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भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

PARTS OF SOUTH ANDAMAN DISTRICTS, ANDAMAN & NICOBAR ISLANDS

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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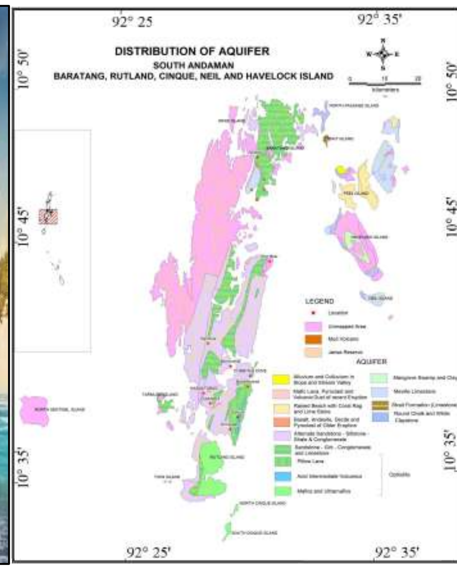
Report
On

NATIONAL AQUIFER MAPPING & MANAGEMENT PLAN

In

Parts of South Andaman Districts, Andaman and Nicobar Islands



Central Ground Water Board

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FOREWORD

To understand the nature and occurrences of groundwater, aquifer geometry, aquifer disposition & characteristics, and management of groundwater resource, National Aquifer Mapping & Management Programme (NAQUIM) has been taken up by CGWB under XIIth Plan. During the Annual Action Plan 2018-2019, Aquifer Mapping studies & Management plan was taken up in South Andaman District, Andaman and Nicobar Island.

The study under the aegis of NAQUIM includes four major components namely; Data generation, Data collection & compilation and preparation of Aquifer maps and Aquifer Management Plan.

This report is presented in two parts, where Part-I embodies general report of the study area, Part-II includes Island wise Management Plans for the district. Relevant data in respect of the said subjects have been collected from different departments and their publications, viz. Andaman Public Work, A & N Island, Directorate of Economics & Statistics, Land & Land Reforms Dept., A & N Islands, Data of Indian Meteorological Dept., National Bureau of Soil Survey & Land Use Planning, etc. of Govt. of India, have also been used. Hydro-geological data is sourced from the scientific studies of CGWB pertaining to groundwater explorations, hydrogeological surveys, and chemical analysis of water samples.

Compilation of this report, evaluation of data and preparation of relevant maps, 2D cross-sections & 3D models of aquifers and their reproduction in the form of present report is the outcome of the effort given by Sh. Awadhesh Kumar, Senior Technical Assistant (Hydrogeology), under the supervision of Sh. Amlanjyoti Kar, Scientist-D (Supdt. Hydrogeologist) & Mrs Sandhya Yadav, Scientist-D (OIC NAQUIM). The section pertaining to Hydrochemistry has been contributed by Sh. Rinkumoni Barman, Senior Technical Assistant (Chemistry), and his effort is thankfully acknowledged.

Effective method of dissemination of the existing technical information to different user agencies is an important aspect of NAQUIM, which plays a very vital role in the safe and optimal development of groundwater resources in our country. In this regard, Central Ground Water Board has taken up great initiative in incorporating NAQUIM project since 2012 to fulfill this directive. It is much anticipated that, this report will become an important tool not only for various user agencies, Engineers, Scientists, Administrators, Planners and others involved in groundwater planning, development and management but also to the common people to make them aware of local groundwater issues and its sustainable management.

(Dr S. K. Samanta)
Regional Director

EXECUTIVE SUMMARY

The study area falls under South Andaman district, which is one of the 3 districts of the Union Territory of Andaman & Nicobar Islands located in the Bay of Bengal. The district of South Andaman comprises three Tehsils Portblair, Ferrarganj and Little Andaman. Portblair is the district head quarter and capital of the Union Territory. The area Shaheed Dweep and Swaraj Dweep is underlain mainly by Coralline limestone which is basically resting on claystone. The latter forming the basement also outcrops as small hills in pockets. Because of high permeability coralline limestone form good aquifer, while the basement does not contain fresh water because of less permeability & Transmissivity. The freshwater is negligible in the basement, and consequently brackish/ saline water is also found in the formation.

In South Andaman Island, in the marine sedimentaries, the shallow aquifer is restricted up to maximum depth of 15 m but do not form good aquifer. In the deeper horizon potential aquifers are available in this geological formation in restricted patches. In Ophiolites the thickness of weathered horizon ranges from 0.5 to 10 mtrs and aquifer potential is moderate, whereas the deeper fracture continues up to 100-120 m and borewells may yield up to the tune of 50,000 to 2,50,000 m^3/ day. Springs are found to be highly potential in this formation in compression to the marine sedimentary group of rocks.

