UvA also have research programmes on soil characteristics and processes in the context of the functioning of landscape ecosystems and the environment.

2.3.7. Hydro(geo)logy

Water plays a dominant role in many geological processes. It is important in geophysical processes and geochemical reactions taking place in the soil, in the shallow and deeper subsurface, in the atmosphere, and in the various surface waters such as rivers and lakes. Moreover, the need for drinking water as well as water for agriculture, makes water supply and management a social issue of prime importance throughout the world, particularly in low relief countries like the Netherlands and in arid, often developing, countries. It is, therefore, understandable that studies of water and aquatic systems are widespread.

The research programme of virtually each Faculty included in the present quality review contains some form of research on aspects of water, i.e. hydrogeology, hydrogeography (or

geographical hydrology or surface-water hydrology), agrohydrology, ecohydrology, hydrochemistry and the related hydrometeorology. In a few universities hydro(geo)logical studies are particularly extensive. At the WUR hydrological research focuses on modelling the movement of water and solutes through porous media, the interaction of water and vegetation and the influence of changing groundwater levels. These programmes are also related to water management with respect to floods and droughts in response to natural and human induced effects of climate and land-use change. This research is still ongoing, but falls outside this review.

At VUA ecohydrological research is pursued investigating the relation between hydrology, vegetation, the atmosphere and biogeochemical cycles. The hydro(geo)logical programme is directed towards understanding the influence of geological conditions on water transport in aquifers, and of microbiological and hydrochemical processes affecting water quality. The response of fluvial processes to morphology, land-use practices and climatic change are subjects of the research programmes of the Physical Geography Research Institute of UU and the Institute of Earth Sciences of VUA. Such research includes, for instance, work on water erosion and sediment transport and landslide prediction. Within the Department of Geotechnology of TUD, research is undertaken on water and hydrocarbon flow modelling, primarily for productivity management, although much of the research on hydraulic engineering at TUD takes place in Institutes which have not been offered for this review.

The field of water sciences is historically and politically a matter of immense importance. The appointment of several young hydrology professors at the Vrije Universiteit Amsterdam and Utrecht University during recent years has substantially stimulated the communication and co-operation between the hydrology groups in the Netherlands, as was deemed desirable by the previous visiting Committee. The establishment of the Boussinesq Centre for Hydrology is another positive factor in this respect.

2.3.8. Geology and Engineering

Some crucial engineering sub disciplines are based on the Earth Sciences: Geo-Engineering and Petroleum Engineering at TUD fall into this category. Petroleum Engineering deals with the exploration and production of oil, and Geo-Engineering with the characteristics of the subsurface with respect to the construction of surface or underground infrastructure. Although the research methods are largely part of the foregoing sub-disciplines, their specialised application is only found at the TUD. In particular, modelling exercises are extremely useful to the resource industry.

Another engineering activity is the development of underground imaging apparatus, using seismic and electromagnetic technology. These subjects have a very high social and industrial relevance.

2.3.9. Physical Geography

The position of Physical Geography within the Earth Sciences differs from that of the other geoscience sub disciplines, in that it is an 'ensemble' of various 'geo-disciplines' mentioned in this section. Physical Geography studies the nature of man's environment and the interaction between people and their physical environment. It includes a number of Earth Sciences that are primarily related to the Earth surface and shallow subsurface such as geomorphology, sedimentology, hydrology, (micro)meteorology and soil science. Increasingly the role of biota and the interaction between biotic and abiotic factors receive attention, but also problems of economic and cultural relevance.

Extremely important aspects of Physical Geography include the relationship between soil patterns and land use and the study of landscapes and changes thereof, in particular land degradation, caused, for example, by soil erosion and deforestation, where hydrology plays an essential role. Consequences such as flooding and landslides are being modelled by the Physical Geography Research Institute (PGRI) of UU, which gives the research predictive value. There are two approaches to studying man's natural environment: These include research on contemporary processes and ongoing interactions between the physical land surface, biota and human activities, and studies of changes and processes in the past.

Another increasingly important aspect is the influence of climatic change. An improved understanding of the associated environmental change can be derived from investigations of paleo-environmental dynamics. At the UU/PG attention is especially directed at cold-climate and at lowland-river regions.

2.4. Limitations of the Review

The review covers the majority of the research in the Earth Sciences at the Dutch Universities. The decision to participate in a particular review is the responsibility of each individual university. A few important fields of the Earth Sciences and sub disciplines related to the Earth Sciences, such as Oceanography, Atmospheric and Polar research (including Meteorology), and Botanical Paleo-ecology have not been reviewed by this Committee, for local or historical reasons. The Centre for Isotope Research of Groningen University was also not included, although it participates in the Research School ICG (Figure 1). The Bio-GeoScience Programme, named the Darwin Center, on the other hand, has been included in the review as part of programmes on Climate and Environment. It is concerned with the interaction of geo- and bio-processes, and involves close cooperation between geoscientists and biologists.
Unlike the preceding review in 2001-2002, the University of Amsterdam has decided to include the original Physical Geography in the Institute for Biodiversity and Ecosystem Dynamics (IBED), *in casu* the Geo-Ecology theme of this Institute, while Wageningen University has chosen to transfer Hydrology and Soil research to the Environmental Sciences.

There are also several research institutes that do not come under the umbrella of the universities, but operate under the responsibility of the Netherlands Organisation for Scientific Research (NWO), or of other governmental organisations. The largest, with their most relevant activities, are (in alphabetical order):

NIOO/CEMO	Netherlands Institute for Ecological Research (KNAW) - Coastal and Estuarine Research
NIOZ	Royal Netherlands Institute for Sea Research (NWO) – Marine Geology, Physical, Chemical, and Biological Oceanography, and Marine Ecology
RIVM	National Institute for Public Health and Environmental Protection - Climate Research
RWS	Rijkswaterstaat (Directorate general for Public Works and Water Management) - Public Infrastructure, Coastal and North Sea Research
TNO-NITG	TNO Built Environment and Geosciences, including the National Geological Survey and the Groundwater Survey - Hydrology, Quaternary Geology, Marine Geology, Energy Resources, Seismics, Engineering Geology.

ASSESSMENT PER UNIVERSITY AND PER PROGRAMME

3. Department of Geotechnology, TU Delft

3.1. Assessment at Institutional level – TU Delft

3.1.1. Introduction

The Department of Geotechnology was established within the Faculty of Civil Engineering and Geosciences as the result of a merger between the former Department of Applied Earth Sciences and the 'geo-sections' of the Faculty of Civil Engineering.

3.1.2. Leadership

Geotechnology is one of five Departments within the Faculty of Civil Engineering and Geosciences of the TU Delft. The research of the Department is executed in four sections/ research programmes, each with 2 to 5 full professors. The overall research policy is defined by the Department Chairman, the Director of Research and the section heads. Within the stated strategy of the Department and Faculty, professors have autonomy in defining their research directions. The section heads are responsible for the overall direction of their research programme. As a consequence of the interdisciplinary character of the research a high level of communication and collaboration exists between the section heads.

The management instruments of the Department of Geotechnology are:

- Management team: a Department Chairman, a Director of Research, a Director of Education and a Director of the Laboratory. The management is supported by the department secretary, a scientific secretary and a secretariat.
- Department meetings that take place once a month and are attended by all tenured academic staff members and secretaries.
- Departmental strategy meetings are held off-site approximately once every two years to reflect on the research, education and general policy of the department
- Section meetings.

3.1.3. Mission & Goals

The mission statement is to "Reveal and explain the Earth's underground resources and support their use in an environmentally responsible manner". Central themes of the research are the judicious exploration, exploitation and use of the Earth's resources and subsurface space. Synergy between the different research programmes is exploited by combining basic sciences with engineering activities. These synergies and strong links to other disciplines are seen as crucial for the long-term future of the department. The strategy is one of open communication and interdisciplinary collaboration, both inside and outside the university.

The key activities of the Department are:

- to characterize the natural subsurface and the processes taking place within it, and to develop quantitative methods that lead to predictive models,
- to develop relevant engineering approaches that permit prudent and environmentally friendly use of the Earth and its subsurface resources,
- to develop innovative engineering methods involving the subsurface and to foster practical application of research results,
- to develop economically and ecologically sound methods of exploitation and construction and to investigate the anthropogenic influence on the Earth.

3.1.4. Strategy & Policy

Previous reviews of the Department of Geotechnology were executed in 2002 (as part of a nationwide assessment of the Earth Sciences) and in 2005 (as part of a review of the Civil Engineering Departments of TU Delft and Twente University). The results of the 2002 evaluation were largely responsible for the reorganization of the Department, which included the incorporation of several sections from other Departments and the transfer of the "Resources Engineering" section to other groups outside the department.

Since January 2006 the four research programmes within the Department of Geotechnology are:

- Applied Geology
- Applied Geophysics and Petrophysics
- Geo-Engineering
- Petroleum Engineering

In 2007 the department was relocated to the new Geotechnology building that comprises modern and open office space as well as laboratory and up-to-date teaching facilities.

The search for a new professor in the Geo-Engineering programme was unsuccessful. As a result, it was decided to follow a "growth-from-within" strategy by recruiting two young and promising researchers as assistant professors. The changes resulted in a clear focus of the Department on problems in the shallow and deeper subsurface of the Earth.

The Department coordinates the TU Delft-based National Research School Centre for Technical Geoscience (CTG). Its scientific mission is the development and dissemination of innovative, integrated geo-technologies in the areas of sub-surface imaging, characterisation and engineering for cost effective and ecologically sound utilisation of the subsurface. Several PhD students of the Section of Geo-Engineering participate in the Structural Engineering programme of the Integral Design of Structures Research School.

Since 2002 several interdisciplinary programmes have significantly intensified the cooperation between the Department's research programmes as well as the cooperation with other groups at TU Delft, other universities and other Research Institutes.

An increasingly important role in the Department's research is played by the observation, monitoring and steering of natural and engineered processes. Control of these aspects will allow for a step-change in managing real-time processes in key areas.

Evaluative remarks on Leadership, Mission and Goals and Strategy & Policy

The Institute's mission is ambitious but clearly defined in the mission statement. This statement is positioning the Institute in the mainstream of interest of such Schools worldwide. Taking into account the recommendations of the previous evaluation Committee – six years ago – the Faculty has quite successfully reshaped the programmes and names of some corresponding Departments (as indicated in fig. 2, page 14). It has, moreover, been clarified during the discussion with the present Committee that the mining programme (as the part remaining from the Resources Engineering section in the former Department) now will be merged with the Petroleum Engineering group in the new Department of Geotechnology, which indeed is a fair way of repositioning mining engineering for anno 2009. Engineering Geology now forms part of the Geo-Engineering group.

The interdisciplinary programmes as listed in the self-assessment report are clearly stimulating the co-operation and interaction of various research groups at the TU Delft. The Geo-Engineering knowledge centre is particularly relevant in this respect. The very newly created Delft Research Initiatives (DRI's), focussing on four clear main research themes, now require an intensive follow-up, and this is strongly recommended at least over the coming couple of years. The present leadership can certainly cope successfully with these suggestions for the future. We believe that the idea raised in our exchange of views with the Institute's leaders, of a possible future merger of the Engineering Geology and the Geo-Environmental Engineering subgroups, could indeed prove beneficial to all partners involved.

3.1.5. Resources

The academic staff has an international orientation and encompasses a large variety of scientific backgrounds.

The Institute has provided an overview of the personnel resources, in full-time equivalent (fte) research time, and a factor for converting fte to research fte (tables 3.1 and 3.2). The increase of staff over the years has benefited all sections of the Department (table 3.3).

	2002	2003	2004	2005	2006	2007	increase*
Full professors	2.5	2.7	2.7	2.9	3.1	3.5	40%
Associate professors	3.2	4.4	5.1	4.6	3.7	3.5	9%
Assistant professors	5.6	3.8	3.5	3.9	5.6	6.6	18%
Total tenured staff	*11.3*	*10.9*	*11.3*	*11.4*	*12.4*	*13.6*	*20%*
PhD students	29.2	34.2	37	35.6	37.7	41.1	41%
Other non-tenured staff	7.6	8.3	10.1	11.3	13.8	12.1	59%
Total non-tenured staff	*36.8*	*42.5*	*47.1*	*46.9*	*51.5*	*53.2*	*45%*
Total research staff	**48.1**	**53.4**	**58.4**	**57.3**	**63.9**	**66.8**	**39%**

Table 3.1. Staff at department level (in research fte); * increase from 2002 to 2007

	factor of research
Full professors	0.4
Associate professors	0.5
Assistant professors	0.5
PhD students	0.8
other non-tenured staff	0.8

Table 3.2. Factor for converting fte to research fte.

At present vacancies exist for one full-time chair and an assistant professor. In addition, three full-time professors will retire in the next five years. Procedures have already been initiated to fill these positions in a timely manner. Policies for recruitment and employment are aimed at promoting high quality research and output, and are achieved by hiring (international) highly qualified and motivated staff at all levels. The self evaluation report states that the current policy indeed results in attracting high-profile, international staff. Most of the research is performed by PhD students. The mixture of PhD students is a combination of home-grown MSc students and students from other universities (both national and international).

Particular attention is given to the training and personal development of the staff, as reflected by an annually updated personal career development plan. All junior academic staff is encour-

aged to present research findings at international meetings, which will also promote their networking. They are, furthermore, involved in teaching activities, writing research proposals and supervising PhD students. MSc projects are often carried out as part of a PhD project. PhD students present their work on a yearly basis at the Department's Research Day.

	2002	2003	2004	2005	2006	2007	increase*
Applied Geology	**9.5**	**13.9**	**13.9**	**11.6**	**11.7**	**11.5**	**10%**
Total tenured staff	2.5	2.1	1.9	1.9	2.7	2.5	
PhD students	6.5	8.1	9.4	8.0	6.3	6.1	
Other non-tenured staff	1.5	3.7	2.6	1.7	2.7	2.9	
Appl. Geophysics & Petrophysics	**17.4**	**18.2**	**19.8**	**20.9**	**23.8**	**24.8**	**43%**
Total tenured staff	2.8	2.8	2.8	3.5	3.7	3.7	
PhD students	11.0	12.5	12.6	12.5	14.1	15.7	
Other non-tenured staff	3.6	2.9	4.4	4.9	6.0	5.4	
Geo-Engineering	**11.0**	**8.8**	**13.6**	**12.9**	**14.9**	**16.3**	**48%**
Total tenured staff	3.9	3.6	4.1	3.7	3.9	5.7	
PhD students	5.6	4.5	7.9	7.3	8.4	9.5	
Other non-tenured staff	1.5	0.7	1.6	1.9	2.6	1.1	
Petroleum Engineering	**9.3**	**12.6**	**11.2**	**13.0**	**13.6**	**14.2**	**53%**
Total tenured staff	2.2	2.5	2.6	2.4	2.2	1.7	
PhD students	6.1	9.1	7.1	7.8	8.9	9.8	
Other non-tenured staff	1.0	1.0	1.5	2.8	2.5	2.7	

Table 3.3. Staff at section level (in research fte); * increase from 2002 to 2007

3.1.6. Funding Policies

Many of the research programmes are large and interdisciplinary, and often involve the participation of several sections. Funding of many research projects takes place through these interdisciplinary programmes as well as through smaller individually financed projects (STW, NWO, and industry). Table 3.4 provides an overview of funding and expenditure of the Department over the review period; table 3.5 shows the funding at section level.

For a solid financial and scientific base, a combination of first, second and third flow funding is required. As a result of the government decision to shift budget for direct funding (first flow) to research funds (second flow) the Department of Geotechnology foresees funding problems in the future. This issue is further described in section 3.10, Strengths and Weaknesses. The self evaluation describes the complex model that TU Delft is using to distribute direct funding. This involves the use of a distribution model that combines teaching load (number of students) and research output (e.g. publications). The final amount of funding received by the Department is influenced by their own (scientific and educational) results as well as by the success of other Departments and Faculties.

	2002		2003		2004		2005		2006		2007	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct Funding	3279	58%	3684	63%	4623	66%	4112	70%	4488	66%	4743	58%
Research Funds	593	10%	1068	18%	585	9%	574	10%	459	7%	279	3%
Contracts	1818	32%	1139	19%	1766	25%	1203	20%	1840	27%	3135	38%
Total funding	*5690*	*100*	*5891*	*100*	*6974*	*100*	*5889*	*100*	*6787*	*100*	*8157*	*100*
Expenditure												
Personnel Costs	3442	66%	3414	64%	3583	49%	3462	57%	3833	61%	3766	48%
Other costs	1774	34%	1901	36%	3701	51%	2663	43%	2491	39%	4060	52%
Total expenditure	*5216*	*100*	*5315*	*100*	*7284*	*100*	*6125*	*100*	*6324*	*100*	*7826*	*100*

Table 3.4. Funding and expenditure of the Department of Geotechnology

Section	2002	2003	2004	2005	2006	2007
Applied Geology	17%	12%	24%	20%	14%	18%
Applied Geophysics & Petrophysics	35%	42%	35%	33%	38%	44%
Geo-Engineering	22%	18%	23%	30%	25%	19%
Petroleum Engineering	26%	29%	17%	17%	22%	19%
Total Funding	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Table 3.5. Funding at the section level

3.1.7. Facilities

The Laboratory is a separate organizational unit with a Director that receives its work from the four research programmes. The laboratory supports both teaching and research and is equipped with 'state-of-the-art' facilities and trained personnel. Some of the large facilities are shared with other groups of the TU Delft, e.g. the Micro CT-scanner, the X-Ray Diffraction and X-Ray Fluorescence equipment.

Evaluative remarks on Resources, Funding Policies and Facilities

In general the current resources and funding policy are satisfactory. However, an effort to increase the second flow of funding might be a recommended step towards more and better research output. The Department's facilities are very good and have achieved worldwide recognition. The Committee has noted that since 2007 the Department has profited from being housed in a new and modern building.

3.1.8. Academic Reputation

Much of the research of the department has been the subject of other reviews in recent years. Those review Committees have recognised the good international profile of the research. The staff has received personal awards from scientific societies as well as several international awards. Many staff members work as Associate Editors of high profile journals, three are Editors-in-Chief. Various books were published by editors from the Department. Many staff members also serve as review Committee members for national and international universities, research centres and funding organisations. Finally, numerous international scientific meetings and conferences benefit from the involvement of the Department staff in various aspects of their organisation.

Evaluative remarks on Academic Reputation
The overall academic reputation of the Department is well recognised, especially when it comes to the close interaction with society at large and the relevant Geotechnology problems encountered at that level.

3.1.9. Societal Relevance
The Department's Research Committee is responsible for the quality control of all aspects of research, including safeguarding the mission of the Department, signalling developments in the internal and external research environment, preparing external research quality assessments, evaluating project proposals and monitoring PhD student progress.

The expertise of the Department staff is in demand for various networks, Councils and Commissions, including IPCC, Dutch Ministries, Royal Netherlands Academy of Arts and Sciences, EU, and many others. This broadens the societal involvement. Much of the Department's research is supported by the oil and gas industry, contractors and large technological institutes, confirming the technological impact of the Department of Geotechnology. The Department strives to disseminate research activities to the general public. For this a Communication Officer from the TU Delft, delegated to Earth subjects is at the disposal of the Department.

Evaluative remarks on Societal Relevance
From both the academic relevance and the broader societal relevance points of view, it is clear that this Department is very well positioned. The contract funding percentage in the overall budget of the Department adds further support to this conclusion.

The self-assessment report shows that much of the research undertaken by TUD is of an applied nature, and that at the TUD it is an essential and intrinsic obligation to place much emphasis on research that is relevant to industry or society. The Committee is highly impressed by the well-balanced attention accorded to both basic and applied research at the Department of Geotechnology of TU Delft.

