



Universiteit Utrecht

KINDRA, a hydrogeology research database

Internship Report Deltares & KNGMG

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Knowledge Inventory for hydrogeology research



1. Introduction

This is the report of my internship at Deltares & KNGMG (Koninklijk Nederlands Geologisch Mijnbouwkundig Genootschap). I participated in the KINDRA (Knowledge INventory for hydrology ReseArch) project, which is financed by the European Union as part of the 'Horizon 2020 Innovation Programme'. The aim of the project is to create an online inventory of hydrogeology research, knowledge and applications from all of the participating countries (Figure 1). The main products of my internship are the database entries of Dutch research, knowledge and applications.

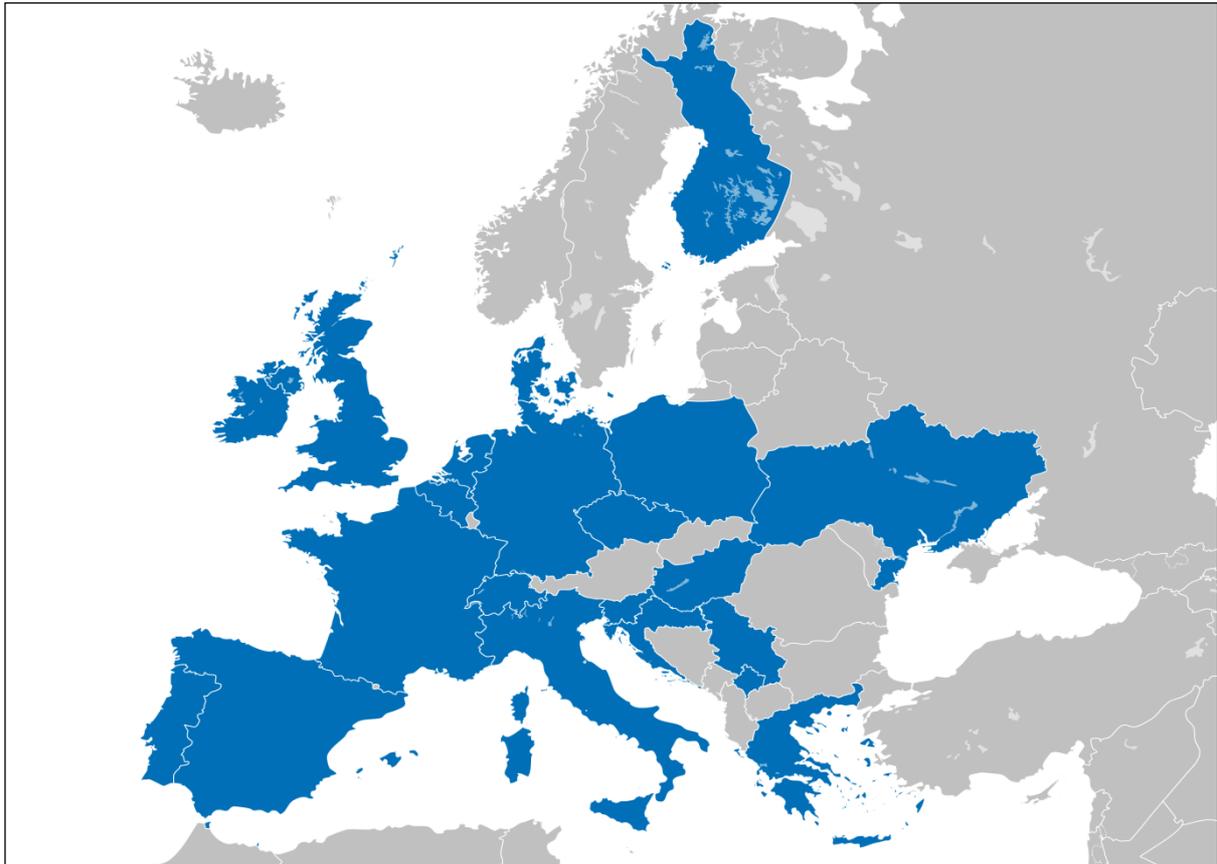


Figure 1. The countries participating in the KINDRA project.

1.1 Companies

1.1.1 KNGMG

The KINDRA project is managed by EFG (the European Federation of Geologists), as their Dutch representative the KNGMG is responsible for the KINDRA activities inside the Netherlands. KNGMG itself is the Royal Geological and Mining Society of the Netherlands, the overarching organisation which brings together earth scientists in the Netherlands. Their aims are to:

- Improve the general state of earth sciences in the Netherlands.
- Look after the interests of its members.
- Improve exchange and contact between earth scientists.
- Increase general awareness of the societal importance of earth sciences.

1.1.2 Deltares

The other partner in my internship is Deltares. Deltares pays for the internship in order to have their name associated with the KINDRA project and increase their public exposure. Deltares is an independent institute for applied research in the field of water and subsurface. They work to apply innovative solutions to manage the tensions between humans, environment and society. Deltares has high standards for the quality of its knowledge and advice. Openness and transparency is strongly valued and therefore all software and models produced by Deltares are considered as open source.

1.2 Learning Objectives

1.2.1 Learning objectives

The learning objective of the internship is to gain experience in a professional company. In the internship experience will be gained in obtaining and making contact with other professionals. As well as conducting interviews and regular conversations with professional people to obtain information and promote the work done in the internship. The assignment is part of a large European project and cooperation with professionals abroad will be necessary.

2. Activities

2.1 KINDRA

To share and spread hydrogeological knowledge in Europe the European Federation of Geologists (EFG) has been working to create the European Inventory of Groundwater Research (EIGR). The EIGR inventory is part of the EU-project KINDRA (Knowledge Inventory for Hydrogeology Research), that aims to create a European inventory of all knowledge, research and data related to hydrogeology. When complete the database should at least contain all publically available data in the participating countries.

