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Water Supply Exploration and Development; Six Village Pilot Programme Hambantota District Sri Lanka

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A water supply exploration and development programme was undertaken for the Ministry of Urban Development & Water Supply- Rural Water Supply and Sanitation Division within Hambantota District, Sri Lanka in late 2005 through early 2006. The objective of the programme was to identify potable supplies of groundwater to serve 3,090 households or 13,677 people within six villages (Bedigantota, Mahapelessa, Weniwalara, Alloluara, Viharagala and Beddewewa West). The exploration area lies east of the Walawe Ganga, south of Allolu Ara and north of the Mahaweligada Ara between 6° 16' 60" Latitude N; 80° 56' 62" Longitude E and 6° 14' 31" Latitude N 80° 57' 11" Longitude E). The area is considered to be within the "dry zone" of Sri Lanka underlain by granitic rocks of the Vijayan complex. Annual rainfall is about 1050 mm, falling mainly during the monsoon months from December through February. Temperatures vary between 32^0 C in the warmer months (May through August) and 23^0 C in the cooler months. Average annual potential evapotranspiration is on the order of 1450 mm, and annual groundwater recharge is on the order of 100 mm. Exploration techniques used to locate potable supplies of groundwater included fracture lineament analysis using remote sensing platforms (satellite and aerial photography), area reconnaissance, mapping and well inventory, vertical electrical geophysical soundings, test well drilling, aquifer pumping tests and water quality analysis. The exploration programme successfully identified areas of potable groundwater within the study area for community development.

Background

In September 2005, the Sri Lanka Ministry of Urban Development & Water Supply initiated a Solar Powered Community Water Supply Pilot Project within Hambantota District. The pilot programme encompassed an area of approximately 30 square kilometers (km^2) within the following six villages:

- Bedigantota
- Mahapelessa
- Weniwalara
- Alloluara
- Viharagala
- Beddewewa West

There are about 3,090 households with a combined population of 13,677 in the project area. The daily water demand for the Project Area is projected to be on the order of 1,200 cubic meters per day (88 liters per person per day), for domestic water usage.

Project Area Overview - Physiographic Conditions

The Project Area lies about 8 km south of the town of Embilipitiya and 7 km north of Angunakolapelessa within Hambantota District. The area is considered as the "dry zone" of Sri Lanka. Mean annual rainfall (**de Silva 1999**) is on the order of 1041 to 1397 mm with most of the rainfall occurring during the monsoon months from December through February. Average monthly temperatures in the Project Area range from about 32 degree Celsius (C^o) during the warmer months (May through August) to 23 C^o during the monsoon season. The mean annual pan evaporation **(de Silva 1999)** is on the order of 1729 to 1868 mm.

Land use in the Project Area is primarily agriculture. The topography is gently sloping from the northeast toward the west-southwest. Ground surface elevations range from 60 meters above mean sea level (m-amsl) to 30 m-amsl. Population density is about 456 people per km^2 concentrated in six villages. Agricultural fields lie predominantly along the fringes of village housing clusters and the predominant crops are banana and rice.

There are three principal drainage streams (Aras) within the Project Area **(Figure 1)**:

1. The Walawe Ganga,
1 The Mahaweligada Ara, and
2 The Allolu Ara

The Walawe Ganga is a perennial river flowing from north to south along the western Project Area boundary. The Walawe Ganga is 138 km in length, with a catchment area of about 2,471 km^2 that lies north-northeast of the Project Area.

The Mahaweligada Ara forms the south-southwestern boundary of the Project Area flowing from northeast to southwest where it joins the Walawe Ganga at the southwestern edge of the Project Area. The Allolu Ara flows through the northern portion of the Project Area, through the villages of Alloluara and Weniwalara, where it joins the Walawe Ganga. Both of these stream drainages originate within the Project Area.

Apart from these three main streams, all other tributary streams within the Project Area are minor-intermittent stream drainages and flow only during and for some time after the monsoon season. Surface runoff from these minor drainages in the Project Area is captured by village reservoirs ("tanks"), built within low-lying areas and across these small intermittent drainages. This captured rainfall runoff is then distributed to the rice and banana fields through an extensive and intricate network of irrigation canals.

Geology

The Project Area is predominantly underlain by Precambrian-age metamorphic bedrock of the Vijayan Complex consisting of massive, granitic-biotite gneiss. Also, garnet-biotite gneiss bedrock of the Highland Complex are located along a northwest-southeast trending thrust zone where the rocks of the Highland Complex have been thrust over those of the Vijayan Complex. This structural contact lies parallel with and slightly east of the Walawe Ganga. The structural trend of the bedrock in the Project Area is northwest to southeast and dip is to the southwest (Sri Lanka Geology; Map Sheet 20, 2001).

In addition to the thrust zone, fracture-lineaments (zones of weakness in the bedrock) and two shear zones are present within the Project Area. The lineaments are shown on the published geologic map and were also identified from an analysis of satellite imagery and aerial photographs for the Project Area.

A relatively thin layer of residual soil on the uppermost layer of the bedrock consists of sandy clay, and clayey sand. In addition to the bedrock, there are minor alluvial deposits along the three major stream drainages. The thickest of these deposits are found within the Weniwalara area along the eastern bank of the Walawe Ganga, and to the south along the western bank of this stream outside of the Project Area.

