The Mapping of Groundwater Resources Worldwide - A Summary of the Worldwide Hydrogeological and Assessment Programme (WHYMAP)

Dr. Willi Struckmeier
Director & Professor
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
(German Federal Institute for Geosciences and Natural Resources)

President
IAH = Largest int’l NGO for Groundwater
Groundwater, a Unique Resource

Global Freshwater Resources

Fresh Groundwater 30,1%

Lakes 0,26%

Rivers 0,0057%

Wetlands 0,033%

Soil Moisture 0,05%

Atmosphere 0,04%

Ice + Snow ( + Glaciers and Permafrost) 69,5%

How much Fresh Water is globally available?

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual renewable water resource</td>
<td>42.400 km³</td>
<td>WRI 2000</td>
</tr>
<tr>
<td>Mean annual runoff</td>
<td>42.000 km³</td>
<td>GRDC 2007</td>
</tr>
<tr>
<td>Mean annual recharge (groundwater)</td>
<td>12.700 km³</td>
<td>Döll &amp; Fiedler 2007</td>
</tr>
<tr>
<td>Water utilisation</td>
<td>4.000 km³</td>
<td>WRI 2000</td>
</tr>
</tbody>
</table>

But the total volume of groundwater stored in aquifer systems is estimated at 10,500,000 km³!
Regional distribution of global freshwater resources

Quelle: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and UNESCO (Paris), 1999.
Hydrogeological maps of continents
The World-wide Hydrogeological Mapping and Assessment Programme

( WHYMAP )

Key ideas

• From regional and continental to global
• Harmonised view of groundwater resources
• Contribution to World Heritage Programme
• Wall map, booklet and Web applications
• Create awareness about groundwater resources
WHYMAP
World-wide Hydrogeological Mapping & Assessment Programme

Main Players
since 2000

UNESCO
Water Sciences
IHP
Earth Sciences
IGCP

IAH
Council + Commissions
National Chapters
Regional Vice-Presidents

UNESCO
Water Sciences
IHP
Earth Sciences
IGCP

IAEA
Isotope Hydrology Section

COHYM
Commission on Hydrogeological Maps

CGMW
Continental Sub-commissions

+ others, e.g.
IGRAC, GRDC,
Universities etc

SC-HYM
Subcommission on Hydrogeological Maps
WHYMAP Network

Consortium
Steering Committee

WHYMAP executing unit

UNESCO regional offices

IHP National Committees

Isotope Hydrology Section

Petra Döll

GPCC    GRDC    IGRAC

Vice-Presidents (8 regions)

IAH Commissions

National Committees

CGMW regional Vice-Presidents

International programmes, organisations, institutions

Regional organisations, e.g. OSS, SADC, OAS ..

Individual freelance contributors
groundwater resources maps
1/50 M & 1/25 M

WHYMAP GIS

Web-Mapping application for visualisation/distribution of WHYMAP data & information pool on hydrogeological mapping

explanatory notes / booklet

small sketch-maps for publications, ...

interactive CD-ROM
Layers (initial list)

Topographical information
Boundaries of rock units
Nature of aquifers / lithology
GW Flow direction
Transboundary aquifers
Recharge to groundwater
Hydrogeologic structure (3D)
GW Potential
GW Quality
Withdrawal / Abstraction centres
Vulnerabilities
Mean annual groundwater recharge

Quelle: Döll et al., 2003
Overlay of Hydrogeological Environments (WHYMAP)
and Recharge from WaterGAP (Döll et al.)
Aquifer Types of North America
- 61% high gw recharge
- 26% medium gw recharge
- 7% low gw recharge
- 1% area with complex hydrogeological structure
- 1% area with local and shallow aquifers

Aquifer Types of Europe
- 20% high gw recharge
- 36% medium gw recharge
- 18% low gw recharge
- 13% area with complex hydrogeological structure
- 1% area with local and shallow aquifers

Aquifer Types of South America
- 44% high gw recharge
- 18% medium gw recharge
- 25% low gw recharge
- 11% area with complex hydrogeological structure
- 1% area with local and shallow aquifers

Aquifer Types of Africa
- 50% high gw recharge
- 26% medium gw recharge
- 12% low gw recharge
- 5% area with complex hydrogeological structure
- 5% area with local and shallow aquifers

Aquifer Types of Australia
- 32% high gw recharge
- 40% medium gw recharge
- 1% low gw recharge
- 27% area with complex hydrogeological structure
- 0% area with local and shallow aquifers

Percentages...
The world’s largest aquifer systems
Great Artesian Basin, Australia

Nubian Sandstone Aquifer System, NE-Africa
Extent of surface water basins (catchments) and underlying groundwater aquifers may differ substantially. 