In Little Andaman Island, the island is underlain by coralline formation and limestone and it is continuing from ground level to the basement, occurring at 40 -50 m depth, where solution cavities from the pathway for downward movements of groundwater. However, during disaster like earthquake ground water availability scenario may change drastically as seen after 2004 earthquake. It was observed that the ground water in many dugwell perished, and water in dams disappeared.

Since, many hotels are mushrooming in the islands like Shaheed Dweep and Swaraj Dweep, to meet the ongoing demand of water both for tourism and agriculture, recharge practice should be made mandatory, for the hotels as also in each household Rain Water Harvesting should be in practice and made mandatory. Apart from Rooftop Rainwater Harvesting emphasis should be given to harvest optimum quantity of rainwater in streams

through check dams & ponds and in depression. The natural lakes and estuaries should be rejuvenated for larger availability of fresh water & sustainable fresh water ecology.

In South Andaman, district from ground water exploration and hydrogeological survey it is revealed that large scale ground water development is not possible in this marine sedimentary geological formation. However, the special study by CGWB has revealed that good amount of water can be conserved in pockets, through sub surfaces Dam/Dyke. Simultaneously, CGWB has put forward guidelines for conservation of Rainwater through series of check dam in stream valleys and Rainwater Harvesting through construction of ponds as also through rooftop RWH. The master plan for ArtificialRecharge-2020 for A & N Island, prepared by CGWB elaborates guidelines and methodologies to be adopted for recharge to ground water and sustainable management of ground water resource. In view of large scale ground water development from Ophiolite aquifer artificial recharge practice should be made mandatory. Central Ground Water Board studies as revealed occurrence of perennial spring sources in nearby Rutland Island. Till date the spring water is coming to Portblair through ships and barges. The project of implementation of inter Island transfer of spring water should be implemented at the earliest for better management of water supply to Portblair.

In Little Andaman Island**,** as such the water scarcity is not as precarious as it is seen in case of South Andaman Island. Detailed study by CGWB as revealed that there are perennial spring fed streams available in the island, which the water may be diverted to the inhabited water scarce villages i.e. Hutbay, Netaji Nagar, Ramakrishnapur, Ravindranagar, and Vivekanandpur. This may solve the apparent water scarcity both for irrigation and drinking.

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PART-I

REPORT ON AQUIFER MAPPING STUDIES AND MANAGEMENT PLAN

IN PARTS OF SOUTH ANDAMAN DISTRICT, ANDAMAN & NICOBAR ISLANDS

CHAPTER-1

1. INTRODUCTION

In XII Five Year Plan, National Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation in the scale of 1:50,000. NAQUIM has been prioritised to study Over-exploited, Critical and Semi-Critical Talukas /Islands, as well as the other stress areas recommended by the State Govt. Aquifer mapping is a process, wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulation mechanism, has rendered detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "traditional groundwater development concept" to "modern groundwater management concept". Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the "Road Map" for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal of ground water management through community participation. The aquifer maps and management plans in parts of South Andaman district will be shared with the administration of Union Territory of Andaman & Nicobar Islands, India for its effective implementation.

1.1 Objective and Issues

The broad objective of the study is to establish the geometry of the underlying aquifer systems in horizontal and vertical domain and characterize them, so as to work out the development potential and prepare aquifer wise management plan with respect to issues concerned i.e. (i) Water scarcity in the Islands, (ii) Post-tsunami changes on quantity and Quality of groundwater resources, (iii) Salinity as well as Iron contaminations within the available limited aquifers, (iv) Groundwater management under the influence of large scale tourism activities, and (v) Rejuvenation of springs as the major source of groundwater.

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major components of the activities, viz. (i) data collection / compilation (ii) Data Gap Analysis (iii) Data Generation, and (iv) Preparation of aquifer maps and management plan to achieve the primary objective. Data compilation included collection, and wherever required procurement, of all maps from concern agencies, such as the Survey of India, Geological Survey of India, State Governments etc. computerization and analysis of all acquired data, and preparation of a knowledge based data base. Identification of Data Gap included ascertaining requirement of further data generation in respect of Hydrogeological, Geophysical, Chemical, Hydrological, Hydro-meteorological studies, etc. Data generation includes those of hydrometeorology, chemical quality of groundwater, litho-logs and aquifer parameters. Generation of groundwater chemical quality data was accomplished by collection of water samples and their laboratory analyses for all major parameters, and some of the heavy metals. Additional data pertaining to sub-surface lithology and aquifer parameters were obtained through drilling of additional exploratory wells and slim holes, pumping tests at drilling sites. As per the revised Annual Action Plan, groundwater management studies in parts of South Andaman district (Neil Island, Havelock Island, Rutland Island, Little Andaman Island and parts of South Andaman Island) covering an area of 800 square kilometres was taken up by Central Ground Water Board (CGWB), Eastern Region, Kolkata. In this report the salient features of aquifer geometry, characteristics, ground water occurrences, availability, and resource vis-a-vis quality, development & management scope of ground water has been covered.