After establishing the database overlapping research can be reduced and cooperation between institutes, companies and universities increased. Research areas in need of extra focus can also be identified to actively reduce the gaps in our current knowledge of hydrogeology. Extra research funds is hoped to be granted to these areas as part of a new distribution of European research money.

2.1.1 Mapping Dutch Hydrogeology

In comparison with other participating countries the Netherlands is already very active in hydrogeological research. Information regarding Dutch hydrogeology is well disclosed through internet platforms such as DINOloket from TNO. Even so a lot of research and knowledge is still spread out between the various institutes (Deltares, TNO, KWR, provinces, etc.) companies and universities. In order to collect all research and knowledge available in the Netherlands literature was studied extensively. In addition visits were made to the various institutes and companies to interview the people active in hydrogeology. The collected research and knowledge was then made available in the online database.

2.1.2 The database

The structure of the online database is made by the REDIAM (Environment and Water Agency of Andalusia) a Spanish institute. Populating the database is the responsibility of the "National Experts" of each country, where I was the "National Expert" of the Netherlands. Presently the focus in populating the database is on relevant, non-scientifically published articles, general research, projects and models. This includes

local reports not written in English, for which an English abstract will be provided by the national expert.

2.1.3 Conference & Workshop

As part of the internship attendance to the KINDRA workshop and conference is compulsory. Initially the conference was planned for the 24 and 25 November in Brussels, this was however cancelled due to a terrorist attack. A new date was scheduled for the 5th of February in Seville instead of Brussels. The people attending the conference and workshop would be the "National Experts" of each participating country. At the conference the structure and contents of the database were discussed and the database itself was presented.

2.1.4 Promotion of KINDRA

Another task of the "National Expert" was to promote the existence of KINDRA and its online database among the persons, institutes, companies and universities that engage in hydrogeological activities. One way of promoting the database are the conducted interviews, as mentioned in paragraph 2.1.1. Other ways used are a poster presentation at NAC 2016 (Nederlands Aardwetenschappelijk Congres), a presentation at the annual meeting of the KNGMG and an article in the Geobrief, the news magazine of KNGMG. In the future there will be a presentation on KINDRA as part of a workshop organised by KNGMG. This falls outside the scope of the internship though.

2.2 AHN

A small side project was also part of the internship due to delays resulting from the cancellation of the KINDRA conference and the final release of the online database. This side project consisted of an analysis of the ground level data of the boreholes found in DINO and of an assessment of the error in interpolating these ground level data when compared to the 'Actueel Hoogtebestand Nederland (AHN)', a laser-altimetric elevation model of the Netherlands..

3. Results

3.1 Glossary

- AHN: "Actueel Hoogtebestand Nederland", database and model of the elevation level anywhere in the Netherlands
- BRO: "Basis Registratie Ondergrond", the future central database in which all information regarding the Dutch subsurface will be gathered, will replace DINO. Participation is largely mandatory.
- DINO: "Data en Informatie Nederlandse Ondergrond", the current database for all information regarding the Dutch subsurface. Access is free.
- GEOTOP: 3D model of the Dutch subsurface up to a maximum depth of 50m. The model has a voxel size of 100m x 100m x 50cm.
- iMOD: Here used as the name for an open source software interface from Deltares for MODFLOW and other modelling codes. Widely used in the Netherlands.
- INSPIRE: An EU initiative to establish an European infrastructure for spatial information to make exchange and access to data and ideas from abroad easier.
- NHI: "Nederlands Hydrologisch Instrumentarium", a hydrogeologic modelling toolset for the Netherlands. NHI is for example used to assess national policies.
- REGIS: The national hydrogeological model from the Netherlands made by TNO. It includes permeability values for the complete Dutch subsurface.

WKO: “Warmte Koude Opslag”, a form of geothermal energy in which the temperature of the subsurface is used to heat or cool water. It is a closed system that can be used to heat or cool buildings and industries.

3.2 KINDRA

3.2.1 Interviews

A total of 20 interviews were conducted at 14 different companies/institutions. In the section below a short summary of the interviews can be found. While in table 1 an overview of the people that have been interviewed can be found.

Name	Organisation
Ab Veldhuizen	Alterra
Paul van Walsum	Alterra
Folkert de Vries	Alterra
Peter Vermeulen	Deltares
Sieb de Vries	Deltares
Timo Kroon	Deltares
Pieter van Stuyfzand	KWR, TU Delft, VU
Janet Hof	Province of Drenthe
Erik Heskes	Province of Noord-Brabant
Janco van Gelderen	Province of Utrecht
Clemens Kester	Province of Holland
Erik Simmelink	TNO
Frans van Geer	TNO
Harmen Mijnlief	TNO
Ronald Vernes	TNO
Jan van Lopik	UU
Marc Bierkens	UU
Jan Hoogendoorn	Vitens
Jurriaan Cok	Waterschap Peel- en Maasvallei
Joost Heijkers	Waterschap Stichtse Rijnlanden

Table 1. An overview of the people interviewed.

Alterra, Ab Veldhuizen, Paul van Walsum and Folkert de Vries

Alterra is a research institute associated with Wageningen University. They focus on research related to policy, management and design of ‘green areas’ in the Netherlands and abroad. Most of their research is focused on the upper metres of the subsurface.

- Dutch Soil Map 2012.
- Archive of manually taken profiles and boreholes.
- Mostly surface water.
- Ecology & Biology.

Deltares, Peter Vermeulen

Deltares is an independent institute for applied research in the field of water and subsurface. They work to apply innovative solutions to manage the tensions between humans, environment and society. Deltares has high standards for the quality of its knowledge and advice. Openness and transparency is strongly valued and therefore all software and models produced by Deltares are considered as open source.

- iMOD (developer)
 - Open source since 2014.
 - Users can use the software themselves without Deltares.
 - Downloaded all over the world.
 - Limited development:
 - Money
 - Personnel
 - Netherlands:
 - 80% of the regional groundwater models uses iMOD
 - NHI uses iMod
 -
- Competition with Haskoning:
 - Tricel & Brabantwater
- Deltashell, cooperation with Haskoning:
 - Marketing advantages abroad.
 - No double effort.
- Other:
 - REGIS and other models stop at country borders. This is problematic as issues abroad affect things in the Netherlands.
 - Possibility of combining iMOD with BRO to make data easier to view and access.