3.1.10. Balance of Strengths & Weaknesses
The self-evaluation report provides a SWOT self-analysis with the following main elements:

Strengths
- Excellent co-operation between the research programmes.
- Participation in large national and international research projects.
- Collaboration with other departments within the Faculty.
- Shared use of laboratory facilities and the high quality of the laboratory facilities.
- High (inter)national reputation of the staff, reflected in publications in high-ranking journals and success in attracting external funds.
- Access to a large pool of potential scientific staff because of the use of the English language.
- Research based education, especially in the master phase.

Weaknesses
- Number of publications per PhD student is moderate and the PhD theses are seldom based on international peer reviewed journal papers.
- Small percentage of young academic tenured staff.
- Low percentage of female scientific staff, particularly at high levels.

Opportunities
- Being the only department in The Netherlands that works on the boundary between Earth Sciences and Engineering.
- Strong bonds with industry (both for financing and stimulation of research).
- Research with societal relevant subjects.
- Relative large number of part-time professors who likewise work in industry.

Threats
- Severe reduction of direct funding from the TU Delft so that research can only be paid for by external funding. In the future matching problems are expected for external funds.
- Reduction of 'open programmes' which supply for the indirect (second flow) funding.
- Finding good PhD students due to strong economy in the sector (industry).
- Loss of academic staff to other universities and industry.
- Increased administrative burden due to centralisation and reduction of support staff.

Evaluative remarks on Strengths and Weaknesses
The self evaluation reports put at our disposal were very well structured; and provided all the relevant data required for the discussion sessions with the Department and Section leaders. Perhaps some more detail could have been provided on publications, the relevant PhD work and interaction with the PhD students.

The number of PhD students is relatively high, which demonstrates that the research is considered of high quality and relevance in the eyes of sponsors and funding organisations. The themes of most of the PhD related work are practitioner-orientated, being indeed strongly related to contract work with industry. It is not an absolute requirement at the TU Delft for PhD students to write several high level journal papers, although they are encouraged to do so. It seems advisable to reflect further on the publication culture in the coming period.

The coherence and coordination, within their research programmes, of the research groups in the new Department of Geotechnology still deserves attention. The Committee believes that the existing interaction between the Section of Applied Geology and the Section of Geo-Engineering is highly relevant.

3.1.11. Interdisciplinary Research Projects
Research projects in the Department of Geotechnology are embedded in interdisciplinary programmes and exist as smaller, individual projects. If the project is only relevant to one research programme, it is described in the programme section. The large projects often include the participation of several research programmes and therefore cannot be classified under one programme. These interdisciplinary projects are described in this section.

The Research Centre Delft Earth
This Research Centre was established by the TU Delft as one of fourteen interfaculty research centres and is coordinated by the Department of Geotechnology. This programme is divided in four sub-programmes that cut across disciplines and faculties, involving crucial elements like observation and monitoring, mathematical modelling, data interpretation and engineering aspects. Numerous cross links exist between the sub-programmes. Of the twenty-two post-doctoral workers and PhD students financed by the Research Centre, sixteen work in the Department of Geotechnology.

The Netherlands Research Centre for Integrated Solid Earth Sciences (ISES)
ISES is one of the national Top Research Centres which involves collaboration between three national research schools in geosciences (Centre for Technical Geoscience, Netherlands Research School of Sedimentary Geology and Vening Meinesz Research School of Geodynamics). The Centre's mission is to perform Earth Sciences research in key areas by integrating expertise of demonstrable excellence in several sub-disciplines. Nine PhD students and postdocs of the Department of Geotechnology are financed by ISES.

The ISAPP programme (Integrated System Approach Petroleum Production)
This programme involves cooperation between TNO, Shell and TU Delft. It aims to increase hydrocarbon recovery through various approaches. At the end of 2007, seventeen projects were running in this programme at TU Delft of which seven (mainly PhD projects) are situated at the Department of Geotechnology.

LOFAR (LOw Frequency ARray)
LOFAR involves cooperation between researchers in astronomy, geophysics and agriculture that aims to build a large sensor network over the northern part of The Netherlands. The geophysical part of LOFAR is called PERSIMMON (PERmanent Seismic IMaging and MONitoring). The Department's research within this programme is aimed at investigating new methods for imaging, monitoring and interpreting structures and processes in the subsurface of The Netherlands.

CATO (CO2 Capture, Transport and Storage in The Netherlands) and RECOPOL (CO2 –Enhanced Coalbed Methane demonstration project in Poland)
The research of the Department within these projects concerns CO_2-enhanced coal-bed methane production and seismic monitoring of this process.

The Delphi consortium
This consortium is currently sponsored by 31 companies from the oil and gas industry and is dedicated to fundamental and applied research in geophysical exploration and covers seismic acquisition, imaging and reservoir characterisation. The Department contributes to the Delphi programme through several projects.

Delft Cluster
The aim of this cluster is to develop and distribute interdisciplinary and validated knowledge for the Soil, Road and Hydraulics sector. It has two (related) themes: infrastructure and water, and is furthermore divided into six sub-themes.

Knowledge Centre Geo-Engineering
This foundation formally establishes the growing cooperation between the Section of Geo-Engineering and the Research Institute GeoDelft. It contains common research themes and agreements on ongoing and new PhD projects, education and sharing of laboratory facilities.

Evaluative remarks on Interdisciplinary Research Projects
The complex set of "interdisciplinary programmes" was not clearly highlighted in the self-assessment report, at least not in terms of the functioning of these programmes and the interaction of the various research groups. For example, the Applied Geology group handles a set of research themes that is probably too diverse to permit in-depth involvement in major interdisciplinary research programmes, with the limited amount of staff available. Other groups seem

better focussed on a limited range of research topics, which allows them to interact with more success in the various interdisciplinary research programmes.

3.2. Assessment per programme – TU Delft

The Committee assessed the following programmes of the Department of Geotechnology at the TU Delft:

	Quality	Productivity	Relevance	Viability
Programmes				
TUD1 - Applied Geology	4	4	4	4
TUD2 - Applied Geophysics & Petrophysics	4	4	4	5
TUD3 - Geo-Engineering	4	3	4	5
TUD4 - Petroleum Engineering	3	4	4	4

The detailed assessment per section follows in the next part of this report.

3.2.1. Applied Geology

Programme number:	TUD 1	
Programme director:	Prof. Dr. S.B. Kroonenberg	
Research staff 2007:	11,5 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

Short description
This programme aims to develop high-resolution quantitative and predictive models of the geological heterogeneity in clastic sedimentary basins of different spatial scales. These models will enhance the understanding of clastic sedimentary systems as a whole and will be applied in discovery, use and sustainable management of subsurface resources. The programme strives to reduce the inherent uncertainty in numerical modelling by developing tools for the quantitative prediction of key subsurface properties such as size, shape, spatial distribution and internal heterogeneity of sediment bodies.

Future aims are to consolidate and expand the expertise of the programme and to cooperate with other research groups. The process of appointing a new section head after retirement of the present one in October 2009 has already been started by the establishment of an Advisory Committee.

Quality
After carefully reviewing and discussing all available information from the self-evaluation report as well as the evaluation of the testing facilities we could visit, it became obvious that the Applied Geology group is doing relevant work for society at large with resources and facilities that are well suited for the task. Almost a third (31%) of the research funding comes from industry. If possible, it would be advisable to embrace research opportunities through the second line of funding (NWO).

The quality of the current work in this programme is very good, focussing mainly on numerical modelling of clastic sedimentary systems, delta linked research etc. Links of the Section's research to structural geology problems (including the role of tectonic movements in shaping the sedimentary basins) and carbonate systems are realised by the 0.0 fte appointment of Prof. Cloetingh and the 0.2 fte appointment of Prof. Reijmer (both from VUA), respectively. Expanding own research on this item might be considered in the future.

Productivity
The section of Applied Geology has maintained a good international level, with an overall productivity that can be classified as very good; even if the research themes covered by this group are of a quite dispersed nature.

The output is still very good, although the number of high-ranking journal papers is somewhat below expectation. However, each of the current staff members is striving to produce a good number of high-level papers, while the number of PhD students is presently at a good level.

Relevance
From both an academic and a broader societal point of view, the work done by the Applied Geology group was found to be very good, especially for the topics closely related to problems of the oil industry. The professional output seems to have decreased over the years.

The dissemination and implementation of the work of this group in societally relevant applications is very good, especially on oil industry problems and on sedimentology driven issues. The Section head, Prof. Kroonenberg, produced a commendable quantity of clarifying publications on scientific issues, informing the broader public.

Viability
The analysis of strength and weaknesses provided in the self-assessment show some concern for the near future in terms of viability for almost all research groups of this Department. For this Applied Geology research group, all is still very much in order today but the group might indeed suffer in the future from the low number of PhD students attracted, certainly if they would have to face a reduction of tenured staff.

Conclusion
The Applied Geology section handles a set of research themes that is probably too diverse to permit them to become very deeply involved in each of them, given the limited number of staff available. Yet, overall, this remains a very good research group, with much potential for the future. An increase in the second flow of research funding is anticipated, with a growing impact on the high level research papers and PhD work.

3.2.2. Applied Geophysics and Petrophysics

Programme number:	TUD 2	
Programme director:	Prof. Dr. Ir. C.P.A. Wapenaar	
Research staff 2007:	24.8 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	5

Short description
This programme executes fundamental and applied scientific research in exploration and engineering in environmental geophysics and petrophysics. The mission is to design techniques and methods of analysis to observe, characterise and monitor structures and processes in the Earth's subsurface in a non-destructive way at different scales. The research is driven by both scientific interest and society priorities within the context of the mission.

Quality
The research is generally of very high quality with focus on applied seismic methods and petrophysics. The methodological development of imaging techniques attracts attention from both industry and fundamental researchers in Solid Earth sciences, e.g. seen in the diversity of funding attracted to the group which includes both industry and public bodies. The group is a partner in an international, research driven teaching programme in applied geophysics and a key partner in the ISES programme, which also attest to its high standing. The petrophysical research is directed towards understanding the significance of physical parameters of porous media.

Productivity
The productivity of the group is very good, and the group leader has an excellent productivity. The impact of the publications in industry is high. The number of PhD theses is good and their subjects are in key aspects of applied geophysics. The publications appear in the best journals in applied geophysics.

Relevance
The group is developing techniques of key relevance to industry, where the results have impact on the development of applied seismics. Several important processing techniques applicable to marine- and land-seismic reflection data have been developed. The large number of research contracts with industry attests to the high direct societal relevance of the research. The strong expertise in imaging techniques will be important to dynamic studies of the evolution of the shallow earth, e.g. related to oil and gas production and CO_2 sequestration.

Viability
The group consists of relatively young, dynamic researchers, although the faculty is of approximately equal age, such that it would be beneficial to attract new faculty members. It has well established contacts with industry which are being constantly developed. Members of the group have posts within the academic community as editors. Another indication of the Section's viability is the fact that a considerable amount of second stream funds has been acquired from the Physics division of NWO.

Conclusion

The group conducts significant research in applied geophysics and petrophysics. The results are of importance to industry and are based on innovative development of techniques. The collaboration with industry provides a strong platform for the future development of the research.

3.2.3. Geo-Engineering

Programme number:	TUD 3	
Programme director:	Prof. dr. ir. A. Verruijt (until March 2002); Prof. dr. ir. F. Molenkamp (from April 2002 until December 2005; Prof. ir. A.F. Van Tol (since January 2006)	
Research staff 2007:	16.3 fte	
Assessments:	Quality:	4
	Productivity:	3
	Relevance:	4
	Viability:	5

Short description
The reorganisation of the Faculty at the beginning of 2004 led to the formation of the Geo-Engineering programme as a merger of four sections (Geotechnical Engineering, Underground Space Technology, Engineering Geology and Geohydrology). The research in this programme is divided into two subjects. The first is the understanding of the thermo-hydro-mechanical transport processes occurring in the ground. The second is the application of this knowledge to improve the construction on, in and by means of the ground and the usage and management of the underground space and a pollution free geo-environment. This is needed to sustain the built and natural environment in the Netherlands that consists of soft soil and high water levels. The research mission is summarised as follows: Striving to optimise the use of the subsurface, the design and maintenance of related infrastructure for a high quality and economic optimised society in a densely populated delta-area, for us and our offspring.

Quality
The quality of the research is very good, with a substantial impact on the society at large and with lots of relevant interdisciplinary approach. There exist in this research group (somewhat hidden) new areas of research of an interdisciplinary research character. We could learn from the discussion with the group leaders, that such research areas can be linked here to crushable material, unsaturated flow through porous media and the still ongoing new developments of soil testing equipment. This is indeed of major interest and certainly beneficial to the international recognition for this research group.

Productivity
The output of the research group is good, but the impact on the scientific level through high quality refereed journals is too low, although it has increased substantially in 2007. The number of conference proceedings and professional publications is high.

Relevance
The work of this group certainly has a major impact on the society at large and so the societal relevance can be quoted as very good. That can also be seen from the large amount of funding through industry contracts (46%).

Viability
The programme and the former sections that now constitute the programme are to be complimented on their promptness of action after the evaluation by the previous Committee. The overall viability of the Section appears to be excellent.

Conclusion
This is a very good research group, however with large needs for more second flow of funding input in order to possibly attract more basic research topics, leading to more scientifically relevant output. The societal impact of this research group is very high and certainly very well appreciated.

3.2.4. Petroleum Engineering

Programme number:	TUD 4	
Programme director:	Prof. Ir. C.P.J.W. van Kruijsdijk (until September 2005); Prof. Dr. P.K. Currie (interim from October 2005 until August 2006); Prof. Dr. W.R. Rossen (since August 2006)	
Research staff 2007:	14.2 fte	
Assessments:	Quality:	3
	Productivity:	4
	Relevance:	4
	Viability:	4

Short description
This programme conducts research on the flow of fluids in oil reservoirs and aquifers, both in the geological formation, and near production and injection wells. Related research concerns flow of water and contaminants in groundwater. Toward this end geological sciences, engineering, physics and mathematics are applied. The primary mission is to develop tools to help maximize the recovery of hydrocarbons from geological formations through better understanding and application of the above mentioned fluid flow. A secondary mission is the protection of groundwater using technology developed for oil and gas recovery.

Research is ongoing on the following topics:

- Closed-loop reservoir management.
- Enhanced oil and gas recovery.
- Subsurface sequestration of CO_2.
- Multiphase flow modelling in porous media.
- Inflow performance and water management.
- Groundwater flow and subsurface environmental control.

Quality
This group is rapidly developing and consolidating, with the recent appointment of two new junior staff. Work is very focussed on practical problems for the petroleum industry, but addresses some topics of wider significance, such as multiphase flow. This is reflected in a funding mix dominated by contracts rather than grants, and the part-time appointments of two professors with Shell. The listed research topics are packaged as applied themes, often with strongly overlapping underlying science. The impact of the more academic work has been good, while on the applied side, work on Closed-Loop Reservoir Management has been particularly effective. For other topics, there is a very high level of competence but it is difficult to identify fundamental new innovations that distinguish the Delft approach as definitive. The review period was one of changes, but the staffing is now stabilised and the group has considerable potential to capitalise on its location in an Institute where engineering, geophysics and geology can interact and develop synergies. We feel that this group is now well placed to develop strongly in the coming years.

Productivity
Publication has traditionally been in conference proceedings, but there has been a marked increase in papers in refereed journals in recent years, and the overall publication rate is very

good. PhD theses have been patchy but seem to have recovered from a significant hiatus. The impact of publications is reasonable for such an applied field, but suggests that they are only now beginning to have a major impact in the wider academic community.

Relevance
This group is primarily an applied research group whose work is aimed at improving the efficiency with which hydrocarbons can be extracted. However their interests extend beyond this, with a developing programme in CO_2 sequestration.

Viability
This group has become established as a viable unit in recent years, with stability in management and new, young staff members. It is well placed for the next review period.

Conclusion
The Petroleum Engineering group at Delft is one of a very small number of such groups worldwide to have interests and aspirations that embrace wider issues of fluid flow in reservoirs. It has for many years worked closely with Shell and been able to address current industry issues. In recent years, it appears to have taken a broader academic approach to the subject and is on an upward trajectory on the international stage.

4. Institute of Earth Sciences, Faculty of Earth and Life Sciences, VU Amsterdam

4.1. Assessment at Institutional level – VU Amsterdam

4.1.1. Introduction

The VU University Amsterdam (VU) has defined a number of priority research themes among of which is "System Earth". The Institute of Earth Sciences (IvA) is one of eight institutes within the Faculty of Earth and Life Sciences at the VU. The IvA studies the Earth System with the aim to better understand the forces and processes operating at different temporal and spatial scales. Formally, the IvA is a Research Institute, the education (bachelors and masters) is administered by the School of Earth and Environmental Science.

4.1.2. Leadership

The Institute is organized according the research structure, clusters form process oriented research programmes and the IvA as a whole constitutes a coherent coverage on the highest scientific level of all key aspects of System Earth. The Institute consists of six programmes, all in charge of the development and implementation of one research programme. The six programmes are subdivided into two research clusters, with two themes. The research programmes are Isotope Geochemistry, Tectonics, Petrology, Sedimentology, Hydrology & Geo-environmental Sciences and Paleoclimatology & Geomorphology. Figure 4.1 is taken from the self evaluation report and shows the research structure of the IvA. Currently, the director of the IvA is Prof. Dolman who acts as the chair of the Board of heads of programmes, assisted by the secretary of the Institute, Dr. Lankreijer (head of the laboratories). Formal responsibilities are according to Faculty regulations. The Board of Heads of Departments (CVA) is the formal decision making body, with the Programme Committee being the main advisory Committee on scientific issues.

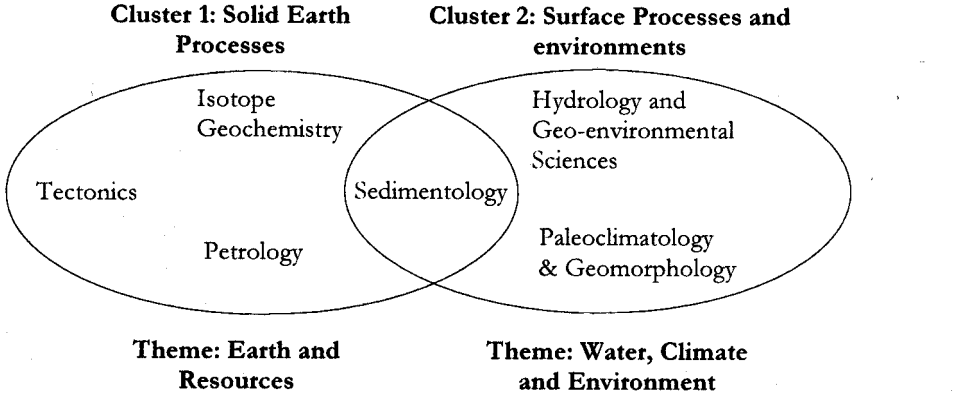

Figure 4.1: Organisational research structure of the Institute of Earth Sciences (IvA).

4.1.3. Mission & Goals

The mission statement of the IvA is to develop understanding of the Earth as an integrated dynamic system. Emphasis lies on the interaction between the geo-, hydro-, bio-, and atmosphere. The IvA aims to achieve this by performing top level research in the before mentioned fields. The research themes aim to achieve international recognition. The Institute focuses on fundamental research, but also engages in applied research. In the execution the research is combined with excellent academic training that crosses traditional sub-discipline boundaries.