1.3 Approach and Methodology

A stepwise approach and methodology adopted to achieve the major objective has been shown below.

i) Compilation of existing data.

ii) Identification of data gap.

iii) Data generation based on data gap.

iv) Preparation of thematic maps in GIS platform.

v) Preparation of Rock-works Software based 2D sections & 3D models of aquifer disposition.

vi) Compilation of Island wise Aquifer Maps and Management Plan.

1.4 Location, Extent and Accessibility of the study area

The South Andaman district lies between 11^0 and 12^0North latitude and between 92^0 and 94^0 East longitudes covering an area of 2672 Sq. Kms. The district consists of three tehsils viz. Ferrargunj, Port Blair and Little Andaman comprising 108 inhabited and 20 uninhabited villages. South Andaman district is located almost in the central part of the Union Territory of Andaman & Nicobar Islands, and it is separated from North-Middle Andaman district by Middle Strait and Nicobar district by 10^0 channels in Indian Ocean. The district of South

Andaman **(Figure-1.4.1)** comprises one subdivision, three blocks/Tehsils and a Zila Parishad. Port Blair is the district and Sub divisional Head quarter of South Andaman. It is also the capital town of the Union Territory of Andaman & Nicobar Islands. Port Blair is well connected with the major cities of Indian mainland like Kolkata, Chennai and Visakhapattanam (Vizag) by sea routes, while Chennai, Kolkata and New Delhi are connected to Port Blair by daily air services. Recently another direct air service from New Delhi to Port Blair via Bhubaneswar has been introduced. Besides this, the capital of the Union Territory is connected to other islands by inter island ships, Helicopter services maintained by Pawan Hans. Recently, sea plane service is introduced which fly in the islands of North-Middle and South Andaman districts.