Deltares, Sieb de Vries (Data usage)

Deltares is an independent institute for applied research in the field of water and subsurface. They work to apply innovative solutions to manage the tensions between humans, environment and society. Deltares has high standards for the quality of its knowledge and advice. Openness and transparency is strongly valued and therefore all software and models produced by Deltares are considered as open source.

- Activities
 - Archaeological expectance map of the Netherlands
 - Archaeological research mandatory for building projects.
 - Hand-made profiles and maps are created based on GEOTOP and borehole data.
 - Quality control GEOTOP
 - Checking borehole descriptions.
 - Compare hand-made profiles to GEOTOP generated profiles.
 - Publications
 - Origin of the Dutch Coastal Landscape (Peter de Vos & Sieb de Vries)
 - A lot of general interest:
 - Tv
 - Expositions
- Cooperation
 - TNO
 - TNO has more detailed borehole data than it releases. (Uniform quality)
 - Borehole data produced and published in DINO often lack a lot of detail because of lack of interest. E.g. a farmer is not interested in most parts of the subsurface.
 - iMOD
 - Simple and useful but lacks functions.

Deltares, Timo Kroon

Deltares is an independent institute for applied research in the field of water and subsurface. They work to apply innovative solutions to manage the tensions between humans, environment and society. Deltares has high standards for the quality of its knowledge and advice. Openness and transparency is strongly valued and therefore all software and models produced by Deltares are considered as open source.

- NHI Project Leader
 - Cooperation and use of NHI problematic
 - Has improved recently
 - Still not used very widely though, lacks detail
 - NHI uses:
 - Fresh water supplies
 - Fresh water budget
 - Groundwater dynamics and interaction
 - Mainly Policy assessment
 - A lot of regional groundwater models are linked and compatible with NHI

KWR, Technische Universiteit Delft & Vrije Universiteit Amsterdam, Pieter van Stuyfzand

KWR Watercycle Research is a research institute that originates from a cooperation between rival water companies in the Netherlands. Their research comprises the whole (drinking) water system from extracting ground water to managing pipeline networks.

- Research archive KWR
 - Soon available online at the KWR website
 - Link to KINDRA possible, but large-scale upload method needed.
- Research
 - Water storage in the subsurface
 - Protection water extraction areas
 - Water transport
 - Application of river bank infiltration
- Functions KWR:
 - Water and Energy
 - WKO's
 - Geothermal energy
 - Assetmanagement
 - Water springs
 - Location of water pipe lines
 - Well blockage; Iron oxide, Aluminium oxide, sedimentary particles
 - Time series analysis
 - MENYANTHES
 - Data validation
- KWR is a unique cooperation of competing water infrastructure companies.
- KWR willing to work with KINDRA but requires a more formal application. This should include an overview of KINDRA itself and answer questions such as: Why KWR should upload to KINDRA? What are the benefits of doing so? Is there a template for uploading multiple files?

Provincie Drenthe, Janet Hof

The provinces are the main regional government body in the Netherlands. Their tasks involve everything from taxes to infrastructure. They are responsible for managing the upper 200m to 300m of the Dutch subsurface. This involves everything from the responsible use of groundwater

to the monitoring of pollutions. To help perform this task efficiently they are one of the main drivers behind regional groundwater models in the Netherlands.

- Monitoring & Modelling
- Hydrogeology often becomes hydro-ecology
- MIPWA
 - Developed in cooperation with TAUW & Grontmij
 - Horizontal scale: 25m * 25m.
 - Incorporates REGIS and GEOTOP.
 - In the region of the Drenthe the "Keileemlaag" is critical for groundwater management. Studied and described extensively for MIPWA.
 - New revision due fall 2016.
 - Used to determine consequences of:
 - Groundwater extraction.
 - Agriculture and water management
 - Infrastructure such as tunnels
 - Menyanthes
 - NATURA2000
 - Normally there is feedback after implementation of the measures to improve MIPWA and determine its accuracy.
- Climate change
 - Less water makes it more complicated to balance the needs of agriculture and nature reserves
 - Peat areas are very sensitive to changes in the water table
- NHI
 - Limited involvement.
 - More cooperation and support would be preferred.
- Cross-border cooperation with Germany
 - Lots of money, data not free → EU problem?
 - Unwilling
 - Bureaucratic
 - Age, old and conservative
- Large scale pollution in and near Hoogeveen
 - Long timescale project
 - Very close to groundwater supply for drinking water
 - Innovative: Seismic measurement instead of drilling to study the subsurface underneath the town
 - Possible solution: WKO's to recycle the water?
- Other (older projects)
 - Keileemkaart
 - Topsoil
 - Groundwater reserves

Provincie Noord-Brabant, Erik Heskens

The provinces are the main regional government body in the Netherlands. Their tasks involve everything from taxes to infrastructure. They are responsible for managing the upper 200m to 300m of the Dutch subsurface. This involves everything from the responsible use of groundwater to the monitoring of pollutions. To help perform this task efficiently they are one of the main drivers behind regional groundwater models in the Netherlands.

- Brabant only province to cooperate a lot with Haskoning in the development of groundwater models
- Cooperation with:
 - TNO

- Deltares
- Flanders -> Roerdalslenk (promotion research)
- Waterschappen
- H3O
- European Geoparks
- Research: New research on the degradation of wells.
 - Used in geothermal systems and groundwater systems.
 - How durable are wells? Do old wells leak increasingly and thus interact with the surrounding subsurface?
 - Subsidence, do wells increase local subsidence?
 - Salinization, do wells affect salinization of groundwater. Either through heat patterns or through metals originating from the well.
- Brabant Model
 - Assess the strategic groundwater supply
 - Policymaking
 - Analysis of the effect of shale gas

Provincie Utrecht, Janco van Gelderen

The provinces are the main regional government body in the Netherlands. Their tasks involve everything from taxes to infrastructure. They are responsible for managing the upper 200m to 300m of the Dutch subsurface. This involves everything from the responsible use of groundwater to the monitoring of pollutions. To help perform this task efficiently they are one of the main drivers behind regional groundwater models in the Netherlands.