4.1.4. Strategy & Policy

The VU has formulated a research mission with the six research *foci*, one being System Earth. The Institute's research plays a central role. Cooperation takes place within the Faculty and with other VU faculties. The research objectives are in line with (a number of) priorities of external organisations (like the Netherlands Organisation for Scientific Research (NWO), the European Science Foundation (ESF) and the European Commission (EC)). The IvA strives at a combination of research priorities that include the generation of external funding as well as maintaining a solid and complete knowledge base in Earth Sciences. This is obtained by the following strategy:

- Integration of ongoing research with masters teaching;
- Maintenance, or increase of the level of external research funding;
- Further strengthening of the IvA in international research networks, by forming partnerships and continuing presence in the European Funding Schemes (KP6-KP7 and ESF);
- Taking initiatives to further develop Dutch Earth Sciences;
- Further integration and modernisation of laboratory infrastructure;
- Further strengthen the impact of System Earth research in society;
- Actively foster and challenge young research talents to secure future research and teaching quality;
- Establishment of the Graduate School Earth, Environment and Ecology.

Significant budget reduction led to a reorganisation plan of the Faculty and the Institute in 2005-2007. This led to an IvA strategy plan for the near future, which was positively received by the Board of the University.

Evaluative remarks about Leadership, Mission and Goals and Strategy & Policy

The Institute has successfully positioned itself to face many of the most important issues in Earth Sciences, and to complement the specialisms of other departments in the Netherlands. While the leadership has been very effective in developing this position, we believe that it has encountered difficulties due to the University approach to Professorships which are discussed in more detail below (4.1.8). The Strategy and Policy of the Institute, and in particular its pursuit of international collaboration, progressive improvements to the infrastructure and integration of teaching with research are all entirely appropriate for an Institute of this size and stature, and we also fully endorse the involvement in initiatives to further Dutch Earth Sciences.

4.1.5. Resources, funding policies and facilities

The IvA has provided an overview of the personnel resources, in full-time equivalents (fte) research time at institute level and at research programme level (tables 4.1 and 4.2).

An overview of funding and expenditure at institutional level is provided in table 4.3. The merger of the Faculty in 2000 and changes in financial regime make it difficult to compare budgets over the years. Direct funding has decreased by 20% between 2003 and 2007, while funding from research funds (second flow) is increased. The IvA aims at a funding ratio of 40:30:30 for first, second and third flow funding. The prognosis of first flow funding is relatively stable. However, this low budget makes the Institute dependent on external funding. The researchers have a good track record in acquiring external funding, but the process puts a lot of strain on the decreased number of (senior) staff members. Furthermore, problems arose and will arise in the future to match granted second flow funding, leading to the abolishment of these grants.

	2002	2003	2004	2005	2006	2007
Full professors	2,61	2,46	2,52	2,45	2,17	2,21
Extraordinary professors	0,05	0,15	0,15	0,15	0,2	0,25
Associate professors	3,04	3,26	3,17	2,82	2,53	3,39
Assistant professors	7,04	7,39	7,56	7,64	6,54	5,71
Other tenured staff	4,24	3,93	3,84	3,57	3,04	4,64
Total tenured staff	*16,98*	*17,19*	*17,24*	*16,63*	*14,48*	*16,2*
PhD students	29,8	27,2	23,3	25,0	26,2	28,6
Other non-tenured staff	13,9	20,4	24,5	21,4	18,9	17,2
Total non-tenured staff	*43,7*	*47,5*	*47,8*	*46,4*	*45,0*	*45,8*
Total research staff	**60,7**	**64.7**	**65.0**	**63.0**	**59.5**	**62.0**

Table 4.1: Research staff at institute level in research fte

	2002	2003	2004	2005	2006	2007
Isotope Geochemistry	**6,8**	**7,0**	**8,8**	**9,7**	**8,6**	**8,4**
Total tenured staff	2,0	2,0	2,1	1,8	1,3	1,3
PhD students	4,2	2,3	3,2	5,5	5,7	5,4
Other non-tenured staff	0,6	2,8	3,6	2,4	1,6	1,6
Tectonics	**16,4**	**16,1**	**14,4**	**10,8**	**10,6**	**14,4**
Total tenured staff	3,0	3,0	3,0	2,9	2,5	4,2
PhD students	9,1	6,6	4,7	4,2	5,7	9,6
Other non-tenured staff	4,2	6,5	6,6	3,7	2,4	0,7
Petrology	**2,4**	**1,5**	**3,4**	**4,5**	**4,4**	**6,9**
Total tenured staff	1,2	1,1	1,3	1,8	1,8	1,9
PhD students	0,3	0,2	1,0	1,5	1,5	2,6
Other non-tenured staff	0,8	0,2	1,2	1,2	1,1	2,4
Sedimentology and Marine Geology	**7,7**	**8,2**	**5,6**	**5,0**	**2,8**	**2,7**
Total tenured staff	2,4	2,1	1,6	1,4	0,5	1,0
PhD students	3,8	3,5	2,1	0,8	0,8	0,3
Other non-tenured staff	1,6	2,7	1,9	2,8	1,6	1,5
Paleoclimatology & Geomorfologie	**12,5**	**17,8**	**19,6**	**19,2**	**18,0**	**14,2**
Total tenured staff	4,0	4,0	4,1	4,1	4,4	4,1
PhD students	5,2	8,4	8,4	7,1	6,5	4,0
Other non-tenured staff	3,3	5,4	7,1	8,0	7,1	6,1
Hydrology & Geo-Environmental Sciences	**15,0**	**14,0**	**13,2**	**13,9**	**15,0**	**15,4**
Total tenured staff	4,3	5,0	5,3	4,6	4,1	3,8
PhD students	7,2	6,2	3,9	5,9	5,9	6,8
Other non-tenured staff	3,5	2,8	4,0	3,4	5,0	4,9

Table 4.2: Research staff at research programme level

	2002		2003		2004		2005		2006		2007	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct Funding	5602	69%	4903	58%	4661	54%	4416	52%	3920	47%	4008	54%
Research Funds	1284	16%	1292	15%	1313	15%	1885	22%	1761	21%	1865	25%
Contracts	1291	16%	1896	22%	1403	16%	1702	20%	1856	22%	1255	17%
ISES	0	0%	103	1%	1166	13%	324	4%	624	8%	236	3%
Other	0	0%	263	3%	155	2%	146	2%	146	2%	49	1%
Total Funding	*8177*	*100%*	*8457*	*100%*	*8698*	*100%*	*8473*	*100%*	*8307*	*100%*	*7413*	*100%*
Expenditure												
Personnel Costs	4930	75%	6337	72%	6792	81%	6650	79%	6546	81%	6688	80%
Other Costs	1608	25%	2499	28%	1560	19%	1718	21%	1580	19%	1684	20%
Total expenditure	*6538*	*100%*	*8837*	*100%*	*8352*	*100%*	*8369*	*100%*	*8126*	*100%*	*8372*	*100%*

Table 4.3: Institute's funding and expenditure at institutional level.

Evaluative remarks about Resources, Funding Policies and Facilities
The level of resourcing is a cause for concern, with a major shift to external competitive funding over the review period. While this is not of itself a bad thing, the excellence of the Department now depends on funds from ISES and other research funds and is no longer in the direct control of the University. This means that ability to bring in external funding must be a major consideration in future appointments and the University and Department should ensure that they are providing effective support for senior academic staff in their fund-raising efforts. At present there are a number of world-class facilities, but some equipment is now in need of replacement and new equipment is needed. This is often difficult to fund through external sources, and the University should seek to ensure that it prioritises the upgrading of facilities, both directly through funding, and indirectly through making it easier for academics to direct external funding towards equipment.

4.1.6. Academic Reputation

One of the key objectives of the IvA is scientific leadership. A number of key researchers of the institute hold positions in the Royal Netherlands Academy of Arts and Sciences (KNAW) and in international academies. Also, prestigious prizes have been awarded to members of the scientific staff. The relatively high success rate in national and international competition for research funds is another indication of high academic reputation. Researchers of the IvA have also been invited on many occasions to participate in international research programmes.

An internal evaluation over the period 2001-2004 judged the performance of the institute as excellent.

Evaluative remarks about Academic Reputation
The IvA is a well known and important player in many areas of international Earth Sciences, and is involved in many international collaborative programmes. This reputation is enhanced by its long tradition of high quality research training for doctoral students, and the dissemination of theses through publications which reach interested researchers worldwide. The Institute maintains a high reputation both in subjects that are closely aligned to the geology of the Netherlands, including some applied areas, and in wider regional and global topics.

4.1.7. Societal Relevance

The validation of the IvA outside the academic community is reflected by the interactions with non-university partners, dissemination of knowledge, employment opportunities and career perspectives of MSc and PhD students outside universities. External evaluation by scientific peers is also of importance to assess the position in its societal context. An effort is made to disseminate knowledge to the general public through popular publications (newspapers, interviews on radio and television).

Evaluative remarks about Societal Relevance

The Earth Sciences are at the forefront of many important economic and environmental issues today, as well as continuing to be an important area of academic advance. The main area of applied research at IvA is in the Program for Hydrology and Geo-Environmental Sciences, but otherwise the department has a strong academic emphasis. Within these areas of academic research however, there is strong involvement with a wider community, nationally and internationally, and some science areas address topics of public interest and concern.

4.1.8. Balance of Strengths & Weaknesses

The institute has provided a SWOT self-analysis of which the headlines are provided in this report.

Strengths:

- The IvA has a good to excellent research status, international reputation and research infrastructure,.
- The IvA has a broad and well focussed research spectrum,
- Fundamental and exact science form the backbone of the IvA, on which further applied and interdisciplinary science can be developed,
- The research climate is informal and interdepartmental, reflected in the publications and PhD students.

Weaknesses:

- The main income of the IvA is generated through research funding. The relative low number of students strongly reduced the first flow budget by changes in allocation mechanisms,
- Overview of the complete research spectrum implies that the research capacity per programme is rather limited (the merging of programmes safeguarded critical mass),
- Career perspectives in science for top-researchers are limited due to temporary contracts.

Opportunities:

- The competitive position in (inter)national funding systems,
- The infrastructure creates opportunities for collaborative research,
- The strong research profile forms the fundament for three specialised research masters,
- PhD students are embedded well in the Research Schools,
- New fields of applied Geoscience can be explored,
- The Graduate School offers opportunities to develop cross cutting courses and masters.

Threats:

- Reallocation of funding by the university has resulted in reduced first flow funding. To maintain budget for research, increased performance in education is required as is a redefinition of the research vs. education balance,

- Matching funds are increasingly important to secure research funds and contracts, which could further limit the earning capacity,
- Maintenance of the high level infrastructure is essential, but this is not addressed in the university or Faculty allocation funding scheme,
- Decrease of first flow funding might negatively impact the ability to attract top researchers.

Evaluative remarks about the SWOT-analysis
The Department is facing uncertain times with a changing funding regime, but is fully aware of the challenges and senior academics are proactive in meeting them. We concur with the self-evaluation SWOT analysis, and would urge the University to work with them to address the problems infrastructure funding. While increased teaching loads are a source of concern for hard-pressed researchers, we feel that since the Earth Sciences are growing in their importance and hence in employment opportunities, it is in the interests of all to meet demands for graduates and to support the department in a way that allows this.

From an external perspective, some of the difficulties that the Department faces seem to be structural in nature and to reflect the way that this University functions. We note that programme VU3 is only now recovering from a long period of uncertainty following the retirement of Professor Touret, with an enormous loss of momentum during the long drawn-out search for a replacement. The Sedimentology department is only now at the outset of recovering from disruption caused by the retirement of Schlager who, like Touret, was a major international figure who had built a very specific research group around him. It is already apparent that some other groups will go through similar downturns when charismatic leaders retire. Most Universities nowadays manage things in a way that places less emphasis on the individual professor and allows less senior staff to develop independently. The widespread availability of competitive external funding makes this much easier and ensures that the best are the most successful. We would urge the University to move towards a management system that allows independent researchers to develop strong groups of their own. Not only will this ensure continuity of excellence during periods of transition, it will reduce the tendency to replace professors by people who are so close to them that a rethink and change in direction is not always possible.

4.2. Assessments per programme – VU Amsterdam

The Committee assessed the following programmes of the Institute of Earth Sciences at the VU University Amsterdam.

	Quality	Productivity	Relevance	Viability
Research programmes				
VU1 – Isotope Geochemistry	4	4	5	4
VU2 – Tectonics	5	4	5	5
VU3 – Petrology	4	4	4	4
VU4 - Sedimentology and Marine Geology	-	-	4	4
VU5 - Paleoclimatology and Geomorphology	5	4	5	4
VU6 - Hydrology and Geo Environmental Sciences	4	4	4	5

The detailed assessment per programme follows in the next section of this report.

4.2.1. Solid Earth Processes: determining high resolution timing and process rates of Solid Earth cycles

Programme number:	VU 1	
Department name:	Isotope Geochemistry	
Programme director:	Prof. Dr. P.A.M. Andriessen	
Research staff 2007:	8.35 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	5
	Viability:	4

Short description
The scientific plan is to improve the understanding of solid Earth cycles and geodynamics. The focus lies on a coherent research programme, with special attention to geological questions and problems that also have societal relevance. Much attention is given to participation in, and providing leadership to, large multidisciplinary (inter)national research programmes, while at the same time deepening and expanding fields of specialization is safeguarded.

The main emphasis is on applications of dating techniques utilising noble gas isotopes, and in recent years there has been a shift towards studies of young processes, utilising technological innovations. Earlier in the review period many theses were on classical "hard rock" regional studies.

Quality
The laboratory facilities are of high quality and the laboratory is a world leader in Ar dating and other noble gas methods, and is also well equipped and active in a range of other dating techniques. The work on Ar-dating has succeeded in pushing back the range of application of the method while greatly improving precision. This is an important part of the current international trend to high precision geochronology. Excellent results are being achieved with rather old equipment, and it will be important to upgrade the mass spectrometers for noble gas work in the next few years. The programme leader, Prof. Andriessen is one of the initiators of ISES (Netherlands Research Centre for Integrated Solid Earth Science) and programme leader of one of the four ISES natural laboratories: the North Atlantic Margin (NorMar).

Productivity
The group has published consistently and at a high quality, with a good impact internationally, judged by the citations of papers by the staff of the group. There is a major emphasis on papers in refereed journals, but a worrying drop in the number of PhD theses towards the end of the review period. There was an average of 21.7 publications per year in the review period, of which 16.8 were in refereed journals.

Relevance
The work of the group is primarily academic in character, but they are involved in development of techniques which will also be used routinely in several areas of applied geology. The group has recognised that technical improvements, which they have helped pioneer, have made it possible to obtain much better ages for a wide variety of geological settings than was possible just a few years ago, and this opens up many new possibilities for geochronology to link with

other disciplines in integrated investigations of geological processes. A particular strength of the group is their widespread collaboration and involvement in a range of projects concerning a wide range of crustal processes, where their techniques, especially using noble gas isotopes, are able to address a wide range of issues.

Viability
This is a small, well focussed group. We understand that some new staff appointments have been made since the formal end of the review period which should provide continuity for the future. Nevertheless, the departure of Dunai did appear to affect the momentum and profile of the team. At present, the appointments that have been made will provide support for the existing research programme, and its natural developments, for some years to come. The group is currently strongly aligned towards noble gas applications, including Ar dating, and it will be important to ensure that as the existing leaders retire they are replaced by people who can carry forward innovation in this field as well as application.

Conclusion
The main emphasis of this department's work is on dating the formation of rocks and their constituent minerals, and the thermal events that they have experienced. Material for investigation is selected to provide markers for specific stages in the geological evolution of a region of the Earth's crust. The research on geochemical processes is concerned primarily with timing and rates and has been particularly successful in developing regional geochronological and thermochronological studies to constrain geological processes in particular areas and settings.

The department is an important international player, which is leading national and international research projects. The group carries out valuable research for which the resources are currently adequate to ensure that the group can operate at the forefront internationally. Other aspects of Isotope Geochemistry are investigated by members of the Petrology Department with shared facilities as appropriate.

We recommend that the replacement of old equipment should be actively pursued, and that the department be proactive in ensuring that, as retiring staff are replaced, the likely long-term developments in the research area are addressed, with an emphasis on continued technical innovation.

4.2.2. Lithosphere Processes, Sedimentary Basin Systems and Tectonic Topography

Programme number:	VU 2	
Department name:	Tectonics	
Programme director:	Prof. Dr. S.A.P.L. Cloetingh	
Research staff 2007:	14.39 fte	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	5

Short description
The research focuses on numerical and analogue tectonic modelling and structural geology field studies, used in an increasingly integrative manner. Central in this integrated approach is the concept of the "natural laboratory", implemented in thematic cooperation with national and international partners. The programme is centred around three interrelated research components that address critical regional and continental-scale geological problems, with a focus on four natural laboratories. The three research components are:

- Observations of the present (neo-tectonics),
- Reconstruction of the past from the geological field (field oriented structural geology),
- Process modelling and validation (tectonic modelling).

Quality
The scientific contributions of the programme leader are outstanding as an international leader. His research is at the forefront internationally and has important and substantial impact in the field. He is leading and coordinating several important national and European geoscientific initiatives, e.g. ISES and TopoEurope. ISES, the Netherlands Research Centre for Integrated Solid Earth Science, is one of only six Centres of Excellence in the Netherlands and has recently been granted continuation of funding for another five years, and TopoEurope is the spear-head, pan-European Earth Science research programme. Prof. Cloetingh was appointed as KNAW Professor in 2006 and he is vice-president of Academia Europaea , which is the European academy of sciences.
The research of the group has clear focus on processes in the lithosphere and their relation to topographic changes, including mountain building and formation of sedimentary basins. The scientific achievements during the evaluation period are outstanding, not least the contribution of new understanding of the formation of sedimentary basins in a variety of settings, including the Pannonian-Carpathian system, the North-West European margin, and the Mediterranean and adjacent areas.

Productivity
The scientific productivity of the programme leader is excellent and at the forefront internationally. He has published several review articles and many high-quality articles in specialist journals. The number of publications by the group as a whole ranges from very good to excellent, although the production is not evenly distributed over the individual researchers in this programme. Almost all articles appeared in first-class international journals. The number of PhD dissertations completed during the period is impressive. The large number of top international collaborators who appear as co-authors of the publications attests to the high-level of cooperative research.

Relevance

The results by the group have clearly advanced our knowledge on processes affecting the lithospheric evolution and have been widely distributed by high-class publications. A very positive aspect is the integrated approach undertaken by the group by combining all aspects of Earth Sciences relevant to lithosphere studies, from field studies to numerical and analogue modelling. The high class analogue modelling laboratory plays an important aspect in this context. The fundamental research attracts significant interest by industry, as can be seen from the number of PhD student grants awarded to the group by industry.

Viability

The group size is appropriate for a programme of this character. The group covers the whole range from young, talented students to the senior leader of the programme. There is a good and healthy working atmosphere which adds to the productivity and quality. Plans for future development appear realistic. The group has managed to attract three extra-ordinary professors during the period, all with industry contacts.

Conclusion

The group carries out research at the highest international level and is clearly among the global leaders in research aiming at understanding processes in the lithosphere and their relation to topographic changes. The research of this relatively small group is linked to the interests of the group leader.

4.2.3. Geochemical Cycles

Programme number:	VU 3	
Department name:	Petrology	
Programme director:	Prof. Dr. P.A.M. Andriessen (acting head until 2004); Prof. Dr. G.R. Davies (2004-present)	
Research staff 2007:	6.87 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	4

Short description
Radical restructuring of the programme together with the appointment of Prof. Davies in 2004 led to a significant increase in funding and an increasing number of postdocs and PhD students. The research programme Petrology applies innovative mineralogical and geochemical techniques to quantify the fundamental processes that drive the formation and differentiation of Earth, Moon and the terrestrial planets. As such Petrology is part of both clusters of the IvA.

The mission of the programme is to quantify the major driving forces that shape the Earth, Moon and terrestrial planets, with a particular emphasis on developing new techniques to study processes controlling planetary formation and differentiation, and those occurring at the biosphere-geosphere interface.

