7
CHAPTER

Conclusions and Recommendations

7.1 Conclusions

The project started with the objective to develop a deep aquifer database comprising all available lithological and water quality data on the deep aquifer of the country. Because of number of constraints, it was not possible to gather all the deep aquifer information in the country. However, most of the information lying with DPHE has been accumulated into the first ever deep aquifer database of the country which contains about 2500 thousand geological logs and more 2000 wells information with water quality parameters.

Data quality has been one of the most limiting factors for the study and this is true for both lithological and water quality data. Most lithological data from the DPHE sources are not properly described with all relevant information, even some data may have been "manufactured". It is therefore very important that whenever a well is drilled, particularly a deep one (~150 m or more) a proper geological record should be kept. The field bore log has to be supplemented by preserving sediment samples at least for a certain percentage of wells drilled. Water quality data are also not very reliable, due mainly to two factors: precision of the analysis and influence on the regional laboratories by the drillers to meet the standard values, particularly for arsenic. At least a certain percentage of the water samples should be tested at a reliable laboratory outside DPHE.

The deep aquifer mapping and water quality evaluation exercise with the available data has been carried out. As sufficient data from other sources are not available, it was not possible to verify the data. So the outcome of the project should be considered with certain amount of uncertainly.

The project started with piles of paper records without accompanying maps. One of the major achievements of the project is to acquire geographical coordinates for all the logs included in the database and it is now possible to produce maps on regional to local scale. These maps can be used as guides for future deep aquifer exploration. In general, as always have been known, there are considerable amount of deep aquifer information available from the south and very limited or no information from the north. However, there are number of uncertainties associated with available data, particularly water quality data. Good number of quality controlled data would help to filter out the uncertain data and thus to produce reliable deep aquifer map. As generation of primary data was not part of the TOR, we were not able to collect any field borelog data under the project.

Use of specialized software for data storage, visualization, preparation of sections, maps, etc. is another highlight of the project. RockWorks 2004 is one of the best software available currently for hydrogeological data management. It has various different options which can be used for planning purposes. However, there are certain limitations of the software. Like many other software, this one also works based on statistical averages and for this, small scale or local variability may not be identified. To overcome this problems a combination of software generated outputs and manually drawn sections can be used. The preparation of manual section can be based on the logs plotted along the section line by the software. If computer and manual skills are combined, the output would become more robust and useful and can address the issues of local scale variability.

By compiling this preliminary deep aquifer database and producing series of maps and sections, we are not in a position to claim that a lot has been done in way to understand the deep aquifer of the country. This exercise further emphasizes the urgent need for a proper evaluation of deep aquifer of the country. The Deep aquifer is becoming more and more important for providing safe water supply. The increase is abstraction from the deep aquifer is going on without knowing the sustainability of the supply: both qualitatively and qualitatively. Already we have created, may be inadvertently, many problems for the shallow groundwater resources of the country. We should not do the same for the deep aquifer as this kind of ultimate frontier for water supply of the country; we need to protect the deep aquifer for the coming generations. In order to protect the deep aquifer we need to understand the geology, hydrogeology, hydraulics, geochemistry of the deep aquifer.

The importance of deep aquifer investigations have been highlighted by various studies in the past, we have not done much until to date on a wider scale. However, there are good localized studies that can help in designing large-scale studies. It is very important that all information on deep aquifer is combined together and put in such a way that everyone can access it. Creation of the deep aquifer database is one small step towards that direction and DPHE should carry this forward by proper management of this database. To continue this training is needed from the field level to the manager level on aspects like data recording, sample collection, sample descriptions, preparation of proper borelogs, data interpretation, data storage and management. A partnership between DPHE and other relevant organization would be a much better way of doing this.

7.2 Recommendations

7.1 Standard Log Format for DPHE

Proper recoding of lithologs is vital for any mapping exercise. As there is no consistent way of describing the lithologs within the DPHE, the existing records lack may vita information. A standard log format is very important for DPHE to overcome the existing difficulties of lithological records. This log format would make the records consistent and more useful by keeping all necessary information on location, water quality, well/exploratory hole, well fixtures, lithologies, sediment color etc. Figure 7.1 present the proposed log header and 7.2 presents the standard log format designed by the study group.