- Groundwater monitoring network
 - Groundwater level
 - Groundwater quality
 - Pollutions
 - Policy by provinces
 - Implementation consultancy agencies
- AZURE
 - Deltares made.
 - Expensive, currently out of money.
 - 2/3 finished.
- HYDROMEDAH
 - In the hands of the waterschappen (Stichtse Rijnlanden).
- National groundwater register
 - A lot of problems to get everyone involved.
- Provinces are independent in their policy but are responsible for:
 - Groundwater quality
 - Surface water quality
 - Water levels. Wet/dryness of areas.
 - WKO assessment (Heat, cold storage systems)
 - Environmental remediation of the subsurface
- Research: New research on exotic pollutions in groundwater. E.G. medical related, industry related pollution.

Provincie Zuid-Holland, Clemens Kester

The provinces are the main regional government body in the Netherlands. Their tasks involve everything from taxes to infrastructure. They are responsible for managing the upper 200m to 300m of the Dutch subsurface. This involves everything from the responsible use of groundwater to the monitoring of pollutions. To help perform this task efficiently they are one of the main drivers behind regional groundwater models in the Netherlands.

- Stroomgebiedbeheersplannen
 - EU originated
 - 3 phases 2009-2027
 - Local: Rijn West Verband
- Activities province
 - Current state of hydrogeology
 - Analyse
 - Implement
 - Salt and fresh water interaction
 - Groundwater monitoring network
 - Subsidence
 - Currently a pilot to tackle the three most threatened areas
- Zuid-Holland
 - Relatively simple
 - Little interaction between surface water and groundwater due to a thick clay layer in the upper part of the subsurface
 - Explanation for the lack of a recent groundwater model.
 -
 - Groundwatermodel 2005
 - Dated
 - Lacks detailed info
 - Lags behind development in other provinces
 - Update of model in 2011-2012 failed (Deltares). Resulted in strange permeability values
 - No money and interest in further updates at the moment
 - Local groundwater models with more detail:
 - Polluted areas
 - Groundwater extraction areas
 - Watercompanies (Lunea, Oase) have their own (limited) groundwater models
 - River bank infiltration is important

TNO, Erik Simmelink

TNO is a nonprofit company in the Netherlands that focuses on applied science. The Geological Survey of the Netherlands is part of TNO. They provide access to all data available from the Dutch subsurface and produce models, web-portals, etc. to provide easy access to this data.

- Sceptical about the usage of a possible database
 - Often no money for maintenance after completion of the database
- What is the link with other EU-programmes such as INSPIRE and EGDI?
- DINO
 - Internet portal containing all data presently available, e.g. Groundwater data, hydraulic head, models, etc...
 - 500 sessions a day on the DINO Website
 - Total number of borehole entries is roughly 500.000.
 - Constantly updated with new data. This is done with automated entries and human quality control.
- REGIS (REgionaal Geohydrologisch InformatieSysteem)

- 3D groundwater model based on the Digital Geological Model of the Netherlands where every layer has been given its own permeability index (K-value).
 - Hand-made, no automated scripts are used.
 - Model has a maximum depth of 300m - 400m.
 - Total number of borehole entries used in constructing REGIS is 17.000.
 - Used in regional groundwater models, local groundwater models (with extra data), WKO
 - Freely available through TNO and DINO
- GEOTOP
 - 3D model of the upper 30 to 50 metres of the Dutch subsurface. Essentially it is the upper part of the REGIS with a higher level of detail.
 - Consists of voxels with a size of 100m by a 100m horizontally and a vertical size of 50 cm.
 - All 500.000 borehole entries are used.
 - Automated scripts are used to recognize similar borehole descriptions.
 - Constantly updated with new borehole entries available in DINO.
- BRO (Basis Registratie Ondergrond)
 - New law to make publication of all information regarding the Dutch subsurface mandatory.
 - Should be fully implemented in 2020.
 - All data should INSPIRE compatible.
 - Less manual quality control. Responsibility of quality lies more with the users.

TNO, Frans van Geer

- KINDRA survey:
 - Not taken very seriously
 - Basic questions
- Data statistics
 - Backwards analysis of processes.
 - Compromise between models: Calculation vs Representation model.
- Workshop
 - Arends Laurens, finishes PhD in the summer. Calibrating bore hole data.

TNO, Harmen Mijnlief

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- Geothermal energy
 - WKO
 - Doublets (deep, shallowest doublet is at 1400m)
 - Limited data available at this depth
 - TNO advises consultancies through tool DoubletCalc
 - Use of existing wells?
 - STRONG: Government project to cover the whole deep subsurface
 -

TNO, Ronald Vernes

TNO is a nonprofit company in the Netherlands that focuses on applied science. The Geological Survey of the Netherlands is part of TNO. They provide access to all data available from the Dutch subsurface and produce models, web-portals, etc. to provide easy access to this data.

- REGIS developer
 - Stops at the Dutch border.
 - Border datasets are separately available.
 - All Dutch groundwater models use REGIS as base model.
 - Lack of feedback from users to improve REGIS. Forced feedback as in BRO unlikely to be much better. Lack of detail, etc.
- Cooperation in the Netherlands/TNO: Responsibility TNO stops at the Dutch border, but water management involves cross-border interaction.
 - H30: Cooperation Belgium, Netherlands and Germany.
 - Troublesome to convert all data to the same standards and definitions. A lot of attachment to everyone's own value.
 - Germany:
 - Data and models are not freely available which obstructs cooperation.
 - Roos Project: Nordrhein-Westfalen & the Netherlands
 - Belgium/Flanders
 - Data is open source.
 - A lot of progress to convert all data to the same standards and definitions.
- EU-projects:
 - Often fail due to lack of maintenance money. Most projects, information or databases is not critical for commercial companies.
 - Weakest link often determines the overall quality of the project. This means that the product created is not good enough for further developed countries.