Quality
This programme has undergone rapid development and change both during and since the review period, making the evaluation of quality difficult. For the first part of the review period there was considerable uncertainty over the group's future and this led to a marked fall in activity for several years. We concentrated on the state of the programme at the time we visited, and judged that numbers had grown sufficiently to cause less concern about the diverse range of activities than we had felt at first. The programmes on planetary geology and experimental petrology have some synergies and are both developing rapidly. The planetary geology work has been successful in obtaining funds but still has to produce substantive results, and the experimental geology work is also still developing, but both are addressing important issues for the science. The group is also actively involved in isotope geochemistry, using some of the same facilities as VU1. Some concerns remain over the wide range of subjects over which the group is spread, but it is hoped that they will be able to consolidate in the coming years, as in fields such as experimental petrology a significant support and equipment base is desirable.

Productivity
The productivity of this group appears exceptionally high, also due to the continuing contributions of retired staff, but underlying trends nevertheless now appear to be strong. PhD theses have been low but this reflects the long period of uncertainty during the process of appointing a new professor, which clearly had a negative impact on the department for a number of years. It appears that the group is now on track after a long hiatus.

Relevance
The work of the group is well focussed on problems that have been widely recognised as significant. They are being particularly successful in applying the classical skills of petrology and geochemistry (including isotope geochemistry) to new scientific problems. Much of this work involves close collaborations with a wide range of organisations.

Viability
This is particularly dynamic group led by young and enthusiastic staff. The main potential problem will be fragmentation because of the wide range of work being undertaken.

Conclusion
The Petrology group has had a difficult period since the retirement of Professor Touret, and it is to be hoped that the Department and the University will learn lessons from this. Despite the difficulties, it is now re-emerging as an internationally significant group with new research directions. They will need support to enable them to consolidate the new research areas and put them on a secure basis for the future.

4.2.4. Sedimentology and Marine Geology

Programme number:	VU 4	
Department name:	Sedimentology and Marine Geology	
Programme director:	Prof. Dr. W. Schlager (until July 2002); Dr. A.R. Fortuin (part-time interim August 2002 –February 2007); Prof. Dr. J.J.G. Reijmer (since March 2007)	
Research staff 2007:	2.72 fte	
Assessments:	Quality:	-
	Productivity:	-
	Relevance:	4
	Viability:	4

Short description
As a consequence of the long search for a new programme director, the research staff of the group was significantly reduced. With the arrival of Prof. Reijmer, the section is currently in a start-up phase, including the acquisition of new PhD projects and contract research. The programme covers a wide spectrum of research. The marine record is to be coupled with the terrestrial record, which is a novelty in the programme. The results are not only of high academic and societal relevance, but also of environmental and economic relevance.

The mission of the Sedimentology and Marine Geology group is to provide fundamental contributions to a better understanding of the sedimentary rocks of the Earth, carbonates as well as clastic sediments and by tradition primarily the former, by studying sedimentary processes and their resulting products, anywhere on Earth and across a range of temporal and spatial scales.

Quality, Productivity and Resources
The Department of Sedimentology has only recently (in 2007) been re-invigorated after the retirement of Prof. W. Schlager (in 2002) and an extended period of serious yet unsuccessful negotiations with highly qualified candidates, coupled with an overall budget cut (in 2004). The only staff member left from the original group (Prof. J. Smit) carried the overwhelming teaching load of the group.

The present staff is almost completely new and is now involved in setting up the BS, MS, PhD and research programmes. During the review these were seen to be well under way, including a joint teaching and research programme with the Department of Geotechnology of TU Delft.

After the retirement of the marine geologist, the immediate future of Marine Geology is still uncertain; for the time being activities will focus on Ocean Drilling Programmes.

During the period of the review a few PhD theses appeared, still under the supervision of Prof. Schlager. However, there are few publications relating to the recent period of new research activity of the present group. Nevertheless, the papers written by members of the present staff justify the presumption that the group has the capability to match the other groups of the Earth Sciences Institute.

Membership of international Committees and editorial boards confirm the good academic reputation of the director and other members of the group.

Relevance
The overall research plan is partly new. In addition to the traditional observation of carbonate platforms, actual sedimentary processes of carbonates will be studied. Furthermore, the possibilities of new methods in Isotope Geochemistry and their application will receive special attention, for instance by observing fluid inclusions.

Sedimentary processes, past and modern, will be also be related to changing atmospheric and oceanic conditions, a highly relevant contribution in particular to the studies on Global Change.

Viability
The Institute of Earth Sciences had the opportunity to terminate its research in this field and to restructure its research programme to focus on the remaining areas. However, it decided not to pursue this option and VU has consciously chosen to reinstate the Sedimentology programme. VU now has to accept the consequences of its decision and provide the group with an adequate number of scientists. At present the complement of scientists is somewhat below the minimum requirement, considering the breadth of the research programme.

Conclusion
The Committee appreciates the decision of the faculty not to abandon the sedimentology research area. It is the overall impression of the Committee that, after years of decline, the sedimentology group of VU has regained its vitality and, as the only national carbonate-research group, is about to regain its international reputation in carbonate sedimentology. The formal exchange of teaching duties and the research co-operation with the Geotechnology Department of TU Delft is welcomed by the Committee.
One point of concern is the relatively high teaching responsibility of the department head as Director of the Graduate School of VU. Leading the research programme of the Sedimentology group should be the prime responsibility.

For the time being, the Committee prefers not to grade the quality and productivity of the Department of Sedimentology and Marine Geology. However, the Committee is confident that in the near future the department will achieve a high level of quality and productivity, as the planned research programme is fully brought into action.

4.2.5. Paleoclimate and Environmental Change

Programme number:	VU 5	
Department name:	Paleoclimatology and Geomorphology	
Programme directors:	Prof. Dr. J. Vandenberghe, Prof. Dr. D. Kroon (until 2007)	
Research staff 2007:	14.2 fte	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	4

Short description
The programme Paleoclimatology and Geomorphology is the result of the merging of two programmes in 2005. Prof. Kroon (until 2004 head of the Department of Paleoecology and Paleoclimatology) and Prof. Vandenberghe (until 2004 head of the Department of Quaternary Geology and Geomorphology) were jointly responsible as of January 2005 for the research programme of the newly merged Department of Paleoclimatology & Geomorphology. However, since the departure of Prof. Kroon in 2007 (while retaining a 0.2 appointment at the VU), it was decided that the programme will again be divided into two separate programmes, namely Paleoclimatology and Geomorphology. These research themes are linked by proxies and models.

The programme identifies two main research areas. The first is "Evolution and dynamics of the climate system", the second is "Evolution and dynamics of selected marine and terrestrial geo-ecosystems". The mission and goals are to understand and quantify:

- global to large-scale regional climate change,
- evolution and variability in terms of forcing, processes and feedbacks involved in oceanic and atmospheric transport of heat and water,
- changes and evolution of selected terrestrial and ocean environments in terms of internal dynamics,
- the response of these systems to changes in climate and other external controls.

The mission is achieved by studying modern processes, reconstructions and model-data comparisons.

Quality
The programme directors have led their groups in a consistent, highly proficient and very successful manner and have inspired their teams to undertake original and highly relevant research. Both directors have strong international reputations and both have served as officers in important international organisations. Their staff include several researchers who themselves have international reputations in their own right. The programme has made a key contribution to important international activities, including the IGU, IGCP, FLAG, PAGES, JGOFS, IODP, IMAGES, and the IPCC and to a wide range of EU/ESF initiatives, including PROPER, EPOCA, EUROCORES, RAPID, RESOLUTION and the EGU. It has also proved highly successful in establishing productive collaborative links with 40 institutes in 39 countries.
Although the previous review Committee recommended to amalgamate the two groups, the recent staff developments in this programme and in adjacent programmes have made their separation a logical development that can be readily justified.

Productivity
In both groups, the volume and standard of publication has been consistently high, with sequences of articles appearing regularly in highly cited and prestigious journals. The group members are also co-operating successfully with other groups in the Earth Sciences' Institute at the VU. The number of PhD completions has varied over the assessment period, from a maximum of 6 in 2003 to 0 in the following year. However, taken over the whole five-year period an average of 3 PhD's have graduated each year. Of these, several have continued scientific careers to take up prestigious positions elsewhere. PhD students are fully integrated into the groups and are carefully and systematically supervised to provide support throughout their programme.

Relevance
The focus of this group's activity on global change emphasises its broad societal relevance and its success is readily demonstrated by both its important contributions to national and international programmes as well as in their ability consistently to raise external funding. Members of the group lead in their respective fields, especially in fluvial processes and evolution through the Quaternary, periglacial processes, palynology, climate reconstruction and ocean and atmospheric circulation.

Viability
Now that the groups have been reinstated as separate entities and new programme directors are appointed for the Paleoclimate and Geomorphology group to replace Prof. Vandenberghe who will retire in two years' time, the programme is well placed to maintain its very strong reputation and position as well to develop new initiatives and exploit new opportunities. Emphasis will be placed on modelling fluvial systems under various climate situations, development of a range of proxy measures for paleoclimate and geomorphological reconstruction, ocean acidification studies, in association with other programmes, especially sedimentology, and finally system reconstruction. The young staff brings important vitality to the programme, but there is a need to promote staff retention, in order to maintain momentum.

Conclusion
Overall this programme is in a very healthy state and its standards are very high to excellent. Its young staff possesses considerable vitality and this produces a very energetic group that offers both staff and students an inclusive and highly productive working environment.

4.2.6. Exchange processes and feedbacks between atmosphere, biosphere and geoshpere

Programme number:	VU 6	
Department name:	Hydrology and Geo-Environmental Sciences	
Programme director:	Prof. Dr. A.J. Dolman and Dr. L.A. Bruijnzeel (Ecohydrology group); Prof. Dr. P.J. Stuyfzand and Dr. H. Kooi (Hydrogeology group)	
Research staff 2007:	15.44	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	5

Short description
This programme started in June 2003 through the merger of two sections (Hydrology & Hydrogeology and Geo-Environmental Sciences). Increase of integration between the two sub-programmes, formerly independent, is being stimulated. Both sub-programmes consist of three research themes.

The main goal of the programme is to contribute to the analysis, quantification and prediction of effects of anthropogenic and climatic changes on hydrological, meteorological, hydrochemical and biogeochemical and ecological processes. A second goal is to understand how these processes are interlinked and integrated at the landscape scale. The focus of the programme is on the analysis and synthesis of ecological and hydrological systems. The research area of the Ecohydrology group is the study of the hydrological and biogeochemical interactions between biotic parts of ecosystems and their abiotic environment within specific constraints of scale and geo-climate setting. The mission of this sub-programme is to study the interactions between soils, land cover and use, and the water, carbon and nutrient cycles at the local to regional scale, including their feedback on atmospheric and climatological processes. The research area of the Hydrogeology group is defined as the study of hydrological processes and conditions in the subsurface, with special attention to the saturated zone and the interactions with the geo-, hydro-, bio- and atmosphere that control groundwater quantity and quality.

The mission is to enhance qualitative and quantitative understanding of groundwater-related hydrological processes and conditions, thereby contributing to a more sustainable use and management of the Earth's water resources.

Quality
This programme was in a state of transition during the early part of the review period, with the former Departments of Hydrology and Hydrogeology and Geo-Environmental Sciences merging in 2003, to form the Department of Hydrology and Geo-Environmental Sciences. This merger has proved highly beneficial in terms of facilitating collaboration and interaction between the various groups and introducing new leadership and direction. However, there is arguably some uncertainty regarding the precise focus of the new department that relates to the boundaries between the earlier departments and groups and their names. Less attention is now given to hydrology *per se* and the title currently used for the overall programme provides a clear indication of the broad interdisciplinary scope of the research currently undertaken by the department. Potential exists to integrate further the Ecohydrology and Hydrogeology groups, as the distinction between surface and subsurface processes is somewhat arbitrary,

and it might be advantageous to create a new theme structure under the general title Geo-Environmental Sciences.

Within the broad area defined by the programme title, the department has established a coherent programme that focuses on ecological and hydrological systems and the links between hydrological, meteorological, hydrochemical, biogeochemical and ecological processes. This is an important area of science and its direct relevance to contemporary concerns for global change and sustainability further emphasises its relevance. The Director and other senior staff are well known internationally and the VU group is developing a strong international reputation. It has developed a distinctive interdisciplinary approach that crosses traditional boundaries and aims to integrate empirical, experimental and theoretical work with modelling, whilst also exploiting the potential of remote sensing. The international significance of its work is well demonstrated by both its global coverage and the extensive involvement of its members in international research programmes and initiatives, such as GCOS, GTOS, the UNESCO IHP, ISMAR, GRAPHIC and SWIM as well as numerous EU FP6 and FP7 projects and the CarboEurope project. The group has developed productive links with a large number of research groups outside of the Netherlands and is also well-networked nationally. At home, it has, for example, made an active contribution to the KNAW Foresight Committee on Hydrology and to the development of the national hydrological platform, the Boussinesq Centre. The refocusing and development of the Department in recent years has produced a marked improvement in the quality of its publications which are now characterised by papers in a wide range of high impact international journals. High quality outputs are being produced by both senior and younger members of the department.

Productivity
The programme has maintained a high level of productivity over the review period, despite retirement of senior staff, the restructuring of the department and the involvement of Dolman as Director of the Institute since 2006. Numbers of papers in refereed journals has, as might be expected, varied from year, but there is evidence of an upward trend over the period. The publication strategy has been successful in targeting higher impact journals and progress has been made in placing outputs in journals such as *Science* and *Nature*. An appreciable number of professional publications have also been produced. During the review period the programme generated 160 papers in refereed journals. With a total research input over the period from tenured staff of 27.1 fte, this equates to 5.9 papers per fte. Over the review period the number of full-time PhD students has averaged about 9 and 18 PhD theses have been successfully examined. The PhD students have made an important contribution to the research output of the Department.

A considerable number of professional publications have been produced. Dr. Bruijnzeel has made a very important input to the UNESCO IHP programme on Forests, Water and People and its publications. The policy of requiring PhD students to publish papers in international refereed journals also ensures that their work is rapidly and widely disseminated. Active involvement in European and international research programmes and initiatives has ensured that ideas and advances generated by the department are readily shared with the wider scientific community.

Relevance
The research of the Department links well with many important contemporary scientific issues related to global change and the sustainability of the Earth system and also has a clear applied

relevance through interests in, for example, the reforesting of degraded tropical landscapes, the fate of contaminants in groundwater systems, salinisation of coastal lowlands and the development of managed aquifer recharge techniques. Unlike other groups in the Netherlands in related fields, the Department has succeeded in maintaining a substantial component of overseas research, for example in tropical areas, where it is making a key contribution to developing an improved understanding of the dynamics of cloud forests and the problems of land use change more generally. Overall the Department is making a very important contribution to international work in its field. Its successful publication strategy has ensured the wider dissemination of its work.

Viability
The restructuring of the programme by merging the former Departments of Hydrology and Hydrogeology and Geo-Environmental Sciences, the development of new interdisciplinary research foci, the exploiting of new technology and particularly remote sensing, the appointment of carefully targeted new senior staff , the fostering of an active group of younger researchers and the development of close links with other research groups, both nationally and internationally, as well as strong leadership have created a very successful and productive Department with a strong commitment to research, that is well-placed to extend this success further in the future. The age structure of the department is well-balanced and the younger staff must be seen as having considerable potential and as contributing important vitality to the department. New opportunities have been identified and the potential for further improving collaboration across the Institute and Faculty, productivity and international standing has been recognised. The future looks bright, although it is important that funding for PhD students should be maintained, that the need to update laboratories and other research infrastructure is recognised, and that a proactive policy of staff retention is seen as an important requirement.

Conclusion
The Department of Hydrology and Geo-Environmental Sciences has grasped the opportunities afforded by its recent restructuring and refocusing and has provided clear evidence of a very good performance over the review period. They are now well placed to further improve their standing, although they will need support to enable them to achieve their full potential.

There is a need to ensure that numbers of PhD students are maintained and that if possible level 1 funding is made available to support a limited number of students, in order to permit the targeting of novel topics and to promote new areas of collaboration both within the department and through wider links across the Institute and Faculty. Funding for experimental work, particularly that undertaken overseas, and for laboratories and other infrastructure must be maintained. Problems of staff retention also need to be actively addressed.

It might also be appropriate to direct further thought to the internal organisation of the Department, to promote closer integration of the hydrogeology group with the other areas of interest. The distinction between surface and subsurface hydrology is arguably of limited relevance. Work on hydrochemistry, biogeochemistry, contaminant transport and diffuse source pollution, for example, clearly straddles this boundary. Furthermore, closer integration of the Hydrogeological and Geo-Environmental research areas could assist in broadening the opportunities for applied research.

4.3. VU Amsterdam: Assessment PhD programme

4.3.1. Objectives and outcome of the PhD programme

The VU University Amsterdam Graduate School Earth, Environment, and Ecology (VUA-GS-EEE) is being developed to integrate the existing MSc and PhD programmes in the field of Earth, Environment and Ecology and make graduation from this Graduate School the entry card to the PhD programmes within three Dutch research schools: NSG (Netherlands Research School for Sedimentary Geology), SENSE (Research School for Socio-Economic and Natural Sciences of the Environment) and ICG (Centre for Geo-ecological research; Inter-universitair Centrum voor Geo-ecologisch onderzoek).

The PhD programme will train students to be capable of dealing with complex societal issues of dwindling resources and global change. To improve the educational part of the PhD programme of the NSG, the future PhD teaching programme will comprise a set number of hours per year in which the student will follow short courses. The choice of courses to follow is made by the PhD student and his/her supervisor. In addition one of the Graduate School colloquia will be attended, where world-top scientists and specialists from the industry will give in-depth and broad courses. In addition, general skills training will remain part of the PhD training programme.

Several additional aims are formulated to improve the PhD programme. These are to develop an innovative PhD education programme based on high quality research and strong international collaboration:

- to further strengthen the international visibility of the PhD programme
- to acquire additional funds for PhD scholarships
- to maintain the quality control at its present level and where possible improve
- to reduce the time in which the PhD students surpass the four-year limit
- to assure that courses that are followed are recognised using the EC system
- to improve the broader Earth System Science context of the PhD programme by strengthening links between the existing MSc programmes, amongst which the formally accredited Basin- and Paleo- Research Master programmes.

4.3.2. Educational components of the PhD programme

The aim of the PhD programme is to deliver highly skilled academic professionals to the job market. Most important for the PhD student is to achieve skills required in order to undertake research. For each PhD student an individual training programme is developed at the initiative of the promotor. For this, three complementary learning methods are used:

- Learning by doing,
- Topical short courses on advanced research topics
- Training in transferable skills.

4.3.3. Training and supervision

The actual research project is supervised by the promotor and copromotor(s). However, scientific interaction within research groups is essential for the success of an individual PhD project. The promotor, often head of the department, is responsible for optimal scientific interaction, including international exposure of the PhD students.

Topical courses are organized through the Research Schools and feature leading international scientists. For PhD students that graduated outside the Graduate School, selected MSc courses may be included in the training programme. In order to prepare for a professional career in science or elsewhere, the broadening of the skills of PhD students is organized in training courses. At present these comprise a proposal writing clinic, project management, scientific writing and oral presentation skills.

4.3.4. Selection and progress monitoring

The first admission criterion is a MSc diploma from a certified university. A small Committee of staff members assesses the possible candidates before admission to the programme. The promotor develops a training and guidance plan for each PhD student. All supervisors are required to be actively involved in ongoing research. Through the years the Departments of Tectonics and Isotope Geochemistry have developed a cooperative programme in which the research of individual PhD students is supervised by advisors from both departments. The VUA-GS-EEE will strive to increase this type of interdepartmental cooperative programme, with an important role for ISES in this development.

4.3.5. Internal quality assurance

The courses of individual research staff members, charged with tuition and supervision are evaluated internally on an annual or biennial basis. One year after starting the PhD project, an evaluation of progress is made and it is decided whether the project will be continued, redirected or stopped. Additionally, a strict scheme of evaluation is implemented through the annual review (*jaargesprek*), which is fully integrated in the Faculty's HRM policy and forms a powerful tool for monitoring and steering both PhD students and their supervisor. The Dean of the Faculty oversees the entire process.

