Hydrogeological mapping for Climate Resilient WASH in Ethiopia – LOT 5

Inception Report – Final BDA/ICB/GW01/2021




ACACIA WATER

aquacon ENGINEERING PLC

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1 Introduction

Drought is the major natural disaster affecting the livelihood of Ethiopians, resulting in water insecurity which in turn causes disruption of livelihoods and loss of life. A significant proportion of the Ethiopian population still lacks access to clean water, even though Ethiopia successfully achieved the Millennium Development Goal (MDG) target of halving the number of people without access to improved drinking water. At the national level, 60 to 80 per cent of communicable diseases are attributed to limited access to safe water, and inadequate sanitation and hygiene services.

The UK Department for International Development (DFID) supports the Government of Ethiopia to improve water security through the One Wash National Programme (OWNP) and other longer-term development and emergency activities. Yet, whilst emergency support is critical, it is also vitally important that resilient WASH development programming takes place in water insecure areas to break the cycle of emergencies. The challenges are greatest in the lowland parts of Ethiopia due to the complex geology and hydrogeology of the areas, which provide challenges to the development of productive groundwater sources. In addition, most regions of Ethiopia lack detailed hydrogeological maps that can be used as a quick reference for siting water wells. As a result, the drilling of dry or low-yielding wells is the main challenge in groundwater development.

Current national mapping is very broad scale and focuses primarily on depth to water and geology. Although an excellent starting point, this level of mapping appears to focus on irrigation, and does not necessarily tie in well with development potential, or range of borehole yields. With accurate borehole attribute data, and accurate geological mapping, hydrogeological characterization and mapping can provide the basis for efficient field verification.

The Ministry of Water, Irrigation and Energy (MoWIE) has received funding from DFID for a three-year project entitled Delivering Climate Resilient Water, Sanitation and Hygiene in Ethiopia (DCRW). As agreed by an MOU between DFID and the Government of Ethiopia work stream? two of the four programme areas are being implemented by the Basins Development Authority (BDA).

This project, which runs to 31 March 2022, is part of the UK government's aid strategy to support the poorest people in adapting to climate change, specifically on building climate resilience in water and sanitation services that contributes to achieving Sustainable Development Goal (SDG) 6. The project complements DFID and Ethiopia's significant programming on water and sanitation and supports effective delivery of the Government of Ethiopia's strategy for sustainable water supply in drought affected areas. A key feature of this program involves funding for groundwater mapping and improvement of groundwater data management.

1.1 Objectives

The project has been subdivided into 5 lots. Lots 1, 2, 3 and 4 cover 53 selected woredas in the regions Tigray, Amhara, Afar, Gambela, Oromia, Somali and SNNPR (Figure 1). Lot 5 deals with the data management and dissemination.

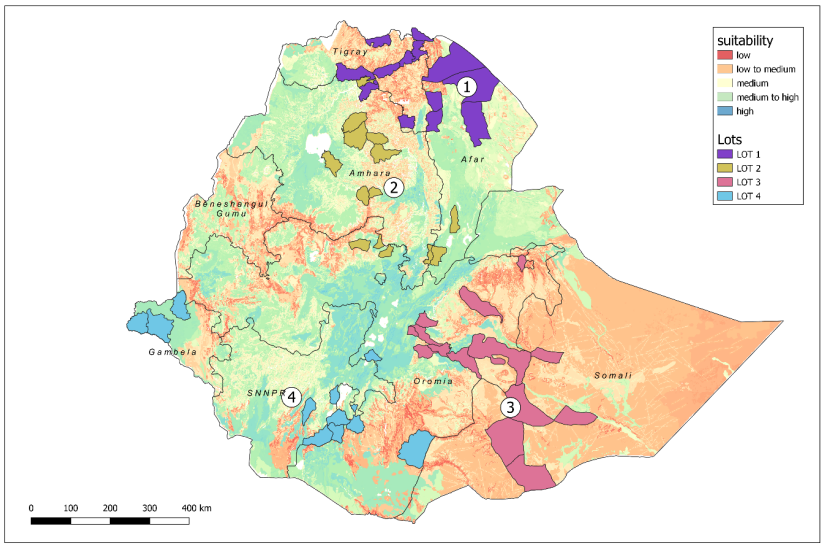


Figure 1 Project area

1.1.1 Overall objective

The objective of this project is to increase access to safe and sustainable water for the people in drought affected regions by producing hydrogeological maps at woreda level and recommend drilling sites which the Government of Ethiopia and other partners can use for developing groundwater resources.

1.1.2 Specific objectives

Lots 1, 2, 3, and 4

- Create detailed groundwater potential maps for each Woreda.
- Identify one optimal drilling site and one alternative (optional) drilling site per Woreda using these maps and geophysical field investigation.
- Recommend the type of drilling methodology to be employed.
- Build the capacity of WDC, BDA, Regional governments, and NGOs to use overlay analysis techniques for groundwater potential mapping in Ethiopia.

Lot 5

- Conduct detailed assessment and review of the status and configuration of the existing Ethiopian national groundwater information system.
- Identify the most effective platform for storage and presentation of the data.
- Develop a web-based platform for two-way information flow and test its
- operation and access to the data.

1.2 Activities

For Lot 5 the following activities are specified in the Terms of Reference:

- Review of the existing Groundwater Information System
- Establishment of a central database
- Migration of existing data into that database
- Development of an online platform for dissemination, analysis, and data acquisition

- Liaise with the Regional Water Bureaus
- Capacity building at BDA on usage of the system and database operation and maintenance

1.3 Remarks on the Terms of Reference

The database to be developed in Lot 5 should not only hold tables with (hydrogeological) data, but also act as a central datastore for the outputs of Lots 1, 2, 3 and 4. The database should be connected to the internet to facilitate access by web applications for data entry, dissemination, and analysis.

BDA has initiated a parallel activity to develop a water resources database that will hold all relevant information related to water resources management. The development is expected to be completed early 2022. Groundwater is an integral part of this database. At the time of writing, the functional design of the groundwater related information for this database was still in an early stage. To avoid duplication of efforts we intend to align the activities of this project with the development of the overall water resources database, so that the data collected and validated during this project can be easily transferred.

Towards adequate groundwater management, there have been earlier attempts to establish a national groundwater database. The projects faced several challenges, including:

- the established databases contained partly unvalidated data
- not all available data was collated, validated, and imported
- the solutions targeted advanced users with high level of knowledge and experience
- the systems were not easily accessible nor user friendly
- non-governmental stakeholders in water sector (NGOs, international organisations) were denied access

The system that is proposed here aims to avoid these challenges and targets not only highly experienced professionals, but also regular users with limited background. Its design is modular with emphasis on accessibility, data sharing, import and export functionalities.
We intend to establish a database with the basic data that is required for adequate groundwater management.

