STOCKHOLM ENVIRONMENT INSTITUTE

FACT SHEET

Groundwater Monitoring in Bangalore, India

Country/Region:	Bangalore, India
Application:	Groundwater monitoring well logs
Users:	Public or private entities, decision-makers

Introduction

In Bangalore (*Bengaluru*), India, monitoring wells could generate data on groundwater quantity and quality necessary for adaptive management. Approximately half of the city's inhabitants depend on a decreasing supply of groundwater, demonstrating the need for well-designed monitoring programs. This fact sheet outlines the requirements of a monitoring program, the challenges and opportunities for well monitoring in Bangalore, and the policy implications of collecting hydrogeologic data.

Well Log Information

A monitoring program needs, at minimum, geochemical and hydrologic data. Once a thorough understanding of a site's hydrogeology is established, sampling frequency and completeness requirements will determine the size of an intended data set. Monitoring programs should generate data which serve two goals: detection, and assessment. Detection and assessment data sets should accommodate chemical and hydrologic parameters, including water level and hydraulic conductivity. See Figure 2 for a sample well log.

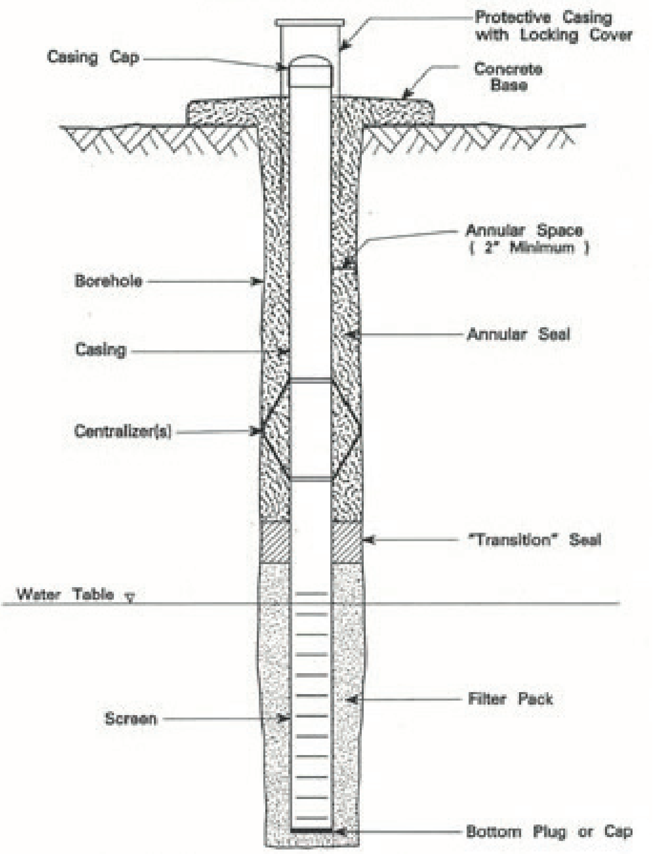


Figure 1: Schematic of typical monitoring well
Source: California Department of Water Resources

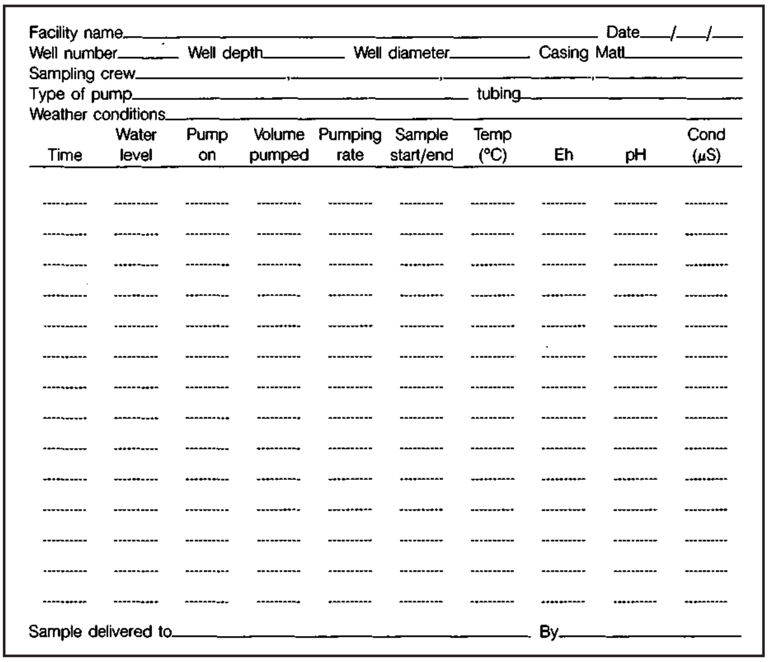
P. Giriraj, a research field team member from the Indian Institute of Science, measures water levels from an abandoned borewell in south-west Bangalore.