UU, Jan van Lopik

- All scientific
- Own research
 - Geothermal energy and shale gas
 - Salinization in a stratified aquifer induced by heat transfer from well casings
 - The use of salinity contrast for density difference compensation to improve the thermal recovery efficiency in high-temperature aquifer thermal energy storage systems
 - Groundwater protection
 - Effects of temperature need to be included in models?
- Research group
 - Varying topics related to hydrology
 - Scientific
 - Not specific hydrogeology

UU, Marc Bierkens

- Everything at the UU is published scientifically
- Dommel groundwater model, Bas van der Grift and Hans-Peter Broers
 - Heavy metal transport in the subsurface
- Wim de Lange, GrondWaterModelDataBank

Vitens, Jan Hoogendoorn

Vitens is the largest supplier of drinking water in the Netherlands. They do independent research focused on the whole drinking water supply chain (e.g. well pollution, pipeline management, groundwater extraction, etc.). And together with EVIDES they support local water companies in developing and transition countries to improve their operations, become financially healthy and extend their services to the urban poor.

- International expert water management:
 - WOP's: Water Operation Partnerships
 - The whole water chain is managed and assessed
 - Existing knowledge applied in developing countries
 - River bank infiltration
 - Limited borehole and geophysical research to assess the subsurface
- Research, limited research by VITENS themselves. Mostly KWR and already published in water related magazines such as H2O.
 - The use of wells with infiltration filters. Brackish water puts.
 - Realtime monitoring networks to assess water quality.
 - Solving well pollution by small particles
 - Management of wells. Which well should pump more water? Etc.
 - Local area studies. (Gebiedsdossiers)
- Currently working to establish their own database with research, reports and publications.
 - Possible link with KINDRA.

Waterschap Peel en Maasvallei, Jurriaan Cok

Waterschappen are the Dutch water boards that are in charge of the management of waterlevels, waterways, water quality and sewage treatment. Together with the provinces they are active promotors of regional groundwater models.

- IBRAHYM
 - Current version 2.0
 - Deltares made, iMOD
 - Limburg relatively complicated:
 - Elevation differences
 - Old mining activities
 - Limestone impossible to model
 - Nitrate pollution
 - REGIS lacks enough detail and is only updated every 3-5 years
 - Yearly budget exists to maintain and update IBRAHYM
 - Used by:
 - Consultancy agencies
 - Universities
 - Province of Limburg
 - Only reviewed internally
- H30
 - Current attempt to enlarge IBRAHYM
 - Germany: Bundeslanden, Erftverbanden
 - Flanders

Waterschap Stichtse Rijnlanden, Joost Heijkers

Waterschappen are the Dutch water boards that are in charge of the management of waterlevels, waterways, water quality and sewage treatment. Together with the provinces they are active promotors of regional groundwater models.

- Nice companies in Dutch hydrogeology:
 - Artesia, Frans Schaars

- Hydrologic, working potential?
 - Tauw
 - Provincie: Small, 4-5 people. GIS, monitoring
- Hydromedah
 - Set to be incorporated in NHI
 - Used for:
 - Policy consequences
 - Calculating hydraulic head
 - Visualisation together with iMOD
- Research:
 - Satellites as measurement instrument (Stromingen)
 - Subsidence western Netherlands
 - Drainage systems to control the water level and reduce subsidence
- STRONG: Structuurvisie Ondergrond.
 - Utrecht has a very dense subsurface water infrastructure
- IGRAC: Dutch Society for expanding water knowledge internationally.

3.2.2 *Uploaded articles Database*

A total number of **64** articles were uploaded and described in the KINDRA database at www.kindraproject.eu. This includes the most important, relevant and recent developments and projects in the area of hydrogeology in the Netherlands (REGIS, DINO, all the regional groundwater models, etc.). A complete list can be found in Appendix A.

3.2.3 *Workshop*

During the workshop in Seville the online database was first presented. In order to make the database accessible and user-friendly several test phases were necessary. These phases consisted of uploading several varying resources to the database to test the functionality of all the options in the database.

Several topics were discussed as well:

1) *What to include in KINDRA?*

Since there is an enormous amount of hydrogeology research, reports and projects available throughout Europe the question is what needs to be uploaded first. The focus in 2016 is to include reports and research which is hard to find and access from abroad. Either because they are written in a local language or are only published internally.

2) *How to promote the use of KINDRA?*

Large-scale inventory projects and databases often fail to retain or even obtain the interest of professionals working in the related field. This is the result of a database of inferior quality or incompleteness. And after the initial grant of money has been spent no more money is available to maintain the database.

In order to avoid this and make KINDRA successful professionals will have to be made aware of KINDRA and actually use it. This is the task of the National Experts; they are to promote the use of KINDRA and guarantee the quality of the resources in the database.

3) *KINDRA maintenance after 2020*

No money is yet available after the initial grant expires in 2020. The most concrete idea to obtain new money was to make sure that the quality of the KINDRA database was very high, a job for the National Experts.

4) *Allowing more people to upload resources to the KINDRA database.*

The question to give other people the right to upload resources to the KINDRA database was raised as well. The Seville management of KINDRA felt this would not be wise as this would very likely result in a lower quality database as people would not adhere to the standards set by KINDRA.

The National Experts argued that allowing more people access to uploading would promote the use of KINDRA as people have to use it as well. And if the National Experts themselves have to upload all resources available it would take them a lifetime.