GPS Readings:	Water Quality:	Lab Name: FK	Project name:	
Longitude:	Sampling Date:		Drilling No:	
Latitude:	Sampled By:		Name of Contractor:	
ID No (Mouza Geocode):	EC:	µS/cm	Name of Driller:	
District:	pH:		Drilling started:	
Upazila:	As:	mg/L	Drilling ended:	
Union/Pauroshava:	Cl:	mg/L	Installation started:	
Mouza/Ward:	Fe:	mg/L	Installation ended:	
Village/Mahalla:	Mn:	mg/L	Drilling Method:	
Location:	Well Fixtures:	m / ft	Drilling Diameter:	inch / mm
Owner/Caretaker:	GI Pipe:	m	Drilling Depth:	m / ft
Supervisor:	PVC Pipe:	m	Well Depth:	m / ft
Sample checked by:	Screen (Filter):	m	Screen (Filter) Depth:	m / ft
Lithological Samples Collected Yes / No	Sand Trap:	m	Well Diameter:	inch / mm

Lithology symbols

Clay	1	
Silt	2	
Silty clay	3	
Sandy clay	4	
Very fine sand	5	
Fine sand	6	
Fine to medium sand	7	
Medium sand	8	
Medium to coarse sand	9	
Coarse sand	10	
Coarse sand with gravel	11	
Gravel	12	

Colour codes

Grey	1	
Bluish grey	2	
Dark Grey	3	
Balck	4	
White	5	
Off white	6	
Yellow	7	
Light brown	8	
Yellwosih brown	9	
Reddish brown	10	
Red	11	
Greenish Grey	12	

Figure 7.1: Log header, lithology and color codes for DPHE standard log format

Format for Geological Log Records of DPHE

GPS Readings:	Water Quality:	Lab Name: /FK	Project name:
Longitude:	Sampling Date:		Drilling No:
Latitude:	Sampled By:		Name of Contractor:
ID No (Mouza Geocode):	EC:	µS/cm	Name of Driller:
District:	pH:		Drilling started:
Upazila:	As:	mg/L	Drilling ended:
Union/Pauroshava:	Cl:	mg/L	Installation started:
Mouza/Ward:	Fe:	mg/L	Installation ended:
Village/Mahalla:	Mn:	mg/L	Drilling Method:
Location:	Well Fixtures:		Drilling Diameter: inch/mm
Owner/Caretaker:	GI Pipe:	m/ft	Drilling Depth: m/ft
Supervisor:	PVC Pipe:	m/ft	Well Depth: m/ft
Sample checked by:	Screen (Filter):	m/ft	Screen (Filter) Depth: m/ft
Lithological Samples Collected: Yes/No	Sand Trap:	m/ft	Well Diameter: inch/mm

Lithological Descriptions

Depth m / ft From	To	Lithological Symbol	Color	Geological Age or Hydrogeo-logical Unit	Description	Well structure	Lithology:	
							Clay	1
							Silt	2
							Silty clay	3
							Sandy clay	4
							Very fine sand	5
							Fine sand	6
							Fine to medium sand	7
							Medium sand	8
							Medium to coarse sand	9
							Coarse sand	10
							Coarse sand with gravel	11
							Gravel	12
							Color Helps:	
							Grey	1
							Bluish grey	2
							Dark Grey	3
							Black	4
							White	5
							Off white	6
							Yellow	7
							Light brown	8
							Yellowish brown	9
							Reddish brown	10
							Red	11
							Greenish Grey	12

Figure 7.2: Proposed Standard Log Format for DPHE

7.2 Recording and Preservation of Lithologs at DPHE

It is very important that DPHE keep rerecord of all deep drilling in the forms of geological borelogs. The standard format proposed in this study can be used for this purpose. DPHE can also serve as the nodal point for the deep aquifer database.

7.3 Deep Aquifer Definition

Deep aquifer can be defined in number of different ways. For the practical purpose there should not be any depth assigned to the definition of deep aquifer. The depth and type of deep aquifer would depend on the local geology and should be defined accordingly.

7.4 Deep Aquifer Database

The study has developed a database containing about 2500 borelogs. This database can be further developed by addition of deep borelogs from various sources. This database can be linked with the National water Resources Database so that one can easily access the information on lithology and water quality of deep aquifers. Provisions can be made for all other organizations such as BWDB, BADC, GSB, Dhaka-WASA and IWM to contribute to this database.

7.5 Preliminary Deep Aquifer Maps for the Southern Bangladesh

It was planned to produce a number of national scale map showing the depth and thickness of the deep aquifer. However, the lack of uniform data coverage does not allow producing such maps. Regional scale and district and Upazila scale maps produced in this work demonstrates the usefulness of the RockWorks 2004 in producing hydrostratigraphic sections and hydrostratigraphic models. This type of outputs can be used for planning purpose. It has also been demonstrated by the mapping exercise in Chandpur Sadar Upazila that if the sub-surface is homogenous, the numbers of borelogs do not influence the mapping exercise substantially. However, this can be an important issue in case of the Upazilas where there is remarkable lateral variability in the aquifer disposition within the Upazila. This can be the case of Upazilas which extend over more than one geological unit or located in the areas characterized by fluvial sediments deposited by meandering rivers.