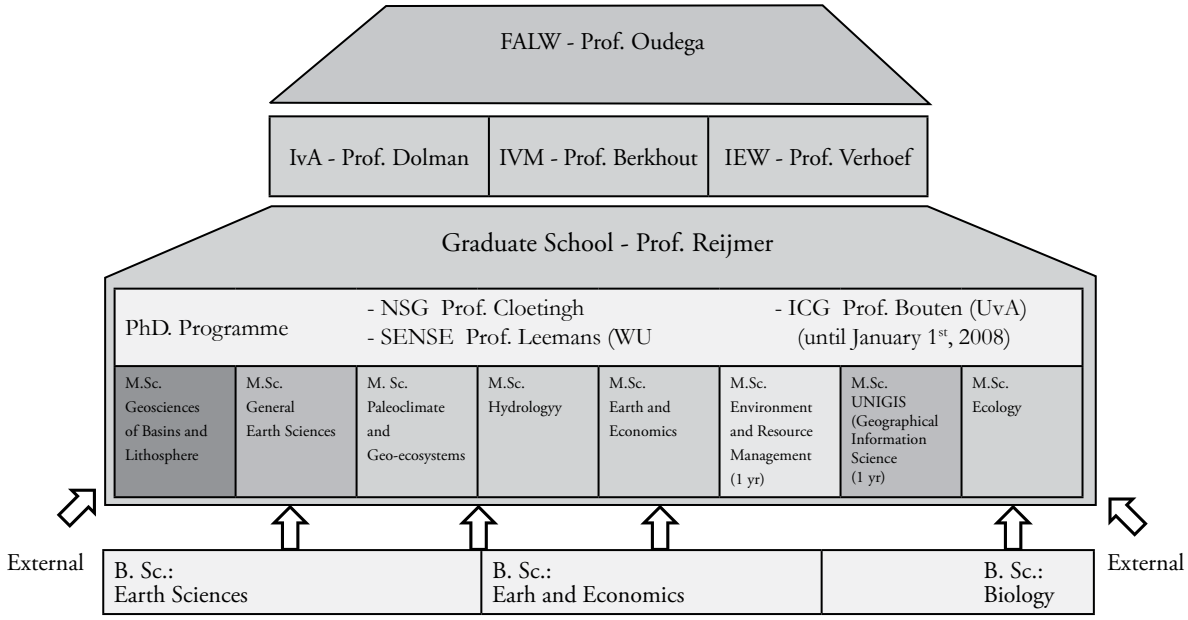

Figure 4.2 Organization of the MSc and PhD programme structure

The standards that apply to Earth Science PhD graduates are significantly higher than those of the formal University Promotion rules. Publication of three international peer review arti-

cles is the minimum requirement for a promotion. At present differences exist between the research programmes in the precise demands for promotion; the graduate school aims to formalise standards in the coming year. Quality of the project is guaranteed by peer review in the national competition for research grants. Additional quality control takes place through accreditation process of the research schools.

4.3.6. Institutional embedding

The PhD programme of the IvA part is executed by NSG. The overall organization of the MSc and PhD programme structure was provided in the self assessment report (fig. 4.2). The VU-GS-EEE is set up to streamline the integration of the MSc and PhD programmes. The graduate school will bundle the wide variety of education programmes into one Graduate School and by doing that it strives to:

- Promote a better student exchange between various teaching and research programmes
- Set new education standards
- Develop new master programmes in response to market demands.

4.3.7. Strengths and Weaknesses

The institute has provided a SWOT self-analysis of the PhD programme of which the headlines are provided in this report.

Strengths

- Strong international reputation of the NSG and ISES Research Schools.
- International network in academic and applied domain and high visibility of faculty members
- Low drop-out number of PhD students.
- Publications in international highly ranked scientific journals.
- Skill training.
- Strong involvement extraordinary professorships from industry and non-governmental organisations.

Weaknesses

- Significant administrative work load for simple start-up procedure.
- Restricted academic funding and restricted financial supply from first stream funding.
- Financial situation IvA, continuous threat to number of scientific staff and laboratory staff, strongly influencing the academic programme of the departments.
- Limited industry funding, e.g. due to the high salary costs of PhD students in the Netherlands.

Opportunities

- Bundle forces of the research departments in FALW – IvA.
- Strengthen collaboration with TU Delft, NIOZ (Texel) and UU Utrecht.
- Attraction of talented national and international students.
- Further development of international networks.
- VU Amsterdam Graduate School: new initiative that needs to find its place in existing structures.
- Strengthening of links with industry and expansion of industry funding.

Threats

- Limited scholarships, no direct funding available to attract talented international students.
- Change in internal financing model, supporting BSc-teaching, but not top research and graduate research training.
- Unbalanced opportunities to acquire income from internal financial sources.

Evaluative remarks on the PhD programme at the VU University

The Committee welcomed the opportunity to review the PhD programme of the Institute of Earth Sciences (IvA) for the period 2002-7 and was appreciative of the full self-assessment documentation, the comprehensive presentation on the PhD programme provided by Professor Reijmer, the director of the VU University Amsterdam Graduate School Earth, Environment and Ecology (VUA-GS-EEE) and his colleagues, and the opportunity to meet with a representative group of six current PhD students. The end of the review period was marked by important changes in the organization of the PhD programme, with the initiation of the VUA-GS-EEE in late 2007, and, although the assessment reviewed practice and achievements over the previous years, it was necessarily also aware of the new structures and procedures that had been put in place and are currently in operation. The comments presented below refer to the PhD programme of the IvA, rather than the wider EES programme.

Overall the impressions of the Committee were highly positive. The quality of the PhD programme was judged to match very closely the very good to excellent performance indicated by the research programme of the IvA and to provide a valuable and essential complement to that programme. The PhD students make a very important contribution to the ongoing research programme of IvA, in terms of both their input and vitality, and it is important that the research strengths of the IvA should be propagated through to the next generation of Earth Science researchers. Key features of the PhD programme with which the Committee were impressed included the well-defined and well-structured programme, the very effective training, the strong outward facing perspective and the links with national and international research training programmes, the high calibre of the intake, the very high quality of the theses produced, the strong commitment to exposing PhD students to the international scientific community, and the enthusiasm and commitment of the PhD students.

The over-arching rationale and objectives of the PhD programme within IvA, as presented in the self-assessment documentation, provide a very sound basis for the programme. The institutional structure is well-defined and recent moves to strengthen the links between the MSc and PhD programmes and with related disciplines, through the newly formed VUA-GS-EEE, as well as the links with ISES, must be welcomed. The close integration of the PhD programme within the IvA, and the GS-EEE more generally, with the three Dutch research schools, namely NSG, SENSE and, until recently ICG, as well as with other European initiatives, including Marie Curie networks, is important in adding both depth and breadth to the training programme and in promoting a multidisciplinary and international perspective.

The high quality of the IvA PhD programme is clearly demonstrated by both the substantial number of applicants and the receipt of applications from many countries outside of the Netherlands. At present, *ca*. 43% of the PhD students within IvA have originated outside of the Netherlands.

The programme for an individual student provides a very effective basis for a sound research education and training. There is clear evidence of good supervision practices and a good balance between learning by experience and exposure to taught courses. Students are researching exciting areas at the forefront of their research areas, as demonstrated by both the need for IvA to compete for funding for research projects and the large number of papers based on PhD research projects that are being published in high quality international journals. The availability of a wide range of taught courses, including both high level scientific courses, many of which are given by international experts, as well as courses linked to 'soft skills' or the acquisition of personal skills, and attendance at colloquia, provides a very sound basis for a well-rounded PhD training. It is good to see clear guidelines as to the proportion of a student's time that should be devoted to receiving such taught courses, as well as to themselves participating teaching activities. The strong encouragement given to PhD students to present papers at international scientific meetings and the provision of funding for such attendance is also an important strength of the programme.

The IvA PhD programme has a strong commitment to internal quality assurance. Admission is competitive and qualifications are carefully controlled. Supervision involves both senior and junior staff, with the Professor or promotor providing overarching guidance. A strict review process, involving a major review of progress after Year 1 as well as subsequent annual reviews ensures that the research undertaken is of high quality and proceeds smoothly. The requirement to incorporate ca. three papers, published or accepted for publication in high level peer-reviewed international journals, in the PhD thesis provides a very strong and rigorous element of quality control on the final thesis, which is also examined by four external reviewers. The recent PhD theses made available for inspection by the Committee were all highly impressive and of a very high quality.

The PhD programme at IvA, whilst very successful and of a high standard, is inevitably constrained by the available resources for funding PhD researchers. Over the period 2002-7, 69 PhD students graduated, resulting in an average of 10-11 completions per year. This represents a significant input of highly skilled Earth Scientists to the system. Most, if not all, found ready employment, suggesting that demand may be greater than supply, particularly when viewed in an international context. Further consideration could usefully be given to assessing the optimum PhD throughput, considering, for example, the national and international demand, rather than relying on the vagaries of project funding to determine numbers. In this context, there are significant differences between the number of PhD students graduating from individual Departments over the review period and there is a need to establish whether such differences are in tune with demand and the need to maintain research vitality within individual subject areas or are again determined by the vagaries of funding. The loss of first level funding for PhD projects represents an important problem and there is a clear need for this to be at least partially restored, in order to permit a more pro-active approach to PhD education and training which would, for example, provide for the encouragement of outstanding MSc students, the targeting of novel research, the promotion of interdisciplinary collaboration and the support for areas that are less likely to receive funding from level 2 and 3 sources. The Committee was, as indicated above, impressed by the support provided to PhD students to attend international conferences to present papers and to visit laboratories in other countries. It is important that such support should be maintained and that it should be available on an 'equal opportunity' basis across IvA, rather than depending on the financial situation of a particular Department or the nature or source of the funding supporting a particular project. Furthermore, the importance of technician support to PhD

projects must be recognised. It is important that such support is maintained if PhD students are to work at the research frontier.

The success rate for PhD students at IvA must be seen as being at a high level, and as having improved further in more recent years. This clearly reflects the strength of the PhD programme and its organisation. Some scope exists for bringing the mean duration closer to 4 years but overall the performance of IvA in this aspect must be seen as good.

The career destination of successful PhD students from IvA provides further clear evidence of a very successful programme and of its high international standing. The objective of achieving high international visibility is undoubtedly being met.

Discussions with a group of 6 PhD students, drawn from different Departments within IvA and representative of different stages of study, provided clear confirmation of the very positive impressions outlined above. The Committee was impressed by the enthusiasm and motivation of the students, which in turn reflected well on the PhD programme. The students were in general happy with the research environment and facilities, but some concerns were expressed regarding the very limited office space and the lack of social space for coffee breaks etc. In addition, they were concerned that the funding currently available for conference attendance and visits to other laboratories should not be eroded in the future.

Conclusions and recommendations

The IvA PhD programme is of a very high quality and has proved very successful in recent years. It provides a very important input to the overall research programme of the Institute, as well as serving an important role in educating and training the future generation of Earth Science researchers. It is of international importance. The recent establishment of the VUA-GS-EEE should enable it to develop further to meet new challenges and its links to ISES and other national and European initiatives offer further opportunities for advancement and development. There is arguably a need to review the balance between supply and demand, since at present the latter may exceed the former, and to establish a more stable system of financial support for PhD education and training. Restoration of at least some of the previous first level funding would permit a more proactive approach to ensuring the future success of the programme in meeting the needs of both the discipline and the wider community.

5. The Physical Geography Research Institute (PGRI), Utrecht University

The Faculty of Geosciences at Utrecht University consists of four Departments that originate from different Faculties within the university. Two Departments, the Department of Earth Sciences and the Department of Physical Geography, are included in this review. Since the merger of the Faculties of Earth Sciences and Geographical Sciences in 2003, collaboration between the two Departments has increased noticeable. A joint teaching Institute already existed and a joint (faculty wide) Graduate School of Geosciences has recently been established. Despite the increased collaboration at research level, research activities are performed separately at two Institutes, the Institute of Earth Sciences Utrecht (IVAU) and the Physical Geography Research Institute (PGRI). Both institutes run two research programmes and each have provided a self evaluation of their programmes. This report will follow the approach of the Faculty of Geosciences by separately describing Institutes and accompanying research programmes.

5.1. Assessment at Institutional level – PGRI Utrecht University

5.1.1. Introduction

The Physical Geography Research Institute (PGRI) is the research Institute of the Physical Geography Department in the faculty of Geosciences. The Institute deals with geographical and environmental research in river and coastal dynamics, geomorphology, soil and land degration, hydrology, and eco-hydrology. In addition, the Institute conducts research in geocomputation and supporting methodologies. Two research programmes run within the PGRI, with the research groups for each programme being formed around two chairs. The research programmes and chairs of the institute are as follows:

Programme 1: Landscape functioning, Geocomputation and Hydrology (LGH):

- Chair: Physical Geography with emphasis on Land degradation and Remote sensing
- Chair: Geographical Hydrology.

Programme 2: Coastal Dynamics, Fluvial Systems, and Global Change (CFG):

- Chair: Physical Geography with emphasis on Coastal Morphodynamics
- Chair: Physical Geography with emphasis on Global Change Geomorphology.

5.1.2. Leadership

The institute is embedded in the department of Physical Geography (DPG) and is headed by the Director of Research Prof. Dr. SM de Jong, who also has a seat in the Daily Management Team of the Department. The board of PGRI consists of the leaders of the two research programmes. The board of the Department and the board of the PGRI are jointly responsible for the Institute's research programme. The position of the research programme, progress of research and future project plans, and the programme as a whole are regularly discussed by the board and the researchers that are part of the programme. Collaborative activities with other Departments and Institutes (e.g. IVAU) are coordinated by the PGRI board. The Director of Research represents the Institute in the Research School as well as the Graduate School of Geosciences.

5.1.3. Mission & Goals

The mission statement of PGRI is to excel in scientific research and graduate education, with research directed to understanding the physical processes, patterns and forms at the Earth's terrestrial surface, their mutual interactions, and their relationship to biotic factors, including humanity. The Institute's research is characterised by high scientific quality of international standing, and fundamental as well as applied research topics. PGRI is also described as integrating a strong physical basis, field knowledge and the development of innovative measurement and modelling techniques. The Institute's ambition is to create a productive, hospitable and stimulating environment for excellent research and graduate education, well-equipped with advanced facilities.

5.1.4. Strategy & Policy

As a result of the reorganisation in 2005 and reduction of staff, the strategic vision was rewritten and new research priorities were set. The outcome is the present Department structure, consisting of two main research groups with complementary and slightly overlapping expertise and knowledge. The new research plan was introduced in 2006. This resulted in developments, including the reduction of financial vulnerability to fluctuating and declining number of students, reduction of number of courses to safeguard sufficient research time and an increased focus on research in the new generation of staff.

The central research area of PGRI is ´Earth Surface Morphodynamics of Terrestrial and Coastal Systems´. The main topics of the Institute are ordered according to the geographical units of the watershed, each unit having its own characteristic processes and landscape forms. The units are also interconnected through a continuous exchange of energy and matter. For all units four important topics of study are defined. Following these units and topics, the research within the PGRI is structured into two programmes, each containing five research themes. A description of the programmes and themes is provided in heading 5B.

Multiple strategic alliances and scientific networks have been established to strengthen the research of the institute. Selection criteria for collaboration include the level of expertise and skills (at least equal to PGRI), the possession of complementary theoretical skills in research, coming from a totally different background, and having a local, regional or national interest and responsibility in land and water management.

Within the UU, cooperation exists at Faculty level, with the Utrecht Centre of Geosciences (UCG) and the Institute for Marine and Atmospheric Research Utrecht (IMAU). Within the Netherlands collaboration with the Research Schools ICG (Interuniversity Centre for Geoecological Research) and Buys Ballot is established, and with several national Research Centres. On an international level PGRI participates in numerous scientific networks.

Evaluative remarks on Leadership, Mission and Goals and Strategy & Policy

The PGRI has set up organizational structures to coordinate and steer the research programme in an effective way. There is clear evidence of successful leadership and direction.

The mission and goals are clearly spelt out and are to the point. The research focus is on the core of physical geography. The reorganization has focussed activities and has provided a more coherent mission.
These are well-adapted to the (financial) constraints. With respect to the strategic alliances, PGRI uses clear criteria for establishing collaboration. The reorganization has resulted in closer integration of the individual components of the previous research programme.

5.1.5. Resources

PGRI encourages its researchers to actively participate in national and international networks, to publish in high-quality journals and books, to participate as an advisor in boards of (non) governmental organisations and to be involved in public debate of relevant societal issues. The institute provided an overview of the personnel resources, in full-time equivalent (fte) research time (table 5.1). The norms that are used to quantify the actual research input are provided in table 5.2.

	2002	2003	2004	2005	2006	2007
Full professors	1,6	1,9	2,1	2,1	1,3	1,5
Associate professors	2,0	2,4	3,0	1,8	1,7	1,3
Assistant professors	4,4	4,2	3,8	4,1	4,3	3,8
Total tenured staff	*8,0*	*8,5*	*8,9*	*8,0*	*7,3*	*6,6*
PhD students	17,7	13,8	15,5	17,7	17,3	14,6
Other non-tenured staff	4,8	6,1	8,5	7,1	7,1	11,1
Total non-tenured staff	*22,5*	*19,8*	*24,0*	*24,9*	*24,4*	*25,7*
Total research staff	**30,6**	**28,3**	**32,8**	**32,9**	**31,6**	**32,3**

Table 5.1: Staff at department level (in research fte)

	factor of research
Full professors, associate professors and assistant professors	0.4
Postdoctoral associates	0.8
PhD students	0.8

Table 5.2: Factor for converting fte to research fte.

Recruitment of new staff follows a policy of open procedures with a selection Committee compiling a shortlist of the strongest candidates. All employees have a yearly Results and Career Development interview with their supervisor in which they evaluate the past year and discuss targets for the upcoming year. This includes scientific activities as well as training opportunities and coaching.

The PhD programme of the institute involves both internal and external PhD students. Internal PhD candidates perform their research as part of the overall research programme. A detailed plan concerning their research is set up by their promotor. For courses and teaching, guidelines exist on which courses to take and how much teaching to perform. External PhD candidates have no obligation to follow educational courses or perform teaching.

With a relatively small group of young scientists as tenured staff, career opportunities for the existing staff personnel are fairly limited. This resulted in the departure of several staff members, able to successfully obtain positions elsewhere. The loss of experienced staff members resulted in a strategic plan to maintain the level of research and education. One of the measures was to stimulate the exchange of UU and foreign scientific staff.

Evaluative remarks on resources

Resources are rarely adequate. Loss of experienced staff members (because of limited career opportunities) has been partly compensated by promoting exchanges between UU and foreign staff. The PGRI faces several problems in terms of the magnitude and the stability of the resource and the lack of direct funding for PhD. students. Currently, PhD students are

funded from research projects which make it difficult to stimulate cross-disciplinary collaboration within the PGRI and to develop new initiatives. However, PGRI appears to have evolved a satisfactory *modus operandi*, which, whilst far from ideal, permits it to function effectively.

5.1.6. Funding Policies

Table 5.3 provides an overview of funding and expenditure of the Institute. As a result of cutback operations in the Faculty, direct funding has considerably decreased over the past years. The Institute was able to partly compensate this reduction by an increase in external funding. An important amount of the external funding was obtained in the form of personal grants.

In order to secure external funding, the strategy for the following years includes applying to institutions, foundations, and agencies across a range of scales that represent opportunities for pure and applied research. All potential external funding sources are carefully evaluated.