Hydrogeology

The massive, metamorphic granitic rocks in the Project Area have very little primary porosity or permeability. Weathering of these rocks produces a regolith (weathered zone) that is thickest along structural lineaments. Additionally, these lineaments are zones of secondary permeability and were found to be areas of enhanced aquifer yield. The thickness of the weathered zone in the Project Area is on the order of 5 to 20 meters and is being utilized for potable supply with hand dug wells that are on the order of 2 to 6 meters in depth.

Given the soil and rock type within the Project Area and the high evapotranspiration rate, groundwater recharge is low. Using a soil-water balance method, **de Silva (1999)** estimated annual groundwater recharge of 90 to 330 mm/year (8.5 to 24 percent of rainfall), for Angunakolapelessa and Embilipitiya, respectively. Seepage from irrigation tanks and unlined irrigation canals, also serves to locally enhance recharge to the underlying weathered-zone aquifers.

Exploration Programme

An analysis of remote sensing platforms using both satellite imagery and aerial photographs was conducted for the Project Area. The primary objective of the analysis was to identify lineaments within the bedrock on a regional as well as local scale. Aerial photographs were purchased in stereo pair from the Sri Lanka Geographical Survey Department, as were topographic and geologic maps for the Project Area.

Additionally, an inventory was made of 77 wells (65 hand dug and 12 tube wells), and 11 surface water sampling locations throughout the Project Area. Well inventory information included well depth, static water level, and field-measured water quality parameters (temperature, electrical conductivity (E.C.) and pH).

Ground geophysical surveys consisting of 61 vertical electrical soundings (VES) were conducted throughout the Project Area. An Integrated Geo-Instrument resistivity meter with a Wenner electrode arrangement was used to conduct these soundings to a maximum investigation depth of 100 meters. Map coordinates of each sounding location were collected using GPS and plotted onto a project base map.

The Project Area VES were concentrated along geologic structural features (i.e. fracture lineaments) identified during the remote sensing analysis. From an interpretation of the VES data, locations were selected for test well drilling. Test wells were drilled at locations showing the thickest alluvium, weathered and/or fractured zones with the potential for relative higher aquifer yield and acceptable water quality.

Nine test wells were drilled within the six-village Project Area. In addition to the nine test well locations, two hand augured boreholes were installed for the specific intention of measuring the surficial-aquifer water level and water quality, along the eastern bank of the Walawe Ganga in Weniwalara and Bedigantota. The test well information are summarized on Table 1.

Table 1. Summary of Project Drilled Test Wells

Test Well	Depth drilled (meters)	Static Water Level (meters)	Yield Estimated during Drilling (Lpm)	Field Measured E.C. (uS)
VES2-08	15	3	200	8400
VES-1-08	13	~1	13	>9600
VES3-09	61	+0.5	65	4500
VES3-02	33.5	3	100	1523
VES-A-02A	9	3	241	420
VES-C-04A	35.05	4	24	969
VES-C-03	21.24	1	60	480
VES-E-05	27	1.5	24	240
VES-4-03/04 (Road Junction)	13.4	6	50	840
Hand Augured Well-Weniwalara	6	5	NA	3190
Hand Augured Well - Bedigantota	4	3.5	NA	1400

LPM = Litres per minute
E.C. = Electrical Conductivity in microsiemens.

Figure 1. Project Area.

Photographs 1 and 2. Project Drilled Well.

Aquifer pumping tests were conducted on six of the nine Project Wells that showed acceptable water quality. The World Health Organization (WHO) guidance value of 1000 parts per million (ppm) was used as a Project Criterion for total dissolved solids (TDS) concentration. This TDS concentration equates to a field-measured electrical conductivity value of about 1,500 uS.

Plots of water-level drawdown versus time and recovery (residual drawdown) were developed and aquifer hydraulic parameters were calculated. Aquifer transmissivity derived from these tests are summarized on Table 2.

Table 2. Aquifer Transmissivity Derived from Pumping Tests.

Well	Pumping Rate (Lpm)	Aquifer Transmissivity (m^2/day) Pumping Phase	Aquifer Transmissivity (m^2/day) Recovery Phase
VES-A-02A	220	83	77
VES-3-02	71	14	22
VES-C-04A	15	1.5	1
VES-E-05	21	2.2	2.7
VES-C-03	65	10	19
VES-4-03/04	25	2.5	2.6

Findings

The findings of the exploration programme showed:

- Brackish groundwater is common throughout the Project Area, mostly along the lower elevations along and proximate to the stream drainages.

- A relatively thin lens of fresh-potable water (< 30 meters in thickness) exists mainly within the higher elevations of the Project Area above an elevation of about 50 meters amsl.

- Relatively greater aquifer transmissivity and well yields are associated with fractured and weathered zones within the bedrock as shown by the well yields encountered at Wells A-02A, 3-02, and C-03.

- Annual aquifer recharge (~100 mm) within the Project Area is low in comparison to annual rainfall (1050 mm), due to the low permeable nature of the rock, combined with a high potential evapotranspiration rate (1450 mm).

- Current water demand for the Project Area (88 Lpd/person) is about 15 percent of annual recharge for the Project Area.

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