7.6 Deep Aquifer WQ Issues

Water quality is of prime importance in terms of usefulness of the deep aquifer. There are good amount of data available on the four quality parameters, i.e. Arsenic, Iron, Chloride and Manganese. All the available analyses were made at the DPHE zonal laboratories. There are concerns about the accuracy o the data. In addition, there are some unusual trends found in the data. A large number of the deep tube wells are found to have arsenic above the WHO provisional limit. This is unusual if compared with the results of the BGS & DPHE (2001) National Hydro chemical Survey data. The study reported that most of the deep tube wells had arsenic well below the WHO limit. About 100 such deep tube wells have been sampled under this project and the samples to have been analyzed for Arsenic at the Environmental Engineering BUET Laboratory. The analytical results show that in general deep tubewell groundwater is low in arsenic where 85% samples comply with the WHO provisional guideline value and only 5% exceeded the Bangladesh standard. A large proportion of samples reported by the DPHE Zonal Laboratories to have arsenic in between 10 and 50 ug/L found not exist under this study.

7.7 Need for Deep Aquifer Investigations

One of the major objectives set in the TOR of this study is to recommend use of deep aquifer. Lack of data over most of the country does not allow making any recommendation regarding the use of deep groundwater. There are big gaps in the current understanding of the deep aquifer of the country in term of geology, hydrogeology, water quality and hydraulic properties. It is therefore very important to undertake a systematic deep groundwater investigation project in the country. In the MPO report in 1986 it was mentioned that lack of necessary data did not allow estimation of deep groundwater resources of the country. No major headway has been made in this direction in last 20 years although the strategic importance of the deep aquifer has increased significantly due to detection of arsenic in shallow groundwater over large areas of the country.

Comprehensive understanding the deep aquifer needs application of geophysical, hydrogeological, hydrogeochemical, isotopic and groundwater modeling techniques. An integrated study can answer some of the key questions like rate and amount of recharge to the deep aquifer; age of deep groundwater; sustainability of deep aquifer. The deep aquifer may include some trans-boundary groundwater as it is likely that recharge areas for some of the deep aquifers of Bangladesh may lie outside the political boundary of the country.

7.8 Wise use of deep groundwater

Deep groundwater is one of the main sources safe water in many parts of the country. Abstractions by hand pumps may not have a large impact of the resource and hydraulic equilibrium of the aquifers. As soon as large production wells start abstracting larger amount of water, the situation is bound to change. Until and unless a comprehensive deep groundwater investigation has been carried out, the deep groundwater should be used with utmost care. Cautious use of groundwater should be advocated by DPHE and all other relevant organizations. Protection of this strategic natural resource is very important to ensure sufficient good quality water for the future generations.

7.9 Protection of Deep Groundwater

To ensure wise use of deep groundwater, a regulatory framework needs to be introduced to protect the deep aquifer from over-exploitation. It is particularly important as there will be increasingly more pressure on the abstraction of deep groundwater to start with domestic uses. If the planned rural pipeline systems are put in place, it will create opportunities for the investors to sell water to small businesses or industries in the catchments of the piped supply. There should be strict regulation in place to protect the deep aquifer groundwater. Awareness should be created among the stakeholder regarding the value and strategic importance of the deep groundwater.

7.10 Deep Aquifer Monitoring Network

Currently there are thousands of water level monitoring wells run by Ground Water Circle of BWDB, DPHE and BADC. However, all these water level monitoring stations record the water level of the upper aquifer only. No water level monitoring is going on at the deeper aquifers. As DPHE has already conducted a survey of groundwater at various depths at more than 50 growth centre of the country covering various hydrogeological provinces, it is possible to convert one set of three test tube wells from each growth centre into a nest of piezometers. This can be done in coordination with BWDB and can be included in the already existing national network for monitoring weekly water level and periodic water quality. Before starting of the data recording following needs to be done:

- Recording GPS location and preparation of an accurate map of all the selected locations;
- A check on the depth of the test tube wells;

- Full development of the wells if clogged;
- Protection of the well heads by putting concrete slabs around each piezometer and barbed wire fencing surrounding all the piezometers;
- Necessary repair of the wells and adding a screw cap for each well to prevent throwing of stones or any other materials;
- Determination of the reference level (RL) of each piezometer;
- Installation of auto-recorders in a selected number of nests in coordination with BADC and BWDB.