	2002		**2003**		**2004**		**2005**		**2006**		**2007**	
Funding	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Direct Funding	2347	67%	2470	75%	2377	75%	2147	69%	1883	58%	1663	50%
Research Funds	429	12%	274	8%	218	7%	471	15%	607	19%	616	18%
Contracts	732	21%	536	16%	583	18%	498	16%	743	23%	1070	32%
Total Funding	*3508*	*100%*	*3280*	*100%*	*3178*	*100%*	*3116*	*100%*	*3233*	*100%*	*3349*	*100%*
Expenditure												
Personnel Costs	2361	89%	3211	84%	3450	91%	2993	85%	2712	79%	2721	86%
Other Costs	286	11%	627	16%	332	9%	510	15%	714	21%	460	14%
Total expenditure	*2647*	*100%*	*3838*	*100%*	*3782*	*100%*	*3503*	*100%*	*3426*	*100%*	*3181*	*100%*

Table 5.3 Funding and expenditure of the Institute PGRI

Evaluative remarks on funding policies

Funding policies are very good, considering the financial constraints (decrease of direct funding). PGRI has successfully coped with the decrease in core funding by increasing the income from research grants and contracts. PGRI participates in an impressive number of FP6 and FP7 EU-research programmes.

5.1.7. Facilities

Sophisticated techniques and methods are required and the Institute's expertise represents a broad range of measurement and sampling techniques and methods. The laboratory is well equipped with an appropriate mixture of equipment and instruments as well as with major facilities such as an experimental flume. Skilled laboratory staff provides co-operative support for field research and laboratory experiments.

The PGRI facilities are:

- Laboratories.
- Facilities for sediment analysis.
- Wave and current flume.
- Measuring frames.
- Experimental Flume for Hydrology and Slope Stability.
- Geocomputation or the Spatial dynamic modelling language PCRaster and GSTAT geostatistical package.

- Database of digital geo-spatial information.
- Borehole archive.

Evaluative remarks on facilities
The PGRI facilities are good to very good. While good at present, there is inevitably a problem in maintaining world-class facilities without a clearly defined budget line for such expenditure.

5.1.8. Academic Reputation
Indicators that are used to reflect the academic reputation are:

- Number of individual grants;
- Publications;
- Membership of NWO and KNAW Committees, foreign and national PhD evaluation Committees and membership of public workgroups and Committees;
- Editorial boards and guest editorship;
- Key note presentation;
- Presence in organisation Committees of symposia and workshop;
- Awards.

The research evaluation Committee in 2001 made several remarks and recommendations in order to sustain and improve the academic reputation. Based on these comments, action was taken.

Evaluative remarks on academic reputation
The academic reputation of PGRI is very good, as reflected by the number of SCI-papers, journal impact factors and citations (all of which have increased in recent years) as well as memberships of national and foreign organisations, editorial boards, keynote presentations and awards. The implementation of a more pro-active publication strategy, targeting high-impact international journals, and increased involvement in European and international collaborative programmes has undoubtedly increased the academic visibility and reputation of PGRI.

5.1.9. Societal Relevance
Staff members take part in policy advisory bodies in the field of water management, coastal protection and global change. The considerable amount of contract research, consultancy, expert advice and many other activities indicate the relevance of the research.

In the 'Year of the Planet' the institute has played a role in the scientific content of the Geotruck. This is an interactive mobile classroom where secondary school students become aware of major environmental challenges. The institute participates in the post-academic training of high school teachers in geosciences. Many articles were published in national and international professional journals and books have been published in the field of coastal management and erosion assessment.

Evaluative remarks on societal relevance
The societal relevance of research conducted by PGRI is very good, as demonstrated by the many activities listed in section A9 (External validation, p. 38-39, of the Self-Assessment Report 2002-2009). Through the redefinition of its research foci, PGRI has emphasized the societal relevance of its work relating to the potential impacts of global change, the role of

human activity in perturbing natural systems and coastal and river basin management. The work on deltas and large river basins is of particular national relevance.

5.1.10. Balance of Strengths & Weaknesses

The institute has provided a SWOT self-analysis of which the headlines are provided in this report.

Strengths:

- An excellent scientific reputation and international standing,
- An excellent tenured scientific staff that spans almost the entire field of Physical Geography,
- A clear research strategy with common ground and clear research *foci*,
- A wide range of advanced methodological tools and an excellent laboratory for field equipment,
- A high-quality and motivated community of PhD students and postdoctoral associates,
- High number of excellent quality PhD theses,
- Extensive participation in (inter)national projects, networks and scientific organisations,
- Research activities that are well represented and provide a core contribution to the UU research area 'Earth and Sustainability',
- A strong and diversified funding base, reflecting the capacity to respond to changing financial constraints and societal demands,
- The institute houses a wide range of complementary disciplines providing excellent opportunities for interdisciplinary research,
- Good to excellent research facilities and support personnel.

Weaknesses:

- The institute has currently no direct funding for PhD and postdoctoral positions, or co-finance the acquisition of state-of-the-art equipment
- It is not possible to hire new tenured personnel and uncertain career perspectives for the staff
- Loss of expertise and knowledge as a result of departure of senior staff
- 30% reduction of tenured staff in the period under review
- Focus on research resulting from UU policy hampers the recruiting of ambitious educational staff,
- Difficulties to grant staff a sabbatical.

Opportunities:

- New research funds from the European Research Council and European Science Foundation.
- Possible research funds from the new Knowledge for Climate Research Programme.
- Expected increase in the NWO budget for Sustainable Earth.
- Increasing number of students since 2007.
- Increasing concern in society for environmental threats, resulting in growing awareness of research.
- Research at the IVAU is clearly complementary, but touches on similar themes.

Threats:

- The continuous concern about budget cuts with negative consequences for research and staff.
- Growing dependency on external research funds and decrease in tenured staff.

- Loss of direct funding for PhD positions reducing the possibilities for existing fundamental research lines.
- Student numbers currently increase, but potential limited enrolment might hamper financial income (which is dependent upon overall student numbers).

Evaluative remarks on the SWOT-analysis
There is evidence of a well-balanced analysis of strengths and weaknesses for a research institute with a rather young staff. Strengths and weaknesses have been meaningfully assessed and opportunities identified, to plan for a successful future.

The PGRI of UU maintains a tradition of very good to excellent field and model-based research. Despite the financial constraints, it has maintained a high level of research output, which has increased over the last years, thanks to very strong leadership. The reassessment and restructuring of the research programme of the Institute, resulting in a more focused and coherent research strategy linked to key contemporary issues, coupled with the implementation of a clear publication strategy and excellent leadership, appear to have generated significant improvements in its performance. PGRI has inevitably faced a number of problems over the review period but these have largely been successfully overcome and the Institute would appear to be well-placed to move forward and to strive to achieve its objectives.

Some additional comments
- PGRI has addressed successfully all recommendations made by the previous assessment.
- The Committee is concerned about the available spaces for setting up the experimental flumes and for storing sediment samples in the new research building.
- A point of continuing concern is the reduction in direct University funding, which led to a drop in tenured staff. The number of tenured staff should not decrease further. The lack of PhD. positions funded by the UU hampers the stimulation of cross-disciplinary collaboration within PGRI.
- The Committee is of the opinion that it is very important that the PGRI should maintain good access to the OSL dating facilities in Delft (Dr. J. Wallinga, Nederlands Centrum voor Luminescentiedatering, TU Delft / Faculteit Technische Natuurwetenschappen, Reactor Instituut Delft). Ideally, the OSL dating facilities should be integrated into the UU.
- The Committee regrets that PGRI has found it necessary to reduce its research activities in developing countries, because of financial restrictions and pressures to produce high-impact papers.
- PhD students of PGRI were highly satisfied with their PhD. training. However, they expressed their concern that some activities, such as the discussion groups involving PhD students from other Dutch universities, would soon resume, after the switch from the national research schools (ICG) to the graduate school organized by UU.
- Overall, there are too few women on the staff, and particularly at senior level. This is a matter that should be addressed.

5.2. Assessments per programme – Utrecht University, PGRI

The Committee assessed the following programmes of the PGRI at the Utrecht University

	Quality	Productivity	Relevance	Viability
Research programmes				
UU 1 - Landscape functioning, Geocomputation and Hydrology	4	4	4	5
UU 2 - Coastal and Fluvial Systems and Global Change	4	4	4	5

The detailed assessment per programme follows in the next section of this report.

5.2.1. Landscape functioning, Geocomputation and Hydrology

Programme number:	UU 1	
Programme director:	Prof. Dr. S.M. de Jong and Prof. Dr. Ir. M.F.P. Bierkens	
Research staff 2007:	7.2 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	5

Short description
The mission is to understand the processes and patterns in terrestrial ecosystems, in particular the way in which landscape, ecosystem functioning and land degradation are related to soil, hydrology, climate, relief and vegetation. An important part of research is devoted to understanding the impact of climate change and human activities.

Key factors in the programme are:

- The quantitative, spatio-temporal modelling of land degradation and hydrological processes at various spatial and temporal scalesgv45rtfb
- The use of *earth observation techniques* to collect input data for the simulation models, to validate and calibrate the models and to survey patterns of degradation.

The programme is structured into five well-defined and coherent research themes:

- Land degradation
- Earth observation for vegetation and soils
- Geocomputation
- Large-scale Hydrology
- Ecohydrology

Quality
The research topics of LGH are very relevant in the context of global change effects on ecosystems and society as well as sustainable development. The research programme is coherent and has made a significant contribution to the discipline thanks to the excellent leadership of its directors and the close cooperation between PhD researchers and postdocs. LGH continues a tradition at UU of very good field and model-based research.

Productivity
Over the 5-year period LGH increased the number of published journal papers and book chapters and has focused on higher impact journals. During the assessment period LGH produced on average 7.4 international refereed journal publications per full-time equivalent tenured staff in research (169 publications / 22.8 fte tenured staff), in addition to a significant number of publications in other journals and book chapters. This represents a very good achievement.
During the assessment period LGH had annually on average 2.1 PhD. students per fte tenured staff (8.1 PhD./3.8 tenured staff/year).

Relevance
Overall the dissemination and implementation of knowledge is very good. PhD students are strongly encouraged to produce ca. 4 SCI journal papers before they defend their thesis which guarantees dissemination of important research findings in the international literature. The work of LGH has considerable applied value and relevance in a world concerned with the impact of global change and sustainability. LGH has also produced a significant number of professional publications and products (e.g. software).

Viability
LGH is a rather young and very dynamic group with a very strong leadership which has successfully addressed the recommendations made by the previous assessment. The research topics identified for the future (p. 101-104 of the Self-Assessment Report 2002-2007) are all highly relevant and important areas of research activity in the field covered by LGH.

Conclusion
The programme Landscape functioning, Geocomputation and Hydrology of the PGRI of UU continues a tradition of excellent field and model-based research and demonstrates very good performance in the fields of geomorphic processes (mass movements, soil degradation), hydrology, geocomputation, remote sensing, Geographical Information Systems and ecohydrology, amongst others.

A point of continued attention is the decline in first level funding which leads to a reduction in tenured staff. The number of tenured staff should not further decrease. The lack of PhD positions funded directly by the UU inevitably hampers the stimulation of cross-disciplinary collaboration within PGRI.

5.2.2. Coastal and Fluvial Systems and Global Change

Programme number:	UU 2	
Programme director:	Prof. Dr. P. Hoekstra and Prof. Dr. E.A. Koster (until 2005, now vacant)	
Research staff 2007:	9,6 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	5

Short description
The research focuses on the morphodynamic and sedimentary processes, patterns and products in coastal and fluvial environments and their response to global change. Global change comprises two major developments: the impact of climate change and the way in which earth surface processes and landforms are increasingly affected by human activities.

The programme has five focus areas, related to the two main chairs. The chair in Coastal Morphodyamics is responsible for:

- Morphodynamics of sandy, wave-dominated environments, including beaches, surf zones and near shore coastal systems.
- Morphodynamics of river deltas, estuaries and barrier island systems (e.g. Wadden Sea); the emphasis is on studies on a time scale of days to months and years to decades.

The Chair in Global Change Geomorphology covers:

- Sensitivity and response of drainage basins to climate change, changing land use patterns and direct human impact in terms of water and sediment fluxes and nutrients.
- Delta evolution: the evolution of alluvial plains and river deltas on relatively 'long' time scales (centuries to millennia).
- Morphodynamics of alluvial rivers.

Quality
The research undertaken within this programme has achieved an international reputation and is clearly of very good to excellent quality, making an important contribution to the field. The programme has been restructured and refocused since the last VNSU review, to address limitations identified by that review. The new mission and strategy continues to reflect the UU tradition of integrating field and model-based research and the range of themes now covered demonstrates a clear overall coherence and exploits important synergies between topics. New appointments have been carefully targeted towards key areas within the programme, thereby further increasing its coherence, and the research group derives considerable benefit from the presence of three Adjunct Chairs linked to Deltares/Delft Hydraulics, KNMI and Royal NIOZ. The new mission links closely to contemporary environmental issues and management problems, whilst still addressing important scientific questions. Links with national, European and international research programmes and initiatives, including the ARGUS network, INQUA/INTIMATE, IGBP-LUCIFS and FLAG, have also been considerably strengthened. The publication strategy has succeeded in targeting appropriate high profile specialised inter-

national journals and citations have increased. However, there is arguably a need for more outputs in journals such as *Nature* and *Science*, to emphasise further the international standing of the programme's research.

Productivity
The programme maintains a high level of productivity, within the constraints imposed by funding and teaching demands. The number of publications shows evidence of a significant increase over the review period and the publication strategy has succeeded in targeting higher impact journals. During the review period, the programme generated 169 papers in refereed journals. With a total research input from tenured staff over the review period of 24.47 fte, this equates to 6.9 papers per fte. Over the review period the number of full-time PhD students working within the programme has averaged 10 and these have provided a significant input to the overall research programme.

Relevance
The refocusing and restructuring of the group has achieved a good balance between fundamental and applied research. The emphasis on global change within one component of the programme highlights its societal relevance and, within the programme more generally, the research on river basins and coastal morphodynamics is proving of importance for informing management and policy. Equally, the central role of deltas, estuaries and shallow seas within the programme clearly demonstrates its strategic importance at the national level. The programme has made an important contribution to international work in its field and the productive publication programme has ensured the wider dissemination of its work. The outputs of programme staff include a significant number of professional publications and products. The policy of requiring PhD students to publish papers in international refereed journals also ensures that their work is rapidly and widely disseminated. Active involvement in European and international research programmes and initiatives has also promoted the wider dissemination and application of the ideas and findings generated by the programme's research. The reduction in overseas research activity and particularly that in tropical areas, whilst understandable in terms of financial constraints, the need to maximise productivity and the important opportunities closer at hand, is, nevertheless, something that must be regretted.

Viability
The restructuring of the group to combine the former coastal and fluvial groups has proved highly successful in increasing critical mass, exploiting synergies between the two topics and promoting collaboration. Staff retirements have necessarily left significant gaps, but have also provided the opportunity for the new leadership to redefine the group's mission and to establish a strategy for achieving that mission. The recent appointment of the Chair in Global Change Geomorphology has completed the restructuring and staffing and, with its strong leadership and current complement of young, active and productive staff with a strong commitment to research, the group is well placed to improve further its international standing and achievements. The younger staff must be seen as providing very considerable potential. The group has set itself the challenge of becoming one of the top 5 groups in Europe in its specific field of research and one of the top 10 globally, within the next 5-8 years. Important advances have already been made in the past few years since the reorganisation, new opportunities have been identified and further improvements can be expected.

Conclusion

The Coastal Dynamics, Fluvial Systems and Global Change Programme within the Physical Geography Research Institute continues the longstanding interest of the Institute in coastal and fluvial systems and in the integration of field and model-based research. However, the opportunity to combine the two groups working in these areas, as recommended by the previous VNSU review, and to redefine the mission and strategy of the new group, has resulted in a revitalized programme with strong leadership and a young, active and productive staff. The performance of the group has shown significant improvement since the last review and is now consistently at the very good level. They are well placed to advance their standing and achievements further, but they will require support to achieve their full potential.

In particular, there is a need to ensure that the number of tenured staff is maintained and that problems of staff retention are actively addressed. Good teams take time to build and develop, but can rapidly dissipate. PhD students are a key component of any programme and it is important that strong efforts should be made to maintain numbers. The loss of PhD positions funded directly by the University impacts on PhD numbers, but also limits the potential to use PhD projects pro-actively, to promote collaborative initiatives across both the group and PGRI more generally and to explore new areas.

Other issues of concern include the need to ensure that the proposed new building provides adequate accommodation for the flumes and related experimental hardware used by the group and for sample storage. Ready access to OSL dating is also an important requirement for the group and it is important that the facility currently based in Delft should be maintained, with the possibility of moving it to Utrecht also being considered.

6. Institute of Earth Sciences Utrecht (IVAU) – Utrecht University

6.1. Assessment at Institutional level

6.1.1. Introduction

The Institute of Earth Sciences Utrecht (IVAU, Instituut voor Aardwetenschappen Utrecht) was established in 2003 as a merger of the Research Institute of Geodynamics (GOI, Geodynamisch Onderzoeks Instituut) and the Institute for Paleoenvironments and Paleoclimate Utrecht (IPPU). _ At present, the Faculty of Geociences has two research institutes in the field of Earth Sciences: the Physical Geography Research Institute discussed in Ch. 5.1 and 5.2, and the IVAU. The latter addresses the dynamics of System Earth at all temporal and spatial scales.

The research is structured into two main programmes with five key themes:

Programme 1: Geodynamics of the Solid Earth
- Theme 1: Earth structure, planetary dynamics, and geopotential fields
- Theme 2: Evolution and dynamics of the crust/lithosphere system
- Theme 3: Earth materials: properties and processes

Programme 2: Climate and Environment
- Theme 4: Paleoenvironments and paleoclimate
- Theme 5: Environmental geosciences

6.1.2. Leadership

IVAU is the research institute of the Department of Earth Sciences. Bachelor and master teaching is the responsibility of a teaching institute. The tasks of IVAU concentrate on research and Ph.D. teaching/training. The board of the Department consists of a head, a director of education, a director of research and a managing director. The director of research is the head of IVAU. Research is performed in two research programmes, divided into five themes and is based on the activities of thirteen research groups. Research is coordinated by the director of research in collaboration with the five theme coordinators.

Daily functioning of the IVAU is regularly discussed by the Institute board and the Department board. Long term and strategic decisions are taken after consulting staff and group leaders that are involved. Individual researchers and research groups build on their own strengths and provide input on improvement and innovation, while fulfilling the general research mission.

The programme development is based on an informal 'bottom up' communication structure. Important instruments for renewal and redirection are yearly monitoring of relevant parameters, discussions in regular staff assemblies, meetings of individual research groups with the Department board, periodic meetings of all chairs with the faculty board and an incentive-based accounting method to distribute direct funding.

6.1.3. Mission & Goals

The mission of the Institute is to advance understanding, description, and prediction of processes that govern evolution and functioning of the Earth, from the molecular to the planetary system scale. By applying the principles and methods of physics, chemistry, biology, mathematics and computational sciences the Institute aims to reconstruct, interpret and predict the

structure and interactive dynamical behaviour of the solid Earth, the hydrosphere, the atmosphere and the biosphere, on time scales ranging from seconds to billions of years.

The ambition of IVAU is to further develop itself as an international centre of excellence in scientific research and research training.

6.1.4. Strategy & Policy

The broad spectrum of the research programmes is in line with the international Earth Science research agenda, testifying to the scientific relevance of the programme. Advances in geosciences increasingly rely on multidisciplinary approaches. To remain at the forefront of research, the institute aims to simultaneously consolidate its expertise and reputation in the core disciplines, while actively exploring emerging scientific challenges at the interfaces between Earth Sciences and other disciplines. Prior to the review period, the filling of vacancies was allocated to the research groups. The Institute and Faculty, since 2002, decide upon tenured positions to be able to respond to external influences. IVAU has made significant efforts to strengthen strategic alliances with industrial partners, public agencies and applied and fundamental research institutes.