5) *Uploading existing archives.*

The KINDRA management said they were working on a template for mass uploading. (See section 5.2)

3.2.4 Promotion of KINDRA

Personal promotion for the KINDRA database was done through the individual interviews and lunch breaks. A leaflet from KINDRA was spread through the breakrooms at TNO and Deltares and given to the interviewee at other companies and institutes. For members of KNGMG an article was written for the "Geobrief", the KNGMG magazine (see Appendix B) as well as a short presentation that will be given at the annual meeting of the KNGMG at the 11th of May. A short article will also be published in "Stromingen", the magazine of the NHV (Dutch Society of Hydrology). And a poster presentation was given at the NAC (Nederlands Aardwetenschappelijk Congres) (see Appendix C).

3.3 AHN

In the Netherlands there are various models made available by TNO that describe the Dutch subsurface. All these models are dominantly based on data collected from boreholes, also available through DINO. The drilling of boreholes is done by various institutions and commercial companies (water companies, universities, TNO, etc.). Depending on the needs of the driller the quality and focus of borehole description can vary strongly.

Two of the things included in the borehole description are the XY-location and the height above sealevel, e.g. ground level. Nowadays GPS is used to determine location and height, which is thought to be very accurate. In the past the XY-location and the height above sealevel had to be estimated manually.

To determine the overall quality of the borehole XY-location and height above sealevel a comparison has been made between the ground level data from boreholes and the AHN (Algemeen Hoogtemodel van Nederland) model from the Netherlands. This has been done in two different ways: (1) A comparison between the absolute ground level height in the borehole data and the AHN and (2) A comparison between an interpolation based on the ground level data from the boreholes. Furthermore the connection between quality of the interpolation and the number of boreholes used for the interpolations has also been studied (3). The reports produced are written in Dutch and can be found in Appendix D.

4. Evaluation

In the duration of the internship I have gained experience in working in a professional environment. I have also visited various companies and institutions and obtained an impression of their working philosophies and the general atmosphere in the company.

A crucial part of my activities was to conduct interviews with individuals active in the Dutch hydrogeology scene. This involved obtaining contact information through various media's such as (hydrogeology) magazines, conversations, and personal communication. In the interviews themselves I had to balance the need to obtain information with the need to promote the KINDRA project.

It was interesting to speak to a large amount of professional people and gain a view of the work they perform in their functions. In the conference I also met a large number of foreign professionals who often have a very different view on subjects, both professionally and personally.

A sometimes frustrating part was the waiting and communication with professional contacts and at times the KINDRA organisation in Spain. Since the main form of communication used was email, replies were often slow. From the EFG there was unclear communication regarding deadlines and release data for the online database. This is understandable though as the project involves a lot of people spread out over various countries.

Overall I think I learned what it is like to be proactive in order to get what I need. Timely communication is the key to be successful in obtaining contact with professional people who might not always have time to answer a request.

5. Future of KINDRA

5.1 Overview of what has been done

The resources that have been uploaded to the KINDRA database are resources that mainly originate from research and projects which are not easily accessible abroad. The reports are mainly written in DUTCH and only published internally or in a Dutch hydrogeological journal. This means that research and projects that are published scientifically have not been looked at, these will be included at a later stage. The showpieces of the current state of hydrogeology in the Netherlands are however included even if they have been published scientifically. This includes the big groundwater models such as REGIS and GEOTOP and the hydrogeological toolsets such as NHI.

5.2 Uploading already existing archives and databases.

Research organisations such as STOWA, KWR already have a digitalised archive containing their own research. Even more commercial companies such as VITENS have archives of their research projects. The KINDRA management in Seville is working to provide a template that can be used to accommodate mass uploading to the KINDRA database. When this template is released contact should be made with the named research organisations to ask them if they are willing to upload their own archives to KINDRA. In order to persuade them to do so, the advantages of doing so should be clearly stated: PR for their organisation, possible EU research grants, advancing hydrogeology knowledge, etc.

5.3 Manuals & insertion of resources in KINDRA

The KINDRA management in Seville has several detailed manuals on how to insert metadata into the KINDRA database. These are currently available through a Google Drive map to which Jan Stafleu has access. No extra manual should be needed for other people. To be able to insert resources one needs to go to: <http://kindra.kindraproject.eu/geonetwork/srv/eng/main.home> and login with the following account:

Appendix A: List with resources added to the online database

Name	Organisation
AZURE	Rijkswaterstaat
RISKBASE: Risk-informed management of European River Basins	Deltares
NHI	Deltares
Subsurface and Groundwater Ecosystem Services	Deltares
IBRAHYM	Province of Limburg
SAT-WATER	Stowa
HYDROMEDAH	Waterschap Stichtse Rijnlanden
Grondwatermodel databank	Deltares
iMod	Deltares
Daily evaporation data in the Netherlands	Stowa
AMIGO	Province of Gelderland
Brabantmodel	Province of Brabant
Salinization in a stratified aquifer induced by heat transfer from well casings	University of Utrecht
The use of salinity contrast for density difference compensation to improve the thermal recovery efficiency in high-temperature aquifer thermal energy storage systems	University of Utrecht
Feedback calibration results to REGIS	TNO
Hydrogeological data exchange in the future	TNO
Determining characteristics of hydraulic head timeseries with a variable frequency	TNO
Thermogis: A Dutch tool to analyse geothermal potential	TNO
FRESHM: Using helicopters to measure salt groundwater distribution	Deltares
Memstill: Desalination of seawater	TNO
Riverbank Filtration in the Netherlands: Well Fields, Clogging and Geochemical Reactions	KWR
HyCA: Hydro Chemical Analysis Tool	KWR
CAVLAR Tool: (Criticality Analysis Valve Locations And Reliability)	KWR