Management areas to be adjusted = GW management challenge.
Opportunities for drinking water from groundwater resources:

- many spots scattered all over Africa

= GW, a local resource
Increasing demand for water supply

- Population
- Economic and social development
- Irrigated agriculture

**Figure 5: Increase of water consumption according to sectors (after UNEP 2003)**

Agriculture is worldwide the biggest single consumer of water, followed by industry and homes. Although considerable efforts have already been made to reduce the water consumption of the latter, there are still many possibilities to further reduce the consumption by the agricultural irrigation technologies. Particular concern is caused by the increasing use of non-renewed groundwater for the irrigation of marginal sites in arid zones.
Groundwater Abstraction and Main Use

Source: Jean Margat: Les Eaux Souterraines, une richesse mondiale (UNESCO, under publication)
Ramon Llamas: Irrigation with GW significantly more efficient than Surface Water (30-50% productivity increase)
World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)

Groundwater is the largest accessible and often still untapped freshwater reservoir on earth. Its world-wide resources are assessed at 10.5 km³. The increasing number of regional water shortages and water crises can only be met with a rational and sustainable use of this resource. Such sustainable use requires understanding and knowledge, as well as careful planning and management. Yet, information on the major resource is still weak in many places.

In order to provide data and information about the major groundwater resources of the world and their important contribution to their reasonable management and protection, the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) was launched in 2000.

The programme, based on data on groundwater from national, regional and global sources, aims to visualise them in maps, web map applications and services. The generated products provide information on quantity, quality and vulnerability of the groundwater resources on earth and help communicating groundwater related issues to water experts as well as decision makers and the general public.
Map applications and services

- **WHYMAP web map application**

- **WHYMAP web map service**

- **WHYMAP in Google Earth**
WHYMAP - World-wide Hydrogeological Mapping and Assessment Programme

Web Map Application

The Web Map Application aims at visualizing hydrogeological information collected within the WHYMAP project at a global scale. For more regional or country level interest additional information on available hydrogeological maps is provided. Please visit the project homepage for more details on WHYMAP.

Reference

Country boundaries are not visible at global scale but become visible if zooming in. Zoom limit is set to a scale of 1 : 7 500 000.

Link to the WHYMAP Web Map Service (WMS).
http://www.bgr.de/service/groundwater/whymap/

The WHYMAP can also be accessed with Google Earth.
Please download whymap.kml and open the file with Google Earth.

Web map applications cannot be fully accessible to people with disabilities. If you need support on interpreting the map content please contact us.

Contact:

Project coordination
Dr. Wilhelm Struckmeier & Andrea Richts
E-Mail: whymap@bgr.de

Web application
Patrick Clos
E-Mail: patrick.clos@bgr.de

© UNESCO & BGR
WHYMIS, World-wide Hydrogeological Map Information System

Philippines

Map no. 1

Title: Groundwater Resources, in: Environmental and Natural Resources Atlas of the Philippines
Scale: 1 : 5 500 000
Year: 1998
Publisher: Center for Environmental Geomatics, Manila Observatory & Department of Environment and Natural Resources, Quezon City

Legend
- Provincial Boundary

Groundwater Resources
- Rocks without Any Known Significant Groundwater
- Rocks with Limited Potential, Low to Moderate Permeability
- Local and Less Productive Aquifers
- Fairly to Less Extensive and Productive Aquifers with Low to Moderate Potential Recharge
- Fairly Extensive and Productive Aquifers
- Extensive and Highly Productive Aquifers
- Lake

Scale 1:5,500,000
Geographic Coordinate System
Projection
Map no. 2

Title: Groundwater Availability Map of the Philippines
Scale: 1 : 2 500 000
Year: 1985
Publisher: Bureau of Mines and Geo-Sciences, Ministry of Natural Resources, Manila
Legend: Legend

EXPLANATION

1. ROCKS IN WHICH FINE IS DOMINANTLY INTERCALATED

2. ROCKS IN WHICH FINE IS DOMINANTLY THROUGH FRACTURES AND THE SOLUTION OPENINGS

3. LOW POTENTIAL AREAS WITH LOW POTENTIAL REGIONS

4. HIGH POTENTIAL AREAS WITH HIGH POTENTIAL REGIONS

5. HIGH POTENTIAL AREAS WITH HIGH POTENTIAL REGIONS

GROUNDWATER AVAILABILITY MAP OF THE PHILIPPINES

SCALE 1:2,500,000
EXPLANATION

I. ROCKS IN WHICH FLOW IS DOMINANTLY INTERGRANULAR

(A) EXTENSIVE AND HIGHLY PRODUCTIVE AQUIFERS—With an average potential recharge of 0.5 to 1 meter, greater near influent rives, with known production well yields mostly between 50 to 100 L/s but as high as 300 L/s at some sites. High to very high permeability.

Quaternary thick unconsolidated sand and gravel aquifers in flood plains, alluvial fans, terrace and beach deposits.

Pliocene, Pleistocene and Recent pyroclastics dominated by tuff with ash and cinder deposits mostly at the apices of volcanic centers. Known springs on strong as 30 L/s.

Pliocene to Pleistocene marine and terrigeneous sediments of interbedded shale, siltstone and conglomerate with thick unconsolidated sand and/or gravel layer as the main aquifer.

(B) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS—With an average annual potential recharge of 0.3 to 0.8 meters, greater near influent rives, with known production well yields mostly about 20 L/s but as high as 60 L/s in some sites. Moderate to high permeability.

Quaternary unconsolidated sand and gravel in flood plains, alluvial fans and terrace deposits.

Pliocene, Pleistocene and Recent pyroclastics dominated by tuffs with ash and cinder deposits mostly at the apices of volcanic centers. Strong springs reported.

Pliocene to Pleistocene sediments, both marine and terrigeneous includes water-laid pyroclastics and localized terrigeneous deposits. Known springs strong as 600 L/s in Calamba, Laguna.

(C) LOCAL AND LESS PRODUCTIVE AQUIFERS—Well yields mostly about 2 L/s but as high as 20 L/s in some sites. Very low to moderate permeability.

Quaternary coastal aquifers whose yields are restricted by sea water intrusion and mixed aquifers that are restricted by low storage due to limited aquifer area and/or thickness, or to recharge potential due to thick clay cover.

Pliocene to Pleistocene semi-consolidated to unconsolidated sediments, both marine and terrigeneous includes water-laid pyroclastics and localized terrigeneous deposits. Well yields mostly within 0.3 to 7 L/s. Aquifers usually have limited thickness.

Upper Miocene to Pliocene sediments and volcanics, mainly sandstone, shale, some conglomerates, coal measures, and marine andesitic and basaltic pyroclastics. Known well yields mostly 2 L/s for the younger rocks and less than 0.01 to 0.6 L/s for the older rocks with a few production well yields of less than 10 to 30 L/s pumped from the Baguio City Aquifer.

II. ROCKS IN WHICH FLOW IS DOMINANTLY THROUGH FRACTURES AND/OR SOLUTION OPENINGS:

(A) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS WITH HIGH POTENTIAL RECHARGE

Quaternary lava flows at the peripheries of volcanic center areas; highly fractured and with known production well yields of mostly 5 to 15 L/s and spring yields of up to 60 L/s.

Pliocene to Pliocene carbonate limestone, bedded to massive but highly karstic with known production well yields of mostly 5 to 15 L/s but as high as 30 L/s in areas.
WHYMIS, World-wide Hydrogeological Map Information System

Spain

Map no. 1

Title: Mapa Hidrogeológico de España y de Unidades Hidrogeológicas
Scale: 1 : 1 000 000
Year: 2000
Publisher: Instituto Tecnológico Geominero de España (IGME), Madrid
Internet: [http://www.igme.es](http://www.igme.es)
Legend: [Legend](http://www.igme.es/internet/ServiciosMapas/siasweb/i_sias_general.asp)
The IAH Facts & Fig’s Project
Rationale and Major Challenges

- findings/calculations of last 40 years not considered
- GW in storage much higher than renewed/recharged GW
- average recharge available (WaterGAP/Petra Doell)
- bulk of GW reserves stored in large GW aquifer systems/basins = 'giant GW deposits'
- GW reserves not addressed/quantified, but more and more GW withdrawn from reserves (largely unnoticed, and increasingly for irrigation)
- IAH has the expertise and potential to come up with rough figs about GW resources (renewed/in storage) and withdrawals (depletion of reserves...?)