Evaluative remarks about Leadership, Mission and Goals and Strategy & Policy

The Institute is among the leading geosciences institutions in the world with an appropriate and well functioning structure. The mission is clearly described and the research of the Institute aims at reaching the goals. The strategy is based on existing strength of the Institute and actively pursues emerging subjects. The Institute is a relatively large organisation (43 staff and 89 students and post-doctoral workers), and as such it is clearly important that its leadership is strong and coherent. On both counts the structure established over 10 years ago seems to function well and integration of the group activities both in teaching and research appears to be successful.. The Institute has very strongly established goals in both the two programme areas, solid earth, and climate and environment. The policy appears to be to adopt strong research objectives on a broad but clearly defined front. Indeed the approach is clearly not to attempt to cover all major areas in the Earth Sciences. For example, traditional topics such as plant and animal paleontology are not included. This is logical in a small country, in order to avoid duplication.

6.1.5. Resources

The IVAU has provided an overview of personnel resources, in full-time equivalents (fte) research time at institute level and at research programme level (table 5.4 and 5.5). The norms that are used to calculate research fte are: tenured staff 0.4 fte, postdoctoral associates 0.8 fte and PhD students 0.7 fte.

The career development of tenured staff is monitored by annual Result and Career Development interviews. A university wide system of qualification and training programmes and a newly developed tenure-track plan within the faculty provide equal opportunities and fair assessments.

Financial cutbacks at university level and decreasing undergraduate enrolment resulted in a reduced amount of first flow funding. Most savings were made on administrative positions, laboratory and technical support and material budget. Hiring of new permanent staff predominantly has been limited to the partial replacement of staff members who retired or transferred. Non-tenured staff increased by more than 20%, which is primarily due to the efforts of permanent staff in raising external research funding to hire PhD students. Recruitment of

all personnel is internationally oriented. PhD students are numerous in the two research programmes, but also many PhD students perform their research outside the university and are employed at allied institutes. For all PhD students a detailed research and graduate education plan is prepared by the supervisor.

	2002	2003	2004	2005	2006	2007	Mean
Full Professors	3.4	3.9	4.1	3,8	3,3	3,4	3,7
Associate professor	3.5	3.2	3.3	4,5	4,7	4,7	4,0
Assistant Professors	8.3	7.6	7.3	6,4	5,9	5,8	6,9
Total Tenured staff	*15.2*	*14.7*	*14.7*	*14,7*	*13,9*	*14,0*	*14,5*
Research Associates	20.2	24.5	24.8	19,1	20,8	20,4	21,6
PhD Students	31.1	25.8	30.3	36,8	40,0	44,5	34,7
Total non-tenured staff	*51.3*	*50.4*	*55.1*	*55,8*	*60,7*	*64,9*	*56,4*
Total Research staff	**66.5**	**65.1**	**69,7**	**70,5**	**74,6**	**78,8**	**70,9**

Table 5.4: Staff at institute level (in research fte)

Programme 1 – GSE	2002	2003	2004	2005	2006	2007	Mean
Full Professors	2.1	2.5	2.3	2.1	1.6	1.7	2.1
Associate professor	1.7	1.5	1.5	2.7	2.7	2.4	2.1
Assistant Professors	4.9	4.9	4.7	3.2	3.2	3.4	4.0
Total Tenured staff	*8.7*	*8.8*	*8.4*	*8.0*	*7.5*	*7.4*	*8.1*
Research Associates	10.8	11.8	9.7	7.6	10.3	11.0	10.2
PhD Students	13.8	13.0	13.9	18.3	17.6	18.6	15.8
Total non-tenured staff	*24.5*	*24.8*	*23.6*	*25.8*	*28.0*	*29.6*	*26.0*
Total Research staff	**33.3**	**33.6**	**32.0**	**33.8**	**35.5**	**37.0**	**34.2**
Programme 2 – CE	2002	2003	2004	2005	2006	2007	Mean
Full Professors	1.3	1.5	1.8	1.7	1.7	1.7	1.6
Associate professor	1.8	1.7	1.8	1.8	2.0	2.4	1.9
Assistant Professors	3.4	2.7	2.6	3.2	2.7	2.5	2.8
Total Tenured staff	*6.5*	*5.9*	*6.2*	*6.7*	*6.4*	*6.5*	*6.4*
Research Associates	9.5	12.7	15.1	11.5	10.4	9.4	11.4
PhD Students	17.3	13.0	16.4	18.5	22.3	25.9	18.9
Total non-tenured staff	*26.8*	*25.7*	*31.5*	*30.0*	*32.8*	*35.3*	*30.3*
Total Research staff	**33.3**	**31.6**	**37.7**	**36.7**	**39.2**	**41.8**	**36.7**

Table 5.5: Staff at Programme level (in research fte)

Evaluative remarks about Resources

The resources available are at present adequate and at admirably high level. However, concern may be expressed that the current cut in first stream funding on the longer term may have negative consequences for maintenance, updating and renewal of facilities. The Institute has traditionally been strong also in applied geophysics, and it could be considered to direct further resources into this aspect of the Earth Sciences, e.g. through a tenured position.

6.1.6. Funding Policies

Direct government funding channelled via the university has been decreasing since 2002. The IVAU has successfully maintained and even extended its total of PhD and postdoctoral positions, in particular via NWO funded posts (indirect, second flow funding).

	2002		2003		2004		2005		2006		2007	
	k€	%	k€	%	k€	%	k€	%	k€	%	k€	%
Funding												
Direct Funding	5086	67%	4807	65%	4782	56%	4371	48%	3847	47%	3847	47%
Research Funds	2117	28%	1849	25%	2810	33%	3681	40%	3255	40%	3255	40%
Contracts	381	5%	722	10%	899	11%	1055	12%	1082	13%	1082	13%
Total Funding	*7584*	*100%*	*7378*	*100%*	*8491*	*100%*	*9107*	*100%*	*8184*	*100%*	*8184*	*100%*
Expenditure												
Personnel Costs	5483	77%	6296	79%	6390	76%	6309	78%	6793	78%	6696	80%
Other Costs	1675	23%	1670	21%	2000	24%	1821	22%	1960	22%	1653	20%
Total expenditure	*7158*	*100%*	*7966*	*100%*	*8390*	*100%*	*8130*	*100%*	*8753*	*100%*	*8349*	*100%*

Table 5.6: Funding and expenditures at institute level

	Programme 1	Programme 2
2002	57%	43%
2003	54%	46%
2004	54%	46%
2005	50%	50%
2006	52%	48%
2007	53%	47%

Table 5.7: Contribution of funding per research programme

Table 5.6 provides an overview of the funding and expenditure of the institute, table 5.7 shows the contribution of the funding per research programme. Notably is the high success rate in obtaining personal research grants for top researchers in various stages in their careers. A significant increase is observed in funding under the form of grants from European programmes (Framework programmes, ESF) and other international stimulation programmes for collaborative research. The funding from other sources, like industry, mission agencies and Ministries is also clearly on the rise.

Evaluative remarks about Funding

The funding level of the Institute appears appropriate, as attested by the high productivity. However, the decrease in direct funding to below 50% causes worry, as it increases the vulnerability to fluctuations in external funding. As mentioned above, a new position in applied geophysics would be an asset to the Institute. The Institute has downgraded the number of directly funded PhD students which fortunately has been partly compensated by the funding available through ISES, NWO, UCG, the Darwin Center for Biogeology, and the EU. The collaboration within ISES appears very important. The Institute has been very successful in attracting funding through the Veni, Vidi, Vici programme.

6.1.7. Facilities

The IVAU researchers have access to a vast array of experimental, field and computational facilities. Some major and distinctive facilities include the general analytical and geoservices laboratory (GEOLAB), the Electron Microscopy Utrecht Centre (EMU), the EUROTANK flume, the paleomagnetic laboratory, the high-pressure-temperature rock deformation laboratory (HPT lab), the Laser-Ablation-ICP-MS laboratory, the Network of Autonomously Recording Seismographs (NARS), and the Geoscience Library.

Major equipment investments heavily depend on external funding. With limited possibilities for matching from direct funding, maintaining 'state-of-the art' facilities is becoming seriously pressured.

Evaluative remarks about Facilities
The Institute has a broad pool of high quality laboratories and instruments, which are important for supporting the high level research. The facilities for research are first-rate and of internationally leading standard. Major maintenance and upgrading of the facilities are necessary at regular intervals in order to maintain the high standards. Concern may be raised as to whether the current low level of direct funding may prejudice the necessary short term maintenance. Hopefully the high standards of the Institute may ensure that long term upgrading will be funded through external sources. The joint efforts by the Institute and TNO regarding sharing library facilities and certain laboratory facilities must be commended.

6.1.8. Academic Reputation
The academic output has increased during the period under review, both in number of articles in refereed journals (+25%) and in mean impact factor (from 2.263 in 2002 to 3.579 in 2006). The large number of keynote addresses, invited conference presentation, memberships of (inter)national research(policy)-Committees and governmental advice Committees, memberships of editorial boards of esteemed academic journals, career development grants, prizes and awards contribute to the national and international academic reputation of the institute.

Evaluative remarks about Academic Reputation
The Institute is among the world's leading players in aspects of the Earth Sciences, not least regarding, seismology, geodynamics and paleomagnetics. There is a fruitful, strong connection between the seismology, geodynamics and Earth materials groups as well as between the groups in climate and environment. The Institute has a high productivity in high profile journals and the impact factor of the contributions has been increasing significantly during the evaluation period. Several awards have been received by the Institute, which also attests to its high reputation The Institute enjoys an international reputation for consistently excellent research across the whole spectrum of its endeavours. The fact that it attracts workers and doctoral students from many countries is a significant indicator of this fact.

6.1.9. Societal Relevance
Collaborative research within and outside the University is commonplace and increasing, reflecting both the growing reliance on multi-disciplinary approaches in the Earth Sciences and the stimulation provided by funding sources.

In 2006 the IVAU was invited to develop a new Earth Sciences module that is currently being implemented at Dutch High Schools in the new course programme Nature, Life and Technology. Two IVAU professors initiated the Geotruck in the context of the International Year of the Planet Earth by UNESCO (see heading 5.1.9).

While the emphasis of the Institute lies on fundamental research, projects linked to innovative industrial applications and environmental management have been funded.

Evaluative remarks about Societal Relevance
The high academic standing of the group attests to its societal relevance. The research is often presented in public media. The Institute has developed a new teaching package in Nature, Life

and Technology to Dutch high schools, which is currently being implemented, as well as a "Geotruck" for bringing Earth sciences to the public during the IYPE. The Technology Transfer Award of The Leverhulme Trust was given to the institute in 2007 for research on clogging of groundwater wells. The external impact of the research undertaken is very apparent. This is especially the case for the work being undertaken by Prof. Hassanizadeh and his colleagues in the Hydrology section. Three professors at the Institute are funded through agreements with Shell and TNO.

6.1.10. Balance of Strengths & Weaknesses

The institute has provided a SWOT self-analysis of which the headlines are provided in this report

Strengths:

- A forward-looking, internationally well-connected and highly ambitious tenured scientific staff.
- A multinational, high-quality and motivated community of PhD students and postdoctoral associates.
- Two well-defined and complementary spheres of excellence reflected in the two research programmes.
- An excellent scientific reputation and international standing, with ongoing growth.
- An attractive environment and high-class facilities for talented incoming young researchers.
- Extensive participation in national and international projects, networks and scientific organisations.
- A strong and increasingly diversified funding base, reflecting the institute's capacity to respond to changing financial constraints and societal demands.
- Extensive national collaboration with strategic partners, providing complementary expertise.
- Good to excellent research facilities and support personnel.
- High standards and good quality control, especially for PhD projects.
- Good visibility of the Earth Sciences at the level of the University.
- A proven record of responding to emerging areas of scientific and societal interest by initiating new research avenues.

Weaknesses:

- Dramatic decrease in direct funding resulted in a decrease in the institute's capacity to financially stimulate new exploratory or collaborative research.
- Reduced possibilities for hiring new tenured personnel, uncertain career perspectives for existing staff and reduced possibilities for improving gender imbalance.

Opportunities:

- A stronger voice for the fundamental research sector at the European level.
- National and European commitments and programmes to support research in the areas of climate, energy, sustainability and natural hazards.
- The expected increase in budget of NWO, diminishing requirements for matching the Innovational Research Incentive Schemes.
- A reversal of the declining trend in enrolment of undergraduate students and more opportunities for the recruitment of MSc students within the enlarged European Community.
- Research is clearly complementary with the PGRI, but touches upon similar themes. Together the two institutes cover the complete spectrum of Earth-system science. Further collaboration will provide new research opportunities at the boundaries of disciplines.

Threats:
A potential lassitude among researchers with the repeated budget cuts.

- Reduced possibilities for sustained investment in research equipment and infrastructure.
- Limited ability to retain young scientific talent.
- Increased management load to obtain and maintain contract research funding.
- The increasing pressure on permanent research staff as a result of the changes in policy at the national, university and faculty levels.

Evaluative remarks about the SWOT-analysis
The institute provides a balanced SWOT assessment. The Committee noticed in particular the long list of strengths which form the basis for the highly successful research at the Institute. The significant cut in direct funding causes worry for a future when ISES may be terminated. In addition, the limited opportunity to employ new tenured faculty may be a threat to the future Institute. However, the Institute has demonstrated its strong ability to attract external funding based on its excellent international standing in fundamental research. The Institute appears to be very strong in the areas in which it has chosen to operate, but in the areas between there is a void. Despite strong integration within the two programmes, they are not strongly integrated, presumably because their areas of interest are so different. The research is fundamental and internationally oriented to the degree that the vast bulk of the research does not involve studies on the Netherlands, apart from the applied work. The interaction with TNO is relatively new after the relocation of TNO to Utrecht. The full benefit of this opportunity, beyond the issues of library and flume facilities, is still to be seen.

6.2. Assessments per programme - Utrecht University, IVAU

The Committee assessed the following programmes of the IVAU Institute at Utrecht University

	Quality	Productivity	Relevance	Viability
Research programmes				
UU3 - Geodynamics of the Solid Earth	5	4	5	5
UU4 - Climate and Environment	4	4	4	5

The detailed assessment per programme follows in the next section of this report.

6.2.1. Geodynamics of the Solid Earth

Programme number:	UU 3	
Programme director:	Theme coordinators are Prof. Dr. J Trampert (theme 1), Prof. Dr. R. Wortel (theme 2) and Prof. Dr. C. Spiers (theme 3)	
Research staff 2007:	± 34 fte	
Assessments:	Quality:	5
	Productivity:	4
	Relevance:	5
	Viability:	5

Short description
The mission is to promote and carry out high-quality, forefront research on all aspects of the Solid Earth as a key component of System Earth and thereby of Earth System Science. This encompasses the structure, dynamics and evolution of the Solid Earth over the full range of spatial and temporal scales and the role of Solid Earth structure and processes in the context of geohazards, energy and resources, environment and sustainability, (paleo-)oceanography and climate, and comparative planetology. The programme is structured into three interrelated research themes:

Theme 1: Earth structure, planetary dynamics and geopotential fields
The objective of this theme is to study *the structure of geodynamic processes* in the Earth and other planetary interiors from the very large, (near-) planetary scale to the local scale.

Theme 2: Evolution and dynamics of the crust/lithosphere system
This theme aims at understanding key *tectonic and geodynamic processes*, including subduction, volcanism and orogeny, intraplate deformation and the formation and evolution of sedimentary basins. It further aims at increasing understanding of the relation between geodynamics and climate and evolution of early life.

Theme 3: Earth materials: properties and processes
This theme aims at quantifying the *thermodynamic, mechanical, transport and magnetic properties* of rocks, minerals and melts, and at understanding the controlling micro- and atomic-scale processes. The broad goal is to provide the fundamental understanding of Earth material behaviour needed to model and interpret large-scale geological and geophysical phenomena.

Quality
The scientific quality is outstanding at an international level. The research has clear focus on fundamental problems and the three themes are truly complementary. 'Geodynamics of the Solid Earth' is a major subject in the geosciences, and the research has led to fundamental results on the structure and processes in the deep Earth. The coordination between subjects is remarkable, particularly between the themes on Earth structure, kinematics and process modelling. There is strong collaboration within national and international research programmes; in particular the collaboration within ISES should be emphasised. Several projects are world-class, e.g. the studies of convergent plate boundaries.

Productivity
The scientific productivity is at the forefront internationally, with relatively high productivity for all faculty members. Basically all articles appeared in first-class international journals, which is the result of a clear strategy by the Institute. The number of PhD dissertations completed during the period is impressive. The documented international co-authorships of the publications attest to the high-level of cooperative research.

Relevance
The impressive results by the group have clearly advanced our understanding of fundamental processes in the solid Earth, and have been widely distributed through high-class publications. The integrative approach between themes is a positive aspect. The group focuses on its mission targets, which are of fundamental character. However, the results have strong implications also for applied research. Due to retirements, aspects of applied geophysics, in particular applied seismics, could be strengthened. The high-class fundamental research is relevant to society, as documented by the wide range of jobs that new PhDs obtain in industry and academics.

Viability
The group can only cover its wide range of research at high level by being relatively large. There is a good relation between the number of young, talented students and senior leaders of the programmes. There is a good and inspiring working atmosphere which adds to the productivity and quality. Plans for future research development appear realistic. The group has managed to attract a large number of external funding contracts from national and international bodies, including funding from the prestigious "Veni, Vidi, Vici" programme.

Conclusion
The research by the group is at the highest international level and world-leading in several aspects. There is a well balanced diversity in subjects and themes, which truly leads to integrated research. The financial cut-back on basic funding from the university may threaten a strong, dynamic group. Increased direct involvement in applied research could be considered, based on the strong standing in fundamental sciences, in particular the strong standing in computational sciences and numerical modelling at all scales.

6.2.2. Climate and Environment

Programme number:	UU 4	
Programme director:	Theme coordinators are Dr. F.J. Hilgen (Stratigraphy and Timescales), Prof. dr. P. Van Cappellen (Geochemistry, till August 2008), and Prof. dr. ir. S.M. Hassanizadeh (Hydrogeology)	
Research staff 2007:	± 37 fte	
Assessments:	Quality:	4
	Productivity:	4
	Relevance:	4
	Viability:	5

Short description
The mission is to promote and carry out high-quality, forefront research on all aspects of the Earth's surface environment as a key component of System Earth and thereby of Earth System Science. It encompasses the evolution and dynamics of the geosphere, biosphere, hydrosphere, atmosphere and cryosphere, and the interaction between them over the full range of spatial and temporal scales. It focuses on the role of the surface environment and specifically aims to contribute to the prediction of environmental changes to the Earth's surface (including climate change, CO_2 rise, ocean acidification, sea-level rise, carbon and nutrient cycles, and water resources). The programme is structured into two complementary research themes, each with three research lines:

Theme 1: Paleoenvironments and paleoclimate
- Proxies and modern processes.
- Astronomical time scales.
- Paleoenvironment and paleoclimate reconstructions.

Theme 2: Environmental Sciences
- Biogeochemical processes and cycles.
- Multiphase flow and reactive transport.
- Environmental behaviour of contaminants.

Quality
This programme embraces two significant and markedly separate themes. Both are strong and they have an enviable reputation and output. Both these groups appear to be working effectively and have consistently built a reputation for internationally relevant and significant research.

The first theme represents in part a continuation of research that has already been undertaken for sometime in Utrecht Earth Sciences. This theme is basically focused on detailed time scale construction, detailed sedimentological investigation, particularly of clastic systems, geochemistry and use of biological proxies for determination of climate change. The application of organic geochemical methods on the molecular scale is a vast prize winning effort and operates internationally in the forefront of paleostudies. Other subjects of theme 1 are more 'traditionally' Earth Science-orientated.