Quantifying the vulnerability of well fields towards anthropogenic pollution; The Netherlands as an example	VU Amsterdam
MENYANTHES Tool: , 'Groundwater System Identification through Time Series Analysis	KWR
TOPSOIL project Drenthe: Electromagnetic induction and soil exploration	Province of Drenthe
Natural Capital Atlas of the Netherlands	Deltares
MIPWA: Hydrologic model toolset in Northern Netherlands	Province of Drenthe
DINOloket: Data and information of the Dutch subsurface	TNO
KRW-Verkenner	Deltares
Overview of Biotic Ligand Modeling methods in the Netherlands	Deltares
REGIS	TNO
Geotop	TNO
BasisRegistratie Ondergrond	TNO
Delft 3D	Deltares
SOBEK Suite 2.14.001	Deltares
Nationaal Watermodel	Rijkswaterstaat
NHI Watermodel	Rijkswaterstaat
NHI Landelijk Sobek Model	Rijkswaterstaat
NHI zoet-zout	Rijkswaterstaat
Landelijk Waterkwaliteitsinstrumentarium	Rijkswaterstaat
The use of wells with infiltration filters. Brackish water puts.	Vitens
Realtime monitoring networks to assess water quality.	Vitens
Solving well pollution by small particles	Vitens
Management of wells. Which well should pump more water, etc.	Vitens
Gebiedsdossiers	Provinces
Aqueduct: Global Flood Risk Analyzer	Deltares
ECOSHAPE Pilot: Houtribdijk	HKV
ECOSHAPE Monitoring program Hondsboschen Pettemer zeekering	HKV
BOS OMAR	Waterschap Peel- en Maasvallei
Landelijk grondwater register	Rijkswaterstaat
Trishell/Triwaco	Royal Haskoning
Pollution of exotic materials	Province of Utrecht
Brabantmodel	Province of Noord-Brabant

IWANH	Province of Noord-Brabant
MORIA	Waterschap Rivierenland
GGOR: Gewenst Grond- en Oppervlaktewaterregime	Rijkswaterstaat
Hydrogeological model of the Roerdalslenk	H30 cooperation

Appendix B: KINDRA Poster for NAC





www.kindraproject.eu

Knowledge Inventory for hydrogeology research

BSc Robert Warmer representing: KINDRA, Deltares & KNGMG | roberwarmer@gmail.com | T 06 104 63 91

The KINDRA project is part of the European Horizon 2020 programme. Its goal is to build a European Inventory of Groundwater Research (EIGR), aiming to assess the current state of hydrogeology knowledge inside Europe. The assessment will be used to identify areas in need of extra research, stimulate the spread of hydrogeology research in Europe and to increase the political awareness of the importance of hydrogeology in a changing world.

The figure below shows the steps to be taken and the steps already taken in the KINDRA project. Currently work is being done on step 4: Test and population of the inventory EIGR by data collection and processing.



The map above shows the countries participating in the KINDRA project.

Present step

Inside the KINDRA project 21 countries are participating to build the EIGR. Each country has a national expert who promotes and populates the database. The inventory uses a simplified system of keywords and locations to classify all of the resources inside. The use of keywords makes the inventory not only accessible for experts but also for policy makers. With the inventory it is hoped that hydrogeology can strengthen its position during the new distribution of research funds in 2020.

The KINDRA project is funded by the European Union in an effort to implement its "Water Framework Directive" and its "Groundwater Directive".



Appendix C: Geobrief article (in Dutch)

KINDRA – Een hydrologische database voor Europa

Zonder water zou er geen leven op aarde zijn. Kennis over dat water – zowel boven- als ondergronds – is bittere noodzaak om voldoende en schoon drinkwater, voedsel en een schoon milieu te garanderen. Om de hydrologische kennis binnen de Europese wetenschappelijke instituten zo goed mogelijk te delen wordt gewerkt aan KINDRA (Knowledge Inventory for Hydrogeology Research), een Europese hydrologische database. Robert Warmer was als stagiair betrokken bij het opzetten van het Nederlandse deel.

Maandag 16 november begon ik met goede moed aan mijn eerste stage-dag bij Deltares en het KNGMG. Een paar weken daarvoor had ik voor het eerst contact gehad met mijn toekomstige begeleiders Jan Stafleu (TNO en KNGMG) en Bob Hoogendoorn (Deltares en de European Federation of Geologists). In dit gesprek bleek dat zij graag zagen dat ik zo snel mogelijk zou beginnen. Op 24 en 25 november zou er een conferentie en workshop in Brussel zijn, waar ik naar toe moest en dan moest ik wel enige kennis van zaken hebben. Ik kon zelf echter pas half november stoppen met het werk wat ik toen deed (heel educatief dozen sjouwen en inpakken in een loods).

Delen van kennis

Mijn opdracht was om de kennis binnen Nederland op het gebied van hydrogeologie in kaart te brengen en online beschikbaar te maken op www.kindraproject.eu. In het kader van het 'European Horizon 2020 research program' en de Europese waterkwaliteitsrichtlijnen 'Water Framework Directive' en 'Groundwater Directive' moet er in de komende vier jaar een volledige 'European Inventory of Groundwater Research' (EIGR) opgezet zijn. Deze database moet de samenwerking tussen Europese en nationale instellingen verbeteren en de hydrogeologische kennis op Europees niveau toegankelijk maken. Daarnaast vindt er een inventarisatie plaats op welke gebieden de huidige hydrogeologische kennis nog gebreken vertoont. Hiermee moet er bij de herverdeling van Europees onderzoeksgeld in 2020 extra geld voor hydrogeologisch onderzoek beschikbaar gesteld kunnen worden zodat elk land kan voldoen aan de eisen van de 'Water Framework Directive' en de 'Groundwater Directive'.

Op maandag 16 november liep ik zodoende dus voor mijn eerste werkdag naar binnen bij Deltares om mij voor te bereiden op de conferentie van de volgende week. In het voorgaande weekend was de wereld opgeschrikt door de bloedige aanslagen in Parijs. Eén van de daders, Salah Abdeslam, vluchtte na de aanslagen naar België. Dit was voor België de reden om het dreigingsniveau in geheel België te verhogen naar niveau 3: 'dreiging is mogelijk en zeer waarschijnlijk'. Terwijl ik mij de eerste week bezig houd met het inlezen in het KINDRA-project en de status van de hydrogeologie in Nederland, wordt het in België en in het bijzonder Brussel steeds onrustiger. Het dreigingsniveau in het Brusselse gewest wordt verder verhoogd tot niveau 4, het hoogste niveau: 'dreiging is ernstig en zeer nabij'. Hierop wordt Brussel een soort spookstad waar mensen geadviseerd om niet in groepen samen te komen en alle evenementen, waaronder conferenties, worden afgelast. De maandag daarop krijg ik het al verwachte mailtje dat de conferentie wordt afgelast. Een goed te begrijpen beslissing, maar ik mis mijn eerste kans om uitgelegd te krijgen wat exact de doelstellingen van het KINDRA-project zijn en de publicatie van de bijbehorende online database. Uiteindelijk wordt op 26 november het dreigingsniveau in Brussel weer verlaagd naar niveau 3.