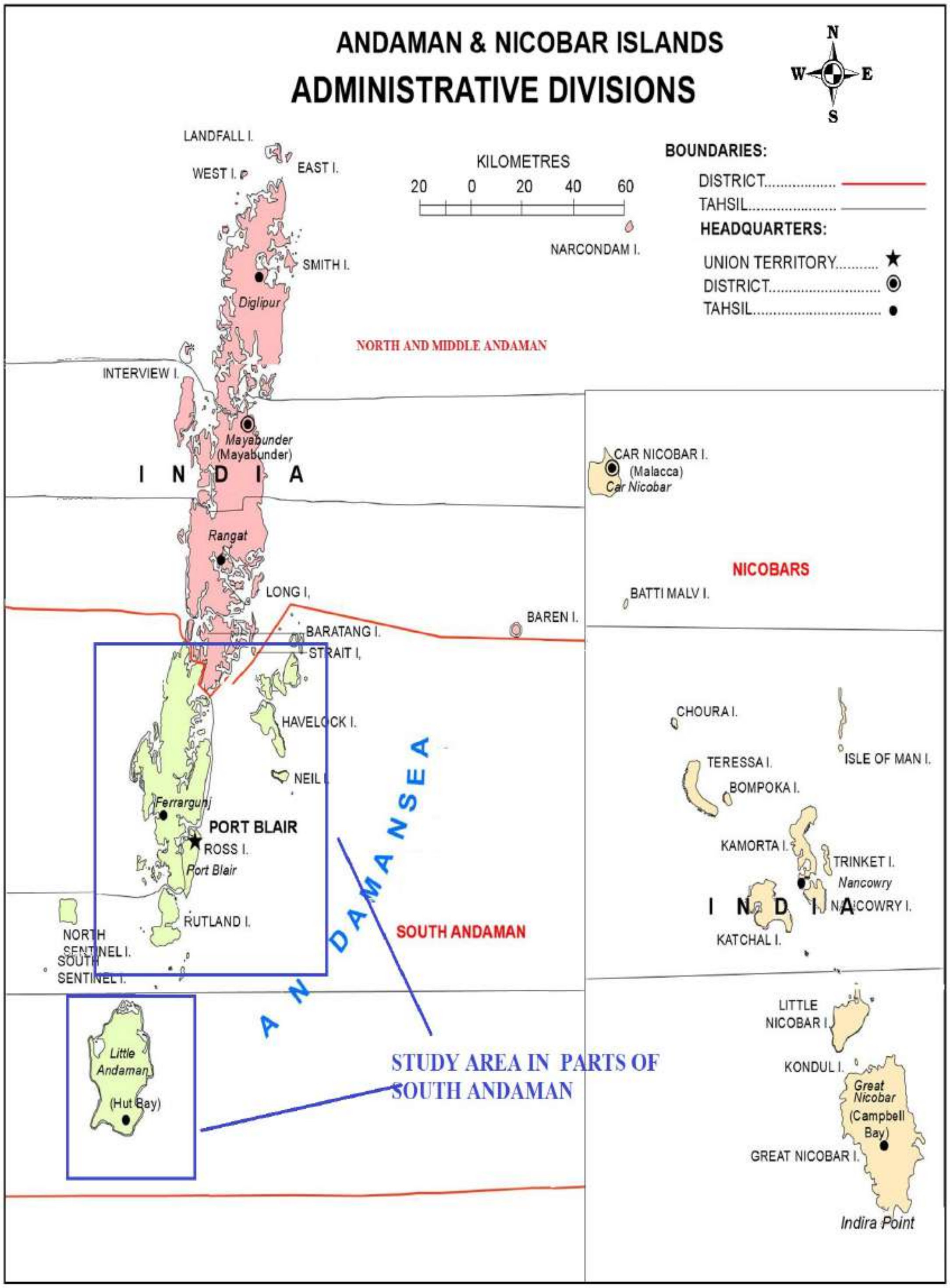


Figure-1.4.1 Location and Administrative Map of South Andaman district, Andaman & Nicobar Islands

1.5 Administrative divisions and population

As per 2011 census, population of South Andaman district is 2,37,586 in which, male population is 1,26,804 and female population is 1,10,782. The population density is 80 per sq. km. Total population of primitive tribes in the district is 2600, which comprises Jarawa (in South Andaman Island), Ongi (in Little Andaman), Great Andamanese (in Strait island) and Sentinels (in Sentinel island).

Table-1.5.1: Population Inhabited Island in South Andaman

UT/ District/Tehsil / Island	Total/Rural/Urban	Population	Scheduled Tribe	Tribe Household
South Andaman District	**Total**	**238142**	**4091**	**59064**
	Rural	97395	2286	23767
	Urban	140747	1805	35297
Port Blair Tehsil	**Total**	**165754**	**2104**	**41473**
	Rural	32969	368	8083
	Urban	132785	1736	33390
Havelock Island	Rural	6315	21	1641
Neil Island	Rural	3040	3	735
South Andaman Island (Part)	**Total**	**156037**	**2064**	**38968**
	Rural	23252	328	5578
	Urban	132785	1736	33390
Ferrargunj Tehsil	**Total**	**53565**	**489**	**12498**
	Rural	45603	420	10591
	Urban	7962	69	1907
South Andaman Island (Part)	**Total**	**53560**	**489**	**12496**
	Rural	45598	420	10589
	Urban	7962	69	1907
Rutland Island	Rural	347	1	119
Little Andaman Tehsil	**Total**	**18823**	**1498**	**5093**
Little Andaman Island	Rural	18823	1498	5093

Source: Directorates of Economics & Statistics Andaman & Nicobar Administration Census (2011)

1.6 Land use, Irrigation and Cropping pattern

Forest covers a major part of the district. Since inception of the colonial British Raj, the forests in and around Port Blair and in parts of South Andaman island were cut to make room for establishments for Penal settlement and agriculture. After fifties there had been considerable loss of forestry for settlement of the refugees from East Pakistan now Bangladesh in South Andaman, Neil, Havelock and Little Andaman islands of the South Andaman district. Gradually, the land use for settlement has been increased in the past few decades because of exodus of people from all over main land in search of livelihood. The low lying lands, mostly under utilisation for settlement and agriculture, were submerged under sea water due to the subsidence of many parts of South Andaman island after the mega earthquake (M=9.3) on 26.12.2004. The land use of South Andaman district is enumerated below (**Table-1.6.1**).

Table-1.6.1: Land use in South Andaman District

Item	Land use in Sq. Km. (as in 2012)
Total Geographical Area	3106.00
Reporting Area for land utilization	2814.32
Forest area	2694.00
Not available for Cultivation	27.29
Other uncultivated land excluding follow Land	28.41
Current fallow	3.43
Fallow lands other than current fallows	13.21
Net area sown	69.03