The second theme of hydrology and environmental investigations is quite separate from the first but it is undoubtedly working at the forefront of pollution studies, water flow and environmental hydrology, all of which have important applied elements.

Productivity
The standard of publication in both groups is very high, with a range of papers being consistently produced. Of the two groups, theme 1 is more traditionally placed at the centre of the Earth Sciences. Both groups are co-operating actively with others in Utrecht, and also with both government and University colleagues in other parts of the country and beyond. The two theme groups have begun working together recently on a project involving early life. The number of PhD students produced by both groups is impressive and has been consistently maintained at a significant level through the assessment period.

Relevance
The content of the research programme is very relevant, both scientifically and for its societal influence. The biogeology professor Van der Zwaan (and his successor, see viability) played a very stimulating role in the setting up and actual operation of the Darwin Center for Biogeology, a special national Centre Programme of NWO in which 4 universities and 2 research institutes cooperate since 4 years.

Viability
As currently constituted, the two theme groups are in 'good health' and appear to be advancing by exploiting new areas and the latest developments and techniques. Of these, theme 2 holds considerable potential both in the academic and applied fields. Of considerable relevance to this country as well on a larger scale are the hydrological investigations and the interaction of microbial processes in water. Nutrient and pollutant fluxes are clearly also of great significance for the marine and continent interaction. The extension of these modern studies to fossil situations is an exciting development which should be encouraged. The since 01-04-2009 effective succession of Prof. Van Cappellen by Prof. Dr. J.B.M. van Middelburg and the expected succession of Van der Zwaan by an equally internationally known scientist will evidently have an effect on the programme contents, but there are no plans to change the research direction dramatically.

Regarding the time-scale development, although it is a fundamental precursor to the above points, it could become to some extent mechanistic and of limited gain in isolation, due to the application in limited areas (e.g. the Mediterranean region) and its progressive systematic application to time periods with limited extension beyond establishment of the scales themselves, although there is no evidence of this at present. In this context there could be closer integration of the Physical Geography fluvial group with that of the sedimentologists and 'paleoclimate workers' to their mutual benefit. A closer co-operation could foster a growth in understanding of longer-term process operation and the climatic events responsible at a range of scales and time periods.

Conclusion
As regards funding, there seem to be some serious issues. The declining government support is currently being offset by external sources through the whole IVAU, but the future is uncertain. One possible solution that is under discussion is the potential merger of the research of the Physical Geography groups with the IVAU. Such a merger would impact most strongly on this programme since there is some duplication and certainly complementary work in

progress. Indeed the two groups are already co-operating on teaching. Merger might be mutually beneficial therefore. What would not be beneficial, however, would be the loss of identity for either of the groups. This should be addressed and steps taken to ensure that group identity and continuity were not damaged, in any discussion of merger.

APPENDICES

Appendix A: Curricula Vitae of the Committee members

Prof. Dr. Willem Mook, Chairman, graduated in 1963 as MSc Physics and Chemistry, specialised Nuclear Physics and Radiochemistry. His PhD was obtained in 1968 at Groningen University on the subject "Geochemistry of the Stable Carbon and Oxygen Isotopes of Natural Waters in the Netherlands". He was head of Radiocarbon Laboratory/Centre for Isotope Research until 1990. Thereafter he became the Director of the Netherlands Institute of Sea Research at Texel. From 1976 to 1997 he was professor of Isotope Physics at Groningen University and between 1986 and 1997 also (part-time) professor Isotopes in the Earth Sciences at the Vrije Universiteit Amsterdam. He has held several administrative positions, like member of the board of SCOR, IGBP (PAGES), and various national Committees. Furthermore, he was Dean of the Physics Faculty between 1976 and 1980. He retired on August 1st 1997. He is member of the Royal Netherlands Academy of Sciences (KNAW). His current professional activities include chairman of the VSNU/QANU Committee on the Assessment of Research Quality of the Earth Sciences in the Netherlands, Chairman of the Netherlands Science Foundation (NWO) Research Programme "Darwin Center for BioGeoSciences" and Chairman for the NVAO/KNAW Earth Science Research Master Accreditation Committee.

Prof. Dr. Philip Gibbard graduated in 1971 with a BSc in Geology from the University of Sheffield. He received his PhD at the University of Cambridge 1975 for his thesis 'Pleistocene stratigraphy and vegetational history of Hertfordshire'. After completing his thesis, he was a post-doctoral researcher until 1984. He spent two years at the University of Oulu, Finland and one year at the University of Western Ontario, Canada before returning to Cambridge in 1978. Phil was appointed as an Assistant Director of Research in the University of Cambridge's Subdepartment of Quaternary Research (SDQR) in 1984, and a Docent at the University of Helsinki, Finland in 1987. In 1995 he was transferred to the Department of Geography where he established the Quaternary Paleoenvironments Group, part of former Godwin Institute. Phil was promoted to Professor in 2005. He has served on NERC, and CNRS Earth Science Committees. He has worked on the editorial boards of several Quaternary and general geological journals, and edited the Journal of Quaternary Science (1990-1994). He was Vice-president of the Quaternary Research Association (1997-2001), and chairs the International Subcommission on Quaternary Stratigraphy (since 2002). His research focuses on terrestrial and shallow marine sedimentation, stratigraphy and environmental evolution.

Prof. Dr. William van Impe is director of the Geotechnics Laboratory of Ghent University (formerly Laboratory of Soil Mechanics), the Flemish research lab on theoretical, experimental and applied soil mechanics. The lab has studied research topics closely linked to daily geotechnical problems such as slope stability, shallow and deep foundations, and has extended its interests towards basic soil parameter experimental research, calibration chamber testing, soil dynamics with related geophysical testing and to environmental geotechnics.

Prof. Dr. Jean Poesen is professor of Geography and head of the Physical and Regional Geography Research Group at KU Leuven. His main research interest is on the intensity, controlling factors and modelling of soil erosion processes, sediment deposition and sediment yield under a range of environmental conditions and over a range of spatial and temporal scales, antropogenic soil degradation due land use changes, desertification, the effectiveness and efficiency of soil and water conservation techniques and experimental geomorphology. He has conducted both field- and laboratory-based research in Europe (particularly in the Mediterranean), Israel, Turkey, Syria, Iran, Ethiopia, Tanzania, Uganda, China, USA, Canada, Ecuador

and Thailand and has participated in several EC-funded projects (EUROSEM, MWISED, MEDALUS, RECONDES, BORASSUS, DESIRE). He has been an editor (for 18 years) of Catena, an interdisciplinary journal of Soil Science – Hydrology – Geomorphology, focussing on Geoecology and Landscape evolution. Jean Poesen has been founding member and secretary of the European Society for Soil Conservation and vice-chair of COST-Action 623 "Soil Erosion under Global Change" (1999-2004).

Prof. Dr. Hans Thybo is professor at the Department of Geography & Geology of the University of Copenhagen. His research includes reflection seismic interpretation of sedimentary sequences in southern Norway, thermal subsidence basin formation and the role of magmatism in rift processes in the North Sea Basins, the Baikal Rift Zone, the East African Rift Zone and the Donetsk Basin in Ukraine, studies of heterogeneity in the Earth's mantle, including the mantle low-velocity zone and the mantle transition zone, active orogens with seismic imaging of the crustal structure of the Alps and the Iranian area.

Prof. Dr. Desmond E. Walling is professor of Geography at the University of Exeter. He is a Hydrologist with particular interests in the field of erosion and sediment yields and catchment sediment budgets. He was formerly Assistant Lecturer, Lecturer, Reader in Physical Geography and Professor of Physical Geography at the University of Exeter, before being appointed Reardon Smith Professor of Geography in 1998. He is also a Visiting Professor at the Academia Sinica Institute of Mountain Hazards and Environments in Chengdu, China. He is a Chartered Geographer and a Certified Professional Hydrologist of the American Institute of Hydrology. In 2007 he received the Linton Award of the British Society for Geomorphology, the International Hydrology Prize awarded jointly by IAHS, UNESCO and WMO and the Chien Ning Award of the World Association for Sedimentation and Erosion Research and the Chien Ning Foundation. He is a past President of the International Commission on Continental Erosion (ICCE) and the International Association of Sediment Water Science (IASWS) and he is currently President of the World Association for Sediment and Erosion Research (WASER) and Honorary President of the International Commission on Continental Erosion. He is an editor of the international journal Hydrological Processes and a member of the editorial board of Catena, Geografiska Annaler, Journal of Sediment Research, Geografisk Tidsskrift, Ecohydrology and Hydrobiology and the Journal of Mountain Environments.

Prof. Dr. Bruce Yardley is professor of Metamorphic Geochemistry at the School of Earth and Environment at the University of Leeds. His research interests are in fluid processes in the Earth's crust, and include aspects of ore formation, diagenesis and prograde and retrograde metamorphism. He is particularly interested in chemical mass transfer by fluids and in the cycle of interactions between fluid flow, temperature, mineralogical reactions and the rheology of the crust. The techniques that his group employs include field and petrographic observations, rock and mineral analysis, fluid inclusion studies (including multi-element chemical analysis), and geochemical modelling of fluid rock interaction. He is also involved in the UK Carbon Capture and Storage Consortium, specifically investigating the rate of response of silicate assemblages to increased acidity. He is founding editor of the Blackwells journal "Geofluids" which was set up to disseminate ideas across the range of sub-disciplines in which Geofluids research is carried out. He was Chair of the Technical Committee for the Bicentennial Conference of the London Geological Society, and the past President of the European Association for Geochemistry.

Appendix B: Schedule of the meetings

Site visits Earth Sciences 9 - 12 March 2009			Dean/Director/Coord.
Monday: Utrecht University (UU)			
		Arrival in Utrecht	
	12:00	Committee Meeting and Lunch	
Faculty	14:00	Dean Faculty Geosciences	Van der Zwaan
Institute	14:30	Dir. Physical Geography Research Institute (PGRI)	De Jong
UU 1	15:00	Landscape functioning, Geocomputation and Hydrology	De Jong, Bierkens
UU 2	15.45	Coastal Dynamics, Fluvial Systems and Global Change	Hoekstra, Middelkoop
	16:30	Lab tour	
	17:30	Interview PhD students	
	18:15	Drinks with hosts & PhD students	
	19:00	Committee dinner	
Tuesday: Utrecht University (UU)			
	09:00	Committee meeting	
Institute	10:00	Dir. Institute Earth Sciences Utrecht (IVAU)	Wortel
UU 3	10.30	Geodynamics of the solid earth	Trampert, Wortel, Spiers
	12.45	Committee Lunch	
UU 4	14:00	Climate and environment	Van Cappellen, Hilgen
	15:30	Lab tour	
	16:30	Interview PhD students	
	17:15	Drinks with hosts & PhD students	
	18:00	Committee travel to Amsterdam; dinner	
Wednesday: Vrije Universiteit Amsterdam (VU)			
	08:30	Committee meeting	
Faculty	09:00	Dean Faculty Earth & Life Sciences	Oudega
Institute	09:30	Dir. Institute of Earth Sciences (IvA)	Dolman
VU 1	10:00	Isotope Geochemistry	Andriessen
VU 2	10:45	Tectonics	Cloetingh
VU 3	11:30	Petrology	Davies
VU 4	12:15	Sedimentology	Reijmer
	13:00	Committee Lunch	
VU 5	14:00	Paleoclimatology & Geomorphology	Vandenberghe
VU 6	14:45	Hydrology & Geo-environmental Sciences	Dolman
	15:30	Lab tour	
	16:30	Management PhD training	
	17:30	Interview PhD students	
	18:15	Drinks with hosts & PhD students	
	19:00	Committee travel to Delft; dinner	
Thursday: Delft University of Technology (TUD)			
	08:30	Committee meeting	
Faculty	09:00	Dean Faculty Civil Engineering & Geosciences	De Quelerij
& Inst		Dir. Department of Geotechnology	Luthi, Wapenaar
TUD 1	10:00	Applied Geology	Kroonenberg, Luthi
TUD 2	10:45	Applied Geophysics	Wapenaar, Slob
TUD 4	11:30	Petroleum Engineering	Rossen, Jansen
	12:15	Committee Lunch	
TUD 3	13:00	Geo-Engineering	Van Tol, Heimovaara
	13:45	Lab tour	Smeulders
	14:45	Interview PhD students	
	15:30	Drinks with hosts & PhD students	
	16:15	Committee meeting; departure 17.30 hrs	

Appendix C: Explanation of the SEP-scores

Excellent (5)	Work is at the forefront internationally and will most likely have an important and substantial impact in the field. Group is considered an international leader.
Very Good (4)	Work is internationally competitive and is expected to make a significant contribution; nationally speaking at the forefront in the field. Group is considered international player, national leader.
Good (3)	Work is competitive at the national level and will probably make a valuable contribution in the international field. Group is considered internationally visible and a national player.
Satisfactory (2)	Work that is solid but not exciting, will add to our understanding and is in principle worthy of support. It is considered of less priority than work in the above categories. Group is nationally visible.
Unsatisfactory (1)	Work that is neither solid nor exciting, flawed in the scientific and or technical approach, repetitions of other work, etc. Work not worthy of pursuing.

Quality is to be seen as a measure of excellence and excitement. It refers to the eminence of a group's research activities, its abilities to perform at the highest level and its achievements in the international scientific community. It rests on the proficiency and rigour of research concepts and conduct; it shows in the success of the group at the forefront of scientific development.

Productivity refers to the total output of the group; that is, the variegated ways in which results of research and knowledge development are publicised. The output needs to be reviewed in relation to the input in terms of human resources.

Relevance is a criterion that covers both the scientific and the technical and socio-economic impact of the work. Here in particular research choices are assessed in relation to developments in the international scientific community or, in the case of technical and socio-economic impact, in relation to important developments or questions in society at large.

Vitality and feasibility. This dual criterion refers to the internal and external dynamics of the group in relation to the choices made and the success rate of projects. On the one hand, this criterion measures the flexibility of a group, which appears in its ability to close research lines that have no future and to initiate new venture projects. On the other hand, it measures the capacity of the management to run projects in a professional way. Assessment of policy decisions is at stake, as well as assessment of project management, including cost-benefit analysis.

Appendix D: List of acronyms

CIO	Centre for Isotope Research, Groningen University
CTG	Research School Centre for Technical Geoscience
DELTARES	Enabling Delta Life: with Delft Hydraulics, RWS and TNO
IBED	Institute for Biodiversity and Ecosystem Dynamics
ICG	Centre for Geo-Ecological Research
IGBP	International Geosphere-Biosphere Programme
IMAU	Institute for Marine and Atmospheric Sciences
INQUA	International Union for Quaternary Research
ISES	Netherlands Research Centre for Integrated Solid Earth Science
ITC	International Institute for Geo-Information Science and Earth Observation
KNAW	Royal Netherlands Academy of Arts and Sciences
KU	Catholic University
NCK	Centre for Coastal Research (together with RWS)
NCR	Centre for River Research
NIOZ	Netherlands Institute for Sea Research
NSG	Netherlands Research School for Sedimentary Geology
NWO	Netherlands Organisation for Scientific Research
PAGES	Past Global Changes (IGBP programme)
RWS	Rijkswaterstaat (Directorate-General for Public Works and Water Management)
SCOR	Scientific Committee on Oceanic Research
SENSE	Research School for Socio-Economic and Natural Sciences of the Environment with 9 universities and UNESCO-IHE
TNO	Netherlands Organisation for Applied Scientific Research
TUD	Delft University of Technology
UNESCO-IHE	Institute for Water Education of UNESCO, Delft
UU	Utrecht University
VMSG	Vening Meinesz Research School for Geodynamics
VUA	Vrije Universiteit Amsterdam
WUR	Wageningen University and Research Centre

Appendix E: Reaction TUD

Date 3 November 2009
Our reference az09.0444/kv
Contact person L. de Quelerij
Telephone/fax +31 (0)15 27 85458/+31 (0)15 27 87996
E-mail l.dequelerij@tudelft.nl
Subject Research Review Earth Sciences

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Executive Board DUT
Attn. to prof.dr.ir. J.T. Fokkema
P.O. Box 5
2600 AA Delft

Dear Executive Board,

With this letter we would like to give our reaction to the report 'Research Review Earth Sciences' of the QANU. This review evaluates the research programs at one university of technology (TUD) and two general universities (VU and UU). We thank the committee members and the committee chairman for accepting the responsibility to carry out this research review of Earth Sciences in the Netherlands. We commend the committee for the balanced evaluation of the 'Viability' and 'Productivity'. However, we believe that the difference in character between the technology and general universities has not been sufficiently taken into account in the evaluation of the 'Relevance' and 'Quality'.

The backbone of the research program of the Department of Geotechnology is formed by application-driven *fundamental* research. The Department publishes its research output in high-quality fundamental and applied journals. The sections perform well in attracting second money stream projects and excel in attracting funding from industry. The number of PhD students per research fte is the highest of the three evaluated universities and all graduated PhD's find excellent jobs in industry, research institutes and universities. In this light we are happy with the following passage in the chapter on the Department of Geotechnology at TUD:

> *From both the academic relevance and the broader societal relevance points of view, it is clear that this Department is very well positioned. The contract funding percentage in the overall budget of the Department adds further support to this conclusion.*
>
> *The self-assessment report shows that much of the research undertaken by TUD is of an applied nature, and that at the TUD it is an essential and intrinsic obligation to place much emphasis on research that is relevant to industry or society. The Committee is highly impressed by the well-balanced attention accorded to both basic and applied research at the Department of Geotechnology of TU Delft.*

This recognition by the committee of the high academic and societal relevance of the research program of the Department of Geotechnology at TUD is unfortunately not reflected by the relatively moderate scores for 'Relevance'. Moreover, we are confident that the quality of the application-driven fundamental research at TUD can compete with

TU Delft

that of the curiosity-driven fundamental research at VU and UU, so in our view the relatively moderate scores for 'Quality' of the TUD research are not justified.

It is without question that the review committee consists of members of great scientific standing. We therefore agreed with the appointment of this committee. In hindsight we believe that the underrepresentation of applied scientists in the committee (one out of seven) has led to an unbalanced judgment of the quality and relevance of the earth science research at the three universities. We recommend that for future research reviews, in which TUD departments are evaluated next to departments of general universities, the applied sciences are more prominently represented in the review committee.

Sincerely yours,

Prof. ir. L. de Quelerij (Dean of the Faculty of Civil Engineering and Geosciences)

S. Luthi

Prof. dr. S.M. Luthi (Chairman of the Department of Geotechnology)

Prof. dr. ir. C.P.A. Wapenaar (Scientific Director of the Department of Geotechnology)

Copy to az, GT

Appendix F: Reaction UU

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H.Hoitink@geo.uu.nl

Datum
12-01-2010

Uw kenmerk

Onderwerp
Response to Review Earth Sciences

Ons kenmerk
10/1841/bu

Recently the Board of the Faculty of Geosciences has discussed the report as prepared by the Review Committee Earth Sciences. The committee reviewed the research results over the period 2002-2008. In general, the Board is very satisfied with the outcome of the review, certainly if one considers the text of the report which indicates even better results than the numerical expression of the Review Committee's judgment.

The Review Committee considered all programs as very good to excellent, as well as relevant and highly vibrant. All programs are considered to bear great promise for the future. No weak programs were found. Also this aspect of the report concurs with the judgment of the Board.

It is very satisfying to note that the quite substantial changes which have been implemented by the Faculty over the past years have brought results already so soon, and that the changes, sometimes induced by financial cut-backs, have weakened by no means the Earth Sciences program, but on the contrary, have strengthened it.

The review confirms the judgment of the Board of the Faculty that all disciplines within the Utrecht University Earth Sciences program are leading in their respective fields and that the opportunities for further development in the future are promising.

The faculty aims at further increasing the quality of the research programs where possible and to this end will use the relevant suggestions as made by the Review Committee.

On behalf of the Board of the Faculty,

Prof.dr. G.J. van der Zwaan
dean