Priority is given to improved access to datasets and documents related to groundwater and groundwater resource management. The information should be reliable, complete, and stored in a well-structured database that is easily accessible.

The system will not include tools for advanced analysis, such as groundwater modelling, geochemical modelling, geophysical well log and pumping test interpretation. Instead, the system provides the mechanisms for easy linkage and input to these tools.

1.4 Project Team

1.4.1 Acacia Water bv

Acacia Water became an independent consultancy company in 2008. Today, Acacia Water is a leading supplier of water consultancy services in The Netherlands and abroad. We add value through highly experienced staff, personal commitment, reliability, and a

strong focus on solutions. Our experts work with a multidisciplinary view, are context sensitive, and can connect the dots. Whether it concerns agricultural plots or global scale, Acacia Water is a sparring partner for governments, the private sector, and both national and international NGOs. Our experts are flexible and able to shift between different scales, and to integrate technical, social, and environmental disciplines. We apply this approach to find solutions to water scarcity challenges faced now and in the near future.

Acacia Water applies a hydrological system-specific approach to generate practical understanding of the groundwater and surface water. This enables the identification of promising locations to create access to water and helps to assess the long-term effects of measures on the environment. A hydrological approach offers a wide insight into the water system. Based on knowledge of the various subsurface sediments and the natural dividing features in the landscape, measurements – even if only available to a limited extent – can be interpreted and scaled up. The result is an impression of the entire area. Several data sources are combined to achieve this, including satellite data, geological data and soil maps, piezometer and drilling data, and local empirical expertise.

Acacia Water often deploys hydrological modelling, including the latest and state-of-the-art modelling software in the field, to gain additional insight in a study area regarding, for example: water availability, water level fluctuations or subsidence, soil processes, etc. Through modelling, a quantitative understanding can be gained of an area making it more possible to judge which and what type of water development options are most suited, how many would be needed and specifics of the infrastructure. Acacia Water has a long track record in the use and application of databases and hydrogeological modelling software, whilst translating the results into practical and customer-focused advice and development and management options.

One of our focus areas is sustainable groundwater development and use. Because of suboptimal mapping and siting, boreholes may have poor yields or run dry. Through the developed methodology on ground water feasibility mapping, Acacia contributes to more successful and sustainable development of groundwater.
Acacia Water has extensive international experience in groundwater investigations and mapping using remote sensing, data management and modelling and in application of a wide range of geophysical methods.

All around the world, for example in Kenya, Uganda, Sudan, Ethiopia, Bangladesh and Suriname, the company locates high-quality groundwater aquifers and provides advice on groundwater monitoring, management, and sustainable use.

1.4.2 Aquacon Engineering plc

Aquacon Engineering PLC is an Ethiopian consulting and engineering company established in 2014 to engage in water supply and sanitation studies, design, and construction supervision; geological, hydrogeological, hydrological and geophysical investigation; water management and environmental studies in Ethiopia and elsewhere. It was established by two Czech Companies and one Ethiopian individual.

Most of the projects the company has undertaken are related to:

- Regional hydrogeological investigations and groundwater resources assessments
- Groundwater potential mapping
- Groundwater resource investigations for water supplies and irrigation

- Design of water supply systems and construction supervision
- Water balance modelling
- Hydrogeological conceptual models, numerical modelling, and monitoring
- Applications of remote sensing and GIS for water resource assessment and management

Under the bilateral agreement between the Ethiopian and Czech governments, the company has been working together with AQUATEST and the Geological Survey of Ethiopia projects for hydrogeological mapping that covered entire Ethiopian territory of more than 1M km2 and is available via Internet.
http://gis.gse.gov.et/hg_maps/index.html.
For the last five years, Aquacon together with other international companies, has been working on shallow groundwater exploration and mapping for development of household irrigation in the Southern Ethiopia, Tana- Beles, Tarmaber – Maychew, Adiremets – Axum, Finch- Gimbe and Gibe – Tapi, Adigrat Abergele, Chancho-Mehal Meda, Kofele-Goba and Harari Identified areas. The company can support its investigation, consulting, research, and engineering services by staff with national and international experience, and in-depth knowledge of groundwater mapping and water resources assessment and monitoring, geophysical measurements, water works and sanitation, engineering design, irrigation schemes, feasibility studies, remote sensing, GIS and data base, surface and groundwater modelling.

It has 10 regular and more than 10 short-contract national experts with a wide range of experience in:
- Groundwater exploration and assessment
- Exploration geophysics
- Geological mapping
- Well siting and drilling and pumping test design and supervision
- Groundwater and isotope and hydro-geochemical studies and modelling
- Groundwater pollution and vulnerability studies
- GIS and remote sensing
- Database management

Together with Acacia, Aquacon successfully completed the national groundwater mapping project for UNICEF in 2020 (GW4E). Also, Aquacon was involved in shallow groundwater mapping for ATA (partly together with Acacia) and harmonization of the national geological maps.

1.4.3 Engaged professionals

The following personnel will be engaged in the project (Table 1):

Table 1. Overview personnel engaged in the Inception Phase.

Name	Position	Tasks assigned
Dr Maarten Waterloo	1. Project manager (1st)	Overall project management (organizational and financial). Training and capacity building

Mr Zenaw Tessema	2. Project manager (2nd)	Together with the PM, responsible for overall project management and official contacts with client, and other stakeholders. Represents Maarten Waterloo as program manager.
Dr Tilahun Azagegn	3. Senior hydrogeologist	Data acquisition and harmonization, contacts with stakeholders, training, and capacity building
Mr Theo Kleinendorst	7. Senior IT expert	Design and implementation of database and website.

2 Methodology

Lots 1, 2, 3 and 4 cover 53 woredas and focus on mapping, resource assessment, and site selection. The activities for Lot 5 on the other hand, focus on data management, accessibility, and dissemination. The Terms of References specify:

- Review of the existing Groundwater Information System
- Establishment of a central database
- Migration of existing data into that database
- Development of an online platform for dissemination, analysis, and data acquisition
- Liaise with the Regional Water Bureaus
- Capacity building at BDA on usage of the system and database operation and maintenance

For Lots 1, 2, 3 and 4 the following tangible outputs are expected:

- Collation of relevant maps, reports, and data
- Conceptual hydrogeological models
- Water point inventories
- Demographic data and maps
- Hydrogeological maps
- Groundwater potential maps per woreda
- Drilling site maps

The central database to be developed in Lot 5 should not only hold tables with (hydrogeological) data, but also act as a central datastore for the outputs of Lots 1, 2, 3 and 4. Its function will be two-fold:

1. Storage and retrieval of hydrogeological data
2. Content management system for maps and reports

The database should be connected to the internet to facilitate access by web applications for data entry, dissemination, and analysis.

2.1 Review of the Existing Groundwater Information System

At the start of the assignment, we review the existing Groundwater Information System and earlier database initiatives in Ethiopia. Although we will focus primarily on the system at different government levels, we will also contact international organizations and NGOs. After evaluation of the availability and quality of the data, we develop a preliminary functional database design, suitable for migration of the existing data. The findings of the review and the preliminary design of database are documented in this Inception Report.

2.2 Establishment of Central Database

Based on the review of the existing systems we develop a functional design of the database and its front-end that provides central storage for dissemination of the project's results and existing groundwater data.

To avoid issues with software licenses we use open-source software only. A PostgreSQL database will be installed on a cloud server to facilitate access, operation, and maintenance. Users can access the system from a website, online map viewer or GIS software. Users with appropriate authorization have access through a dedicated web-interface and a predefined REST API.

During the development stages, we will use the servers of our Internet Provider in the Netherlands to host the database and apps. After the project, the database and related software will be physically transferred to the BDA. If desired, we can also continue hosting the system and provide the required operation and maintenance services.

2.3 Migration

During the review of the existing Groundwater Information System, we will collect as much existing data as possible. The acquired data will be validated, harmonized, and migrated to the central database on the cloud server.
The harmonization is necessary to ensure consistency in units and coordinate systems. Data that do not pass the basic validation tests will not be migrated. This is to warrant the quality of the data stored in the database.
For the validation, a set of rules will be developed that will enable automatic validation of incoming data. The rules identify possible problems/inconsistencies with:

- Coordinates and coordinate systems
- Units (for water quality, discharge, and depth)
- Duplicated of entries

After the Inception Phase, the project team will not actively collect, validate, and import data. Instead, the team will provide the necessary training and support for harmonisation and validation by the target users, such as Regional Water Bureaus and the consultants working for Lots 1, 2, 3 and 4.

2.4 Online platform

We will develop an online platform, like the website of the UNICEF project "Groundwater Mapping for Climate Resilient WASH in Ethiopia" (https://gw4e.acaciadata.com). The site will be customized to the needs of the BDA, regional water bureaus and the project. For database administrators we will enable a separate interface for data entry, validation, and querying.

Data that was not made available during the Inception Phase should be entered in a later stage. This can be realized through the administrator's web-interface (data entry for single records such as waterpoint data). For larger quantities of data (spreadsheets) we will provide a bulk import functionality.

It is foreseen to launch the alpha release of the web portal and database in October 2021. The beta release is planned for December 2021. In March 2022, at the end of the project, the final version will be released.

The alpha release will be validated in October and November. The project team will validate and migrate the existing data into the database using the new validation and migration tools. The beta version will be validated by a test panel in January and February 2022. The panel will consist of selected BDA and MoWIE staff members.
The final validation and acceptance will be carried out at the end of the project (March 2022) by BDA.

2.4.1 Help and support

We will provide both user's and administrator's manuals, to support users and database administrators in accessing or uploading data and database maintenance. The first version of the manuals will be made available at the launch of the web portal, the final versions at the end of the project.
At the launch of the web portal, we will make a helpdesk available to answer questions and provide support to users and administrators. The helpdesk will also act as a repository for change requests (RFC) and bug reporting. After the launch, the system will be updated regularly with feature enhancements, changes, and bug fixes.

2.5 Capacity building

At the end of phase 2, at the beta release of the portal, we will organize a 5-day training and workshop. The training will focus on the use of the system, data validation, data entry, querying and up- and download functionality. We will demonstrate the use of the portal in the field, for well inventories on a tablet, and organize a dedicated training for database administrators.
The training and workshop targets BDA and RWB staff, and other potential users.
During phase 3, (January – March 2022), the target users are expected to migrate their own data to the system. During this period, we provide necessary assistance and support for the validation and migration processes.

3 Planning

3.1 Planning

The contract was signed on May 21, 2021. The total lead time is 10 months, and the project should be competed in March 2022. The project consists of 3 phases with the following expected due dates and deliverables:

Phase		Due	Deliverable
I	Desk Study	August 2021	Inception report
II	Design and implementation	December 2021	Beta release and manuals
III	Training and Migration	March 2022	Final release and report

A detailed workplan is attached as Annex 1

3.2 Work practice

The Joint Venture (JV) of Acacia Water (Acacia) from the Netherlands and Aquacon Engineering PLC - Ethiopia (Aquacon) of Addis Ababa, Ethiopia with Acacia Water as lead firm. The team will operate from the Acacia Water office in Addis Ababa.

The team will have regular meetings with BDA designated point of contacts to review progress and discuss any technical or management issues. Minutes of the meetings will be shared with the concerned team members to assure follow up on agreed actions.

4 Inception Phase

4.1 Introduction

The work for the Inception Phase started on June 1, 2021. In June and July, a review of existing data has taken place and a preliminary design was developed. The results of these activities are presented below:

4.2 Review of existing databases

MoWIE has two software packages for storage, retrieval, and analysis of groundwater data:
ENGDA (USGS) and ENGWIS (Schlumberger Water Services). Both packages are outdated and dysfunctional. However, we were able to retrieve the data stored in ENGDA. The data from ENGWIS could not be retrieved, because the license has expired long ago and was not renewed. Moreover, the software runs on an outdated versions of Microsoft Windows and Internet Explorer (Windows XP, IE 5.0).
Fortunately, the groundwater staff of MoWIE keeps copies of the data on different computers. We retrieved most of the data and analysed their contents.

4.2.1 ENGDA

ENGDA has been developed by USGS in 2004-2007. It uses Microsoft Access as database engine and contains information about the following topics:

Topic	Number of records
Boreholes	2983
Springs	796
Well construction	662
Pumps	57
Lithological logs	398
Aquifer tests	32
Water use	14
Discharge	988
Water levels	1413
Water samples	1902
Drilling	32
Well development	69

After analysing the structure and database fields it is felt that the structure of the ENGDA database is well suited for management of groundwater resources by the BDA. It could serve as a base for further development. There have been initiatives by USGS to develop the Horn of Africa Groundwater Database (HAGRD) based on ENGDA.
Detailed information about the structure and field definitions of the ENGDA database can be found online at http://pubs.er.usgs.gov/publication/ofr20071099.

The main advantage of ENGDA is a clear database structure, that targets the needs of BDA on groundwater management. Disadvantages are the outdated database software (MS Access), lack of GIS support and interoperability functionality.

4.2.2 ENGWIS

ENGWIS uses Microsoft SQL server 2005 as database backend and consists of three main packages, all with commercial licenses:

Hydro Geo Analyst

Hydro Geo Analyst is an information management system for managing groundwater and environmental data. It provides database utilities, borehole logging/reporting, 2D mapping and cross sections and 3D visualisation.

Aquifer Test Pro

AquiferTest Pro is designed for graphical analysis and reporting of pumping test and slug test data, offers the tools necessary to calculate an aquifer's hydraulic properties such as hydraulic conductivity, transmissivity, and storativity.

AquaChem

AquaChem is used for the management, analysis, and reporting of water quality data. It includes the geochemical reaction model PHREEQC.
This software suite targets professionals in the field of groundwater research, development, and management. It contains a collection of advanced tools to support the groundwater professional in daily work and can interface with external modelling software such as MODFLOW and PHREEQC

The Microsoft SQL database backend stores information about the following topics:

- Site description
- Well construction
- Well history
- Geological descriptions
- Geophysics
- Monitoring

The number of records and quality of the data could not be determined because the system is not functional anymore. The design is somewhat different than ENDGA, but it contains similar database fields. A description of the database structure is attached as Annex 2 to this report.

The advantages of ENGWIS are the flexible template system that allows users to define or modify the database fields and tables, and the strong linkage with postprocessing and modelling software. The latter is also a disadvantage, because the linkage is only with predefined set of (advanced) software tools such as AquaChem, Aquifer Test pro, PHREEQE and MODFLOW that require specific hydrogeological knowledge and experience. Another disadvantage is the closed system that relies on proprietary, licensed software running on a single computer, not in a shared environment.

4.2.3 MoWIE data

Individual staff members of MoWIE keep groundwater data on their computers. We have retrieved a total of 1865 files with water point data, water quality data, well logs, time series, well completion reports and other reports. The files contain database dumps of ENGDA, ENGWIS, and WASH inventories, as well as well completion reports and other relevant documents.

From these 1865 files we have retrieved 136450 records with tabular data. Before importing the data into the database, it needs to be thoroughly analysed and validated.

4.2.4 National Water Inventory Database

The data from the National Water Inventory Database has not been received so far. It will in validated and migrated as soon as the data is available (during phase 2 or 3 of the project).

4.2.5 Lessons learnt

The main lessons learnt from the previous experiences with database systems are

- Database tables contain unvalidated data
- Accessibility challenges (only accessible through computer at MoWIE)
- No backup/restore system in place
- No formal database management procedures
- Many (redundant) tables with limited data
- Complex support and postprocessing software
- Monitoring data (quality, levels, discharges) is missing, and databases contain mainly inventory data

4.3 Proposed system

4.3.1 Background

Previously, the database systems were installed on computers at the Ministry. The database software (Microsoft Access and Microsoft SQL server) was at the time of installation a logical choice. The systems could still be functional because the underlying database systems are still supported and maintained. Microsoft Access however is not designed for remote access, and installation in a client-server environment is discouraged because of security and performance issues. ENGWIS's database system (Microsoft SQL Server) is better suited in these environments. The main disadvantage of ENGWIS is the user interface and support software that was supplied by SWS. This is proprietary software that is subject to license fees and does not run on current operating systems versions without (costly) upgrades.

4.3.2 The system

The system we propose here is a web-based client-server system, based on open-source software. Its main purpose is to store groundwater data in a structured manner and provide data entry, validation, and querying/display functionality. Advantages of using open-source software is that the owner of the system is not dependent on a single supplier and that no license fees are involved.
The database tables and fields will be designed in such a way that no data will be lost during the migration process. The new database should be able to store all existing data, from both ENGWIS and ENGDA databases.
Because the system is web-based, there are no installation, hardware, or software requirements for the end-users and data integrity is guaranteed though automatic backups in the cloud. Users can access the system (with appropriate credentials) on any device using any major Internet browser like Edge, Chrome, Firefox, Safari and Opera. It will be accessible from computers, tablets, and smartphones. We will provide download functionality for offline usage in the field on mobile devices and develop a REST API to facilitate exchange of data with external systems, such as databases and sensor platforms.
Finally, the proposed system will provide web services (WFS and WMS) to enable online linkage with third party GIS packages and (online) mapping applications.

The proposed system is visualised in Figure 2.

4.3.3 Software

As database server we will use the most advanced open-source relational database: PostgreSQL (https://www.postgresql.org). PostgreSQL is a powerful, open-source object-relational database system with over 30 years of active development that has earned it a strong reputation for reliability, feature robustness, and performance. It is one of the most used open-source database systems and has excellent performance, security, and support.

The backend will be developed using Django and the Django Rest Framework (https://www.djangoproject.com). Django is a high-level Python web framework that encourages rapid development and clean, pragmatic design. Built by experienced developers, it takes care of much of the hassle of web development. It is free and open source.

The font-end will be developed using Django and JavaScript. All these software components are expected to be supported and developed further for many years to come.

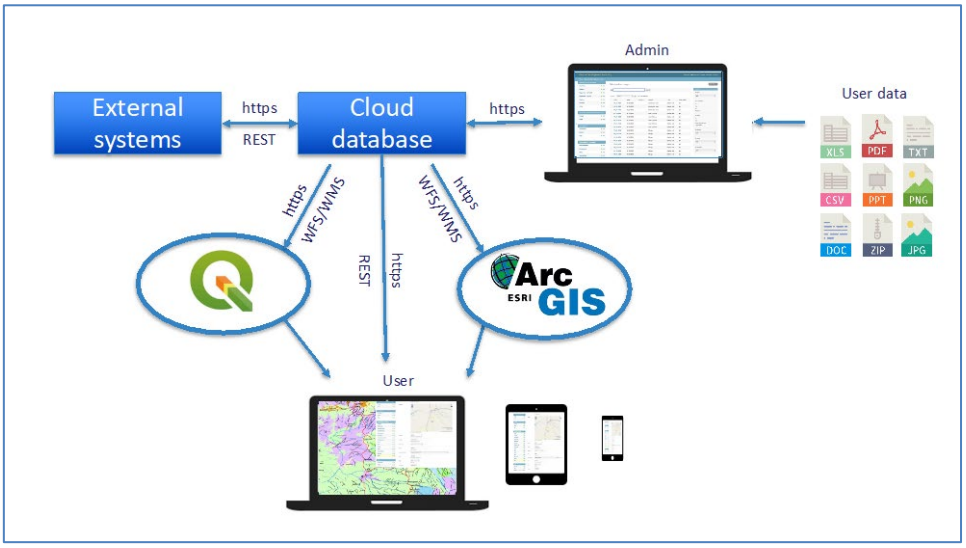


Figure 2 Proposed system

4.3.4 Security and access rights

To avoid compromising the integrity of the system and prohibit unauthorized access, all access to the system is channelled through secure, encrypted SSL connections. Users are assigned a role that defines their access rights. Possible roles are administrator, database user, regular BDA user and anonymous user (the public). The roles and related authorizations are to be determined during the project.

4.3.5 Location and hardware

During the development phase we will use a dedicated server from our service provider in the Netherlands. The server will be physically located in Amsterdam 1 data centre in Schiphol, near Amsterdam (Figure 3).

We propose to use a dedicated server with a RAID mirroring, and a second server for backups. The exact hardware specifications have not yet been determined but will meet at least the following specs:
4-core 64-bit processor
32 Gb RAM
4 x 1 TB SSD disk
OS: Ubuntu 20 LTE 64 bit
Bandwidth: 1 Gb/s, 30 Tb

Figure 3 Amsterdam 1 data centre

After the project, the system may be transferred to a service provider in Ethiopia, or to a physical server in the Ministry. We can also continue to provide hosting services from the Netherlands if desired.

4.4 Preliminary design

4.4.1 Backend

For the backend data storage, we have developed a preliminary design using the database structures of ENGDA and ENGWIS as starting points.

The design is modular, clear, straightforward, concise and should:

- Support upload of all existing data
- Keep existing database fields, except unused fields
- Distinguish between validated and unvalidated data
- Focus on data integrity
- Be optimized for storage space and query speed
- Support upload of documents and maps

Groundwater data

The groundwater data is subdivided into 5 main classes:
Waterpoint data
Well construction data
Groundwater data (timeseries of quality and quantity)

- Well logs (driller's logs, lithological and geophysical logs)
- Water samples and analyses
- Pumping tests

Other resources

The backend will also hold other data such as:

- Documents, spreadsheets, pictures, GIS files, etc.
- Administrative divisions, and map sheet numbering
- Map compositions for the interactive map viewer

Proposed database fields are listed in Annex 2, and Entity Relationship Diagrams (ERD) of the preliminary design is attached as Annex 3

4.4.2 Front-end

The frontend design is based on the dissemination tool developed during the UNICEF project "Groundwater Mapping for Climate Resilient WASH in Ethiopia", tailored to the needs of BDA and with some additional database functionalities.
The frontend contains three main modules:

1. Database interface
2. Map viewer
3. Document browser

Database interface

The database interface is meant to query groundwater layers and inspect time series. Authorized users may use this interface for data entry and advanced querying.
Functionality for the database interface:

- User administration
- Groundwater data management
- Import/export
- Time series browser
- Validation
- Map composition management
- Document management (uploads)

A sample interface is show in Figure 4.

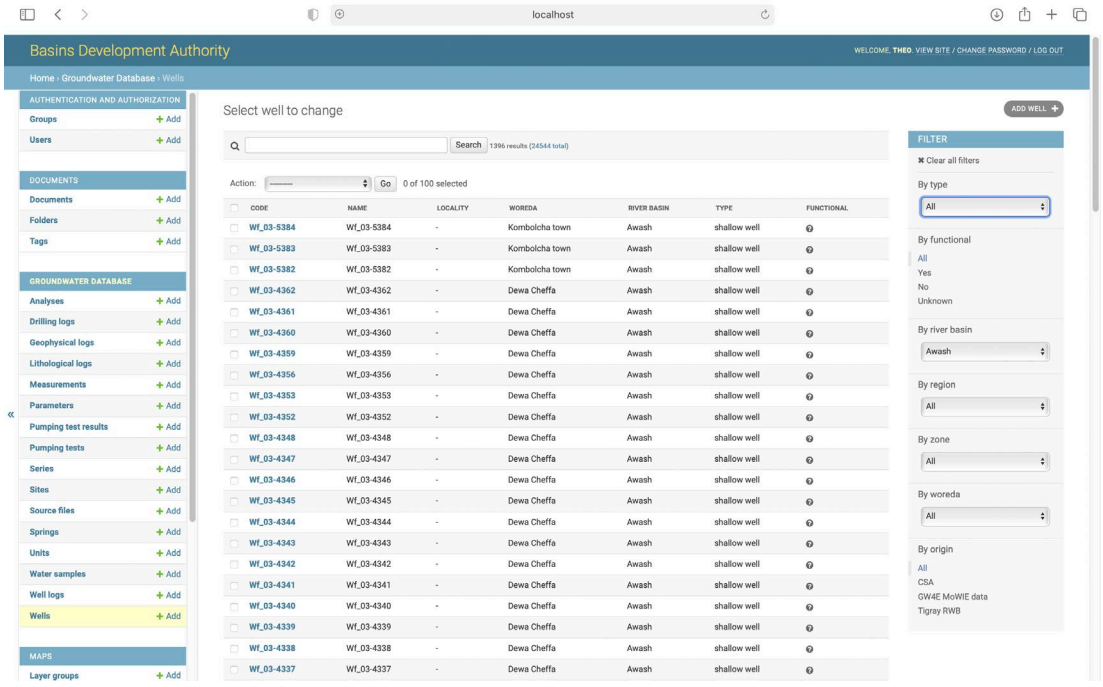


Figure 4 Administrator interface

Document browser

The document browser lets the user browse through the repository of uploaded material, such as reports and maps. Authorized users can preview or download the documents and maps directly from the website. A sample screenshot is shown in Figure

5. The project will propose, in coordination with BDA, an initial structure for the document repository. The structure can be modified by the database administrator. The documents can be tagged, and linked to database entries, such as wells. This facilitates querying and retrieval of related documents such as well completion reports, well logs or pumping tests.

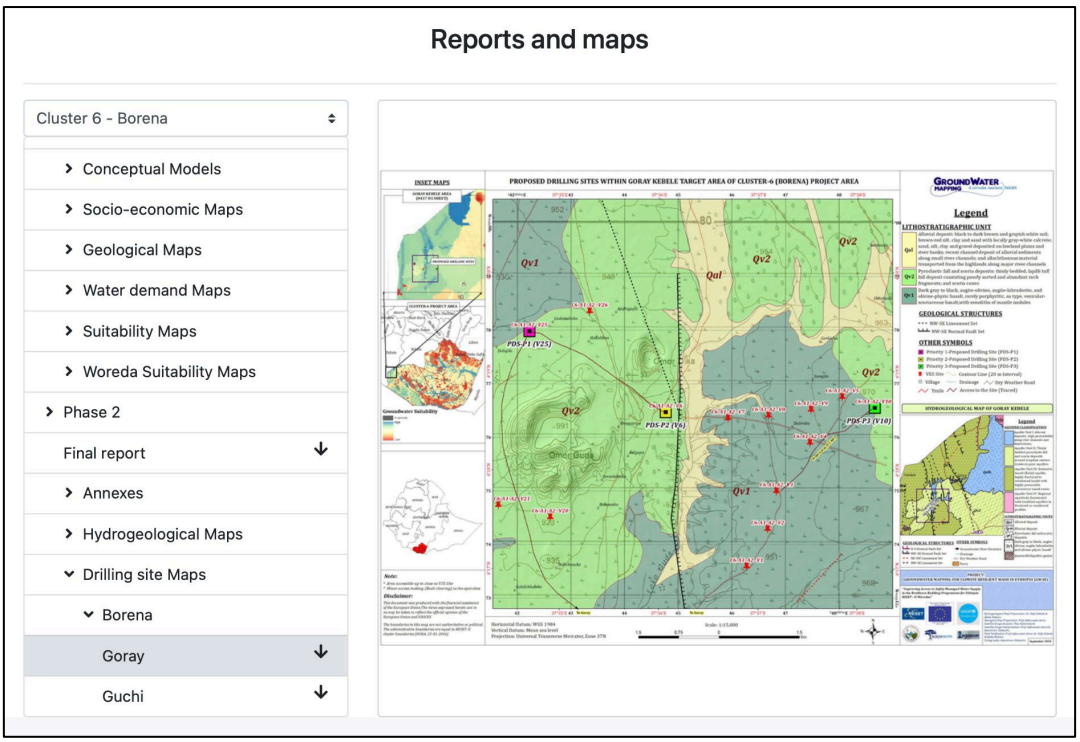
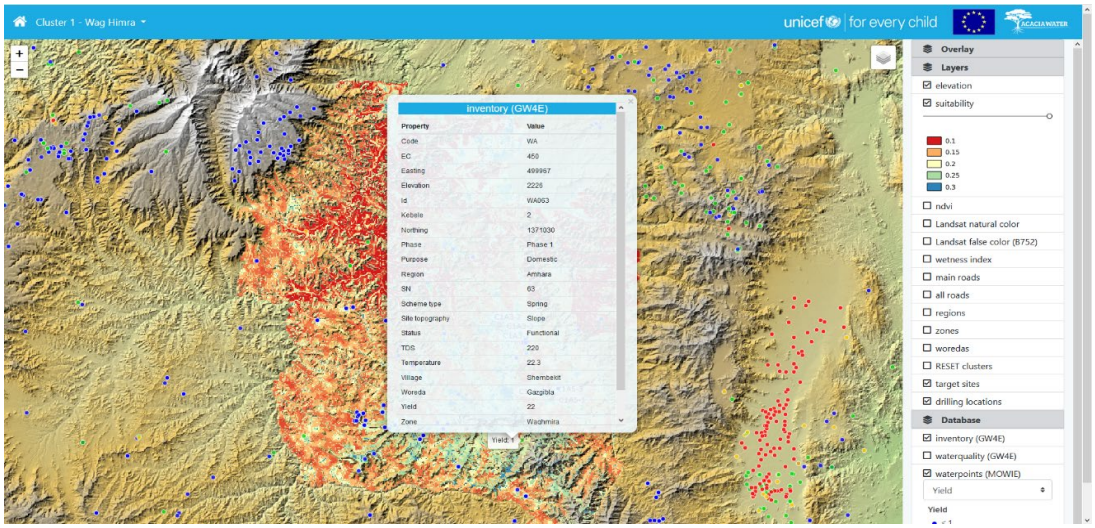


Figure 5 Document browser

Map viewer

The interactive map viewer lets the user open a map with a predefined set of layers. Map compositions are configured by the system administrator and stored in the backend. Only the configurations (compositions) are stored, the actual maps can be served from any OGC compliant webserver. For this project we will create a dedicated web service to serve the groundwater layers from the database, and specific project related layers such as satellite imagery and hydrogeological maps. A screenshot from the GWE4 site is show in Figure 6.

Figure 6 Map viewer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Id
WA093
Kebele
2
Northing
1371030
Phase
Phase 1
Purpose
Domestic
Region
Amhara
SN
63
Scheme type
Spring
Site topography
Slope
Status
Functional
TDS
220
Temperature
22.3
Village
Shembekit
Woreda
Gazipkia
Yield
22
Zone
Wadhmira
Yield: 1
Overlay
Layers
elevation
suitability
0.1
0.15
0.2
0.25
0.3
ndvi
Landsat natural color
Landsat false color (B752)
wetness index
main roads
all roads
regions
zones
woredas
RESET clusters
target sites
drilling locations
Database
inventory (GW4E)
waterquality (GW4E)
waterpoints (MOWIE)
Yield
Yield

Annex 1

Timeframe

LOT V	2021							2022		
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1. Phase I: Desk Study										
1.1 Assess and review the status and configuration of the existing NGDB										
1.2 Identify alternate sources of groundwater information										
1.2 Identify existing functional and non-functional components and system requirements										
1.3 Functional Design										
1.6 Draft Inception report										
1.7 Validation workshop										
1.8 Final Inception Report										
2. Phase II: System design and implementation										
2.1 Design and implementation of database stucture										
2.2 Design and implementation of front-end										
2.3 Design and implementation of validation protocol										
2.4 Migration and validation of available data										
2.5 Testing (unit, integration and system)										
2.6 User manual										
2.7 Release										
3. Phase III: Training and migration										
3.1 Training to BDA staff for the migration of existing information										
3.2 Data migration and support to BDA										
3.3 Final report										
3.4 Validation workshop and acceptance test										
3.5 Data and software transfer to BDA										

Annex 2

ENGWIS tables

HGA MOE-WWIS Data Model

waterloo hydrogeologic
A Schlumberger Company

Geologic Description

formation

PK,FK1,I1 PK,I1 PK,I1	**Station** **from_** **to_**
	mat1 mat2 mat3 description_ color pattern layer gscode

hydrogeology

PK,FK1 PK,I1 PK,I1	**Station** **from_** **to_**
	formation_type

Description

station

PK,I1	**ID**
	Type **Name** X Y Zone TAG Elevation TOC Depth Export

wwr

FK1	**Station** county muncip conreg conn lot owner compdate piezindic utmzone utmrc elevrc basinm testmeth pumprate pumpdurh pumpdurm staticlev pumplev prindic lev15 lev30 lev45 lev60 flowrate clr_cloud rec_set rec_rate spec_cap final_sta use_2nd use_1st drillmeth data_src contractor rec_date flowing date_contructed basin subbasin dp2br dpwell codeob remarks twncheck cadcheck watcheck dist abandoned date_received

Well Construction

drilling

PK,FK1,I1 PK,I1 PK,I1	**Station** **from_** **to_**
	drilling_method diam_

annular_fill

PK,FK1,I1 PK,I1 PK,I1	**Station** **from_** **to_**
	filling volume

screen

PK,FK1,I1 PK,I1	**Station** **screen_id**
	from_ to_ screen_material diam_ slot layer length depth

casing

PK,FK1,I1 PK,I1 PK,I1	**Station** **from_** **to_**
	material diam_ layer depth

Well History

plug

PK,FK1,I1 PK,I1 PK,I1	**Station** **from_** **to_**
	type layer date_

Monitoring Event

water

	sampling_date depth_ layer kind level_ remarks
FK2 FK2	Station screen_id

Annex 3

Groundwater Tables and Fields

Site information
- Site id
- Site Name
- Altename site name
- Site description
- Topographic setting
- Source of data
- Inventoried by
- Date inventoried

Location
- Latitude
- Longitude
- Method

Geographical subdivision
- Region
- Zone
- Woreda
- Kebele
- Village
- Mapsheet 250,000
- Mapsheet 50,000
- River basin

Borehole
- Type
- Depth
- Diameter
- Year of construction
- Water use
- Status
- Project
- Siting geologist
- Siting method
- Aquifer lithology
- Aquifer type
- Aquifer name
- Owner name
- Owner address
- Owner permission

Spring
- Pool altitude
- Altitude method
- Altitude accuracy
- Type
- Development
- Year developed
- Development possibility
- Rock type
- Permanence
- Protection
- Sanitairy condition

Water use
- Type of use
- Method
- Data source

Well construction
- Start
- End
- Supervisor
- Geologist

Drilling records
- Drilling
- Water struck
- Casing
- Packing
- Lithology

Development
- Start
- End
- Contractor
- Name
- Rig number
- Duration
- Pump description
- Pump capacity
- Pump depth
- Comment

Drilling records
- Top
- Bottom
- Start
- End
- Comment

Drilling
- Diameter
- Rock type
- Driller
- Method
- Rig number
- Bit numer
- Hammer number
- Drilling fluid

Water struck
- Yield
- Level

Casing/Screen
- Material
- Diameter
- Thickness
- Slot length
- Slot width

Packing
- Filling material
- Packing material
- Grain size
- Quantity

Lithology
- Lithology code
- Primary colour
- Secondary colour
- Texture
- Features
- Atrtribnutes
- Sorting
- Roundness

Aquifer test
- Test number
- Start
- End
- Duration
- Contractor
- Test type
- Comment
- Obs wells
- Test wells
- Safe yield
- Pump type
- Discharge method
- Pump depth
- Final water level
- Flow rate

Test results
- Date
- Transmissivity
- Conductivity
- Specific storage
- Storage coefficient

Water level/discharge records
- Date/time
- Level
- Discharge
- Temperature
- Conductivity
- Turbidity
- Appearance
- Comment

Discharge
- Discharge
- Discharge method
- Type of discharge
- Discharge measure by

Water level
- Level
- Held/cut
- Equipment id
- Method
- Well status
- Measuring point
- MP height
- Measured by

Pump information
- Number
- Contractor
- Supervisor
- Date installed
- Date removed
- Type
- Depth
- Power type
- Rating
- Horsepower
- Manufacturer
- Serial number
- Capacity

Well Logs
- Date
- Type
- Agency
- File name

Water sample
- Date/time
- Type
- Sampled by
- Agency
- Project
- Sample number
- Sample method
- Well depth
- Water level

Purging
- Well status
- Pumping rate
- Pump time
- Volume pumped
- Heigh of water
- Casing diameter
- Casing volume
- Volumes purged

Quality (field)
- Date/time
- Temperature
- Conductivity
- Oxygen demand
- pH
- Bicarbonate
- Carbonate
- Alkalinity
- Other

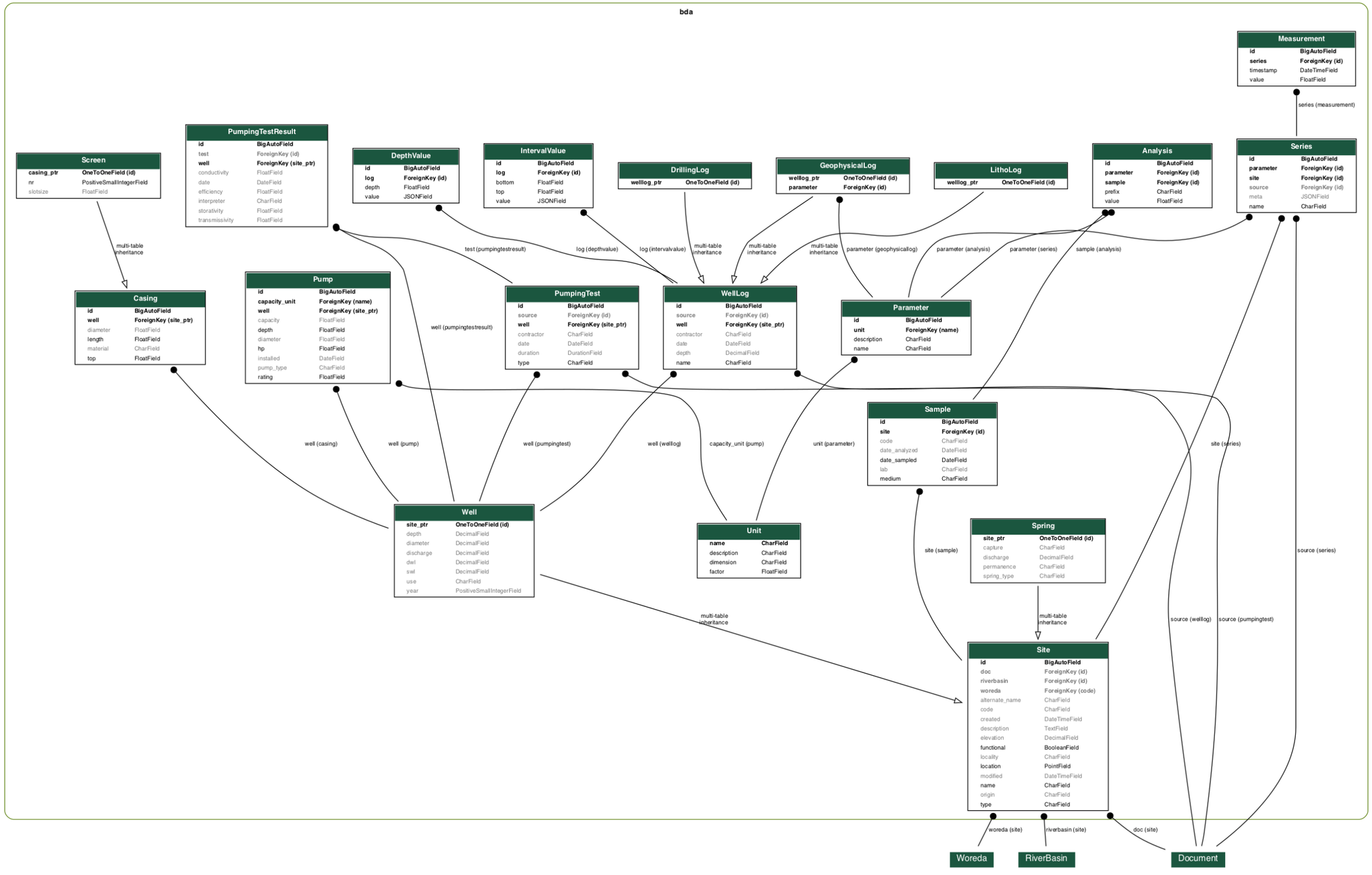
Sample bottle
- number
- type
- Filter size
- Bottle size
- Acid type
- Laboratry
- QA
- Remarks

Lab info
- Filtration
- Acidification
- Date of analysis

Analysis records
- Sample
- Code
- Result

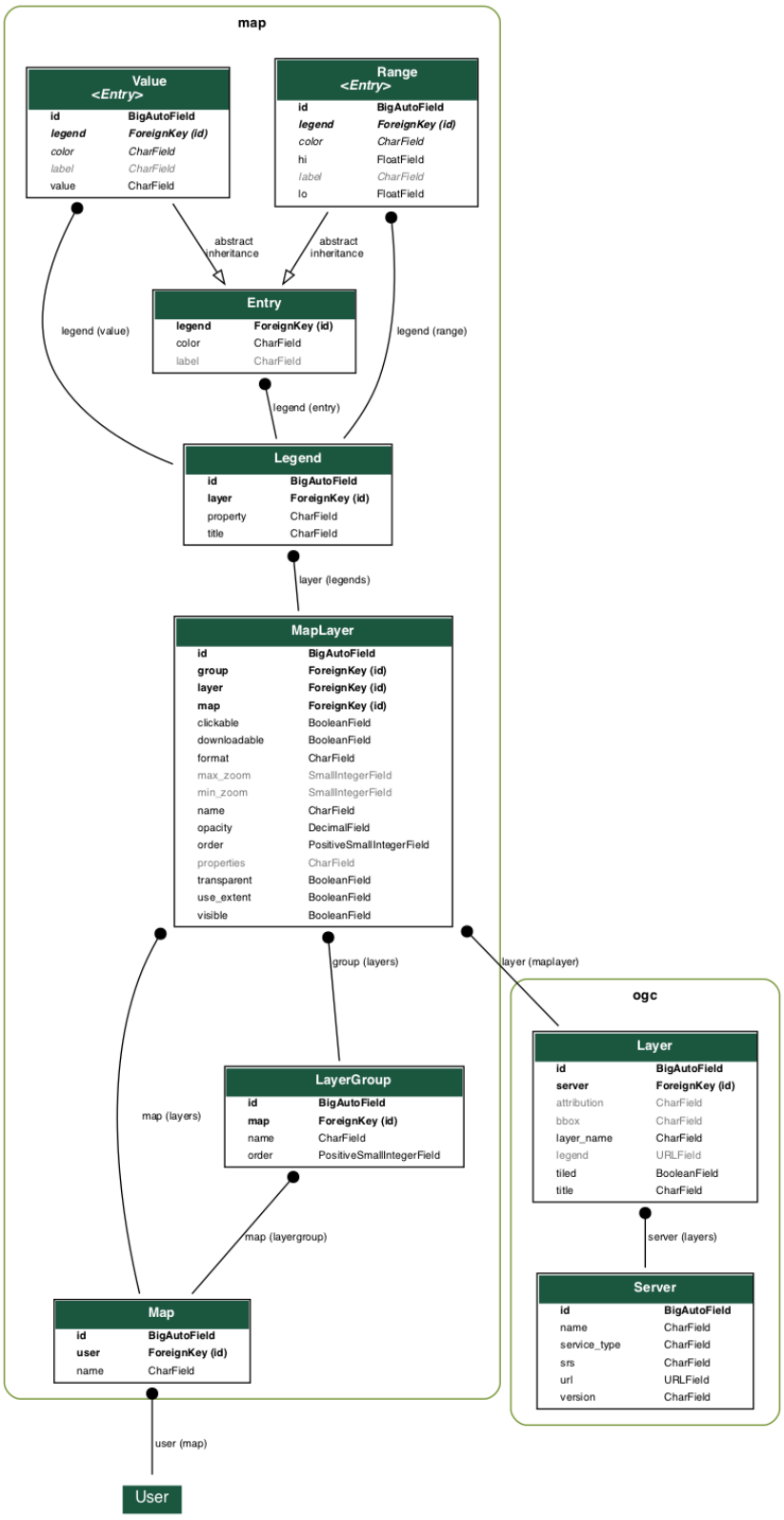
Annex 4a

Relationship diagrams for Groundwater



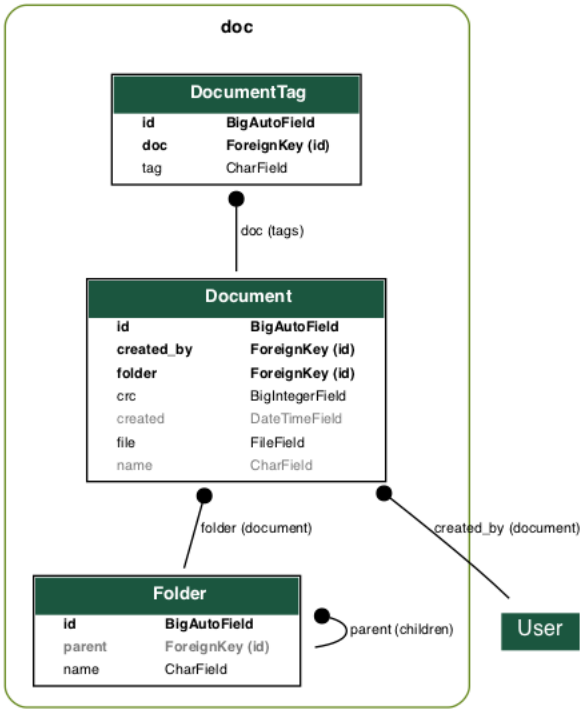
Annex 4b

Relationship diagram for Maps



Annex 4c

Relationship datagram for Documents



Van Hogendorpplein 4
2805 BM Gouda
The Netherlands

Tel: (+31)182 – 686424
www.acaciawater.com
info@acaciawater.com