Voor onze conferentie is het echter te laat. Er moet een nieuwe datum gevonden worden, voor mij het liefst zo snel mogelijk.

Het KINDRA-project

Tot een nieuwe datum voor de conferentie afgesproken is, ga ik echter wel verder met het KINDRA-project. Ik begin met het in kaart brengen van de hydrogeologische kennis in Nederland. Na een lange mailwisseling met de organisatoren van KINDRA denk ik te begrijpen wat de opzet is van het project. De database moet door het gebruik van simpele keywords en indelingen ook bruikbaar zijn voor mensen zonder hydrogeologische achtergrond. Mensen zoals (Europese) ambtenaren, beleidsmakers, managers en ministers.

De database structuur wordt opgezet door het REDIAM (Environment and Water Agency of Andalusia) instituut in Andalusië, Spanje. Het bevolken van de database is de verantwoordelijkheid van de 'National Experts' uit de deelnemende landen. Voor Nederland ben ik dat. De 'National Expert' zorgt voor het uploaden van onderzoeken, projecten en modellen in zijn eigen land. De focus ligt voorlopig niet op wetenschappelijk gepubliceerd onderzoek maar op relevant onderzoek wat lastig te vinden is voor mensen uit het buitenland. Bijvoorbeeld lokale rapporten die in het Nederlands geschreven zijn. Indien het eindproduct van een onderzoek in het Nederlands is komt er in de online database een Engels abstract te staan. Niet het hele onderzoek hoeft vertaald te worden.

Een andere taak van de 'National Expert' is de kennis van het bestaan van KINDRA zo wijd mogelijk te verspreiden. Dat gebeurt onder andere door contact op te nemen met bedrijven, instituten en mensen die actief zijn in de hydrogeologie, in de hoop dat zij eigen onderzoeken die geen geheime informatie bevatten ook in de database willen plaatsen. Omdat veel bedrijven en instituten een eigen archief hebben, wordt er gewerkt aan manieren om deze archieven (of een selectie hieruit) automatisch te kunnen uploaden naar de KINDRA-database. Bedrijven die informatie in de KINDRA database stoppen, kunnen voordeel hebben met het bemachtigen van subsidies voor onderzoek. En de aanwezigheid in een Europese database kan de nodige PR en naamsbekendheid opleveren. Maar het bevorderen van kennis en samenwerking binnen de hydrogeologie voor vakmensen is natuurlijk het belangrijkste doel.

Sevilla

De naweeën van de aanslagen in Parijs maken het moeilijk om een nieuwe datum voor de conferentie vast te stellen. Het wordt 5 februari in Sevilla, waar het hoofdkantoor van REDIAM zit. Het betekent dat mijn stage iets uitloopt en ik verheugde mij op een mooi tripje naar Sevilla. Tot die tijd houd ik mij bezig met het interviewen van mensen betrokken bij de hydrogeologie, dat wil zeggen mensen bij TNO, Deltares, provincies, waterschappen, KWR, STOWA, waterleidingbedrijven en adviesbureaus. Uit deze interviews maak ik, gecombineerd met literatuuronderzoek, een overzicht van studies en rapporten die ik in de database moeten.

Voor de conferentie in Sevilla heb ik een aantal dagen gefietst in de omgeving van Ronda onder een strakblauwe lucht in een aangename temperatuur net boven de twintig graden, terwijl het winter is in Nederland. De omgeving rond Ronda is zeer interessant voor geologen; Ronda zelf is gebouwd op een conglomeraat plateau dat hoog boven de omgeving uittorent. Dwars door Ronda loopt de

'Tajo de Ronda', een kloof die het plateau in tweeën splitst. De prachtige omgeving heeft vele mensen geïnspireerd. Zo hebben onder andere Ernest Hemingway en Orson Welles lofbetuigingen aan Ronda opgenomen in hun boeken. In dit prachtige berggebied rondom Ronda bevindt zich één van de grootste ontsluitingen ter wereld van peridotiet (een groen mantelgesteente). De conferentie stond in het teken van uitleg en discussie over de doelen van KINDRA, de structuur van de database en de mogelijkheden om gebruikers (bedrijven, instituten en beleidsmakers) te activeren de database te vullen en te gebruiken. Hier werd eindelijk de online database gepresenteerd. Maar één van de uitkomsten van de conferentie was dat de database nog uitgebreider getest en verbeterd moest worden voordat hij officieel in gebruik genomen kon worden. Ik moest een aantal artikelen met verschillende metadata in de database te zetten en de bruikbaarheid en overzichtelijkheid van de database beoordelen. Ondanks vele beloftes om zo snel mogelijk alle feedback te verwerken, kwam er pas in maart een verbeterde versie van de online database. Nu deze beschikbaar is, kan ik de laatste fase van mijn stage afronden: het bevolken van de KINDRA-database. Tegelijkertijd lees ik op het moment van schrijven dat Salah Abdeslam opgepakt is in Brussel. Een passend einde van mijn stage.

In de jaren tot 2020 zal er zeer waarschijnlijk nog vaker aandacht worden besteed aan het KINDRA-project. In de nabije toekomst zijn er al twee nieuwe KINDRA gerelateerde projecten die vanuit Deltares en KNGMG uitgevoerd gaan worden.

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Appendix D: AHN reports (in Dutch)