Measuring Groundwater Depth and Quality

The most common water level measuring devices are steel tapes, electric drop lines, and pressure transducers. Mechanical float recorders, dippers, and data loggers provide continuous or real time water level measurement, but they tend to be more expensive than manual methods. Water quality programs should include sampling plans that specify the objectives of the program, parameters to be analyzed, location identifier, frequency of sample collection, sampling protocol and analysis methodology. Devices to measure water quality include bailers, syringe samplers, suction-lift (vacuum) pumps, gas-drive samplers, bladder pumps, gear-drive submersible pumps, helical rotor submersible pumps, and gas-driven devices. Singhal et al. (2009) provides a sample of associated device costs.

Hydrogeologic Settings and Monitoring Well Design

Monitoring systems must account for hydrogeologic characteristics. Important characteristics include the type of aquifer (e.g. confined or unconfined, mobility of water, texture and underlying lithology).


Facility name __________ Date __/__/__
Well number ______ Well depth ______ Well diameter ______ Casing Matl ______
Sampling crew __________
Type of pump __________ tubing __________
Weather conditions __________

Time	Water level	Pump on	Volume pumped	Pumping rate	Sample start/end	Temp (°C)	Eh	pH	Cond (µS)

Sample delivered to __________ By __________

Figure 2: Logbooks document the steps and information involved in sample collection.
Logs sometimes include additional information such as the presence of immiscible layers, parameters requested for analysis, and types of sample bottles used. Source: Illinois State Water Survey's Practical Guide for Ground-water Sampling

Bangalore's hard-rock aquifers exhibit high spatial variability in hydraulic conductivity and specific yield. The portions of its aquifers that are deeper – with fractured fresh rock – have very low hydraulic conductivity, while shallower portions, or 'weathered zones,' have slightly enhanced conductivity. This inherent variability has made it difficult to accurately map groundwater levels, and it must be accounted for when determining well location.

Well design should account for the well depth, well diameter, screen size, and grouts and seals. In determining well depth, officials should consider the hydrogeology of the site and the goals of the monitoring program. For instance, depth might be contingent on monitoring goals such as water levels versus flow direction. Screen length should ideally be as short as possible so that water level data will represent depth-discrete information. Seals should be accurately applied to ensure that monitoring samples are uncompromised.

Challenges and Opportunities for Monitoring in Bangalore

Challenges:

- Lack of institutional capacity for generating data on the number of private unregulated wells, the aquifer depth, and the city's precise total water demand
- Unmapped, low yielding fractures
- Insufficient number and density of monitoring wells

Opportunities:

- Domestic and irrigation wells provide an opportunity to monitor groundwater though crowdsourcing approaches – and at high density and spatial resolution – since there may be as many as 500,000 private wells in Bangalore alone.
- High frequency, hourly data offer the potential to remedy equipment malfunctions and more accurately model groundwater hydrology.

Policy Implications

- Comprehensive monitoring allows decision-makers to more accurately adjust regulatory water pricing schemes – and correct for issues such as overdraft – in critically depleted groundwater zones.
- Monitoring helps identify principal water users. This allows decision-makers to better prioritize need-based allocation.
- Monitoring can help track the effectiveness of policies that impact groundwater scarcity, such as rainwater harvesting or water reclamation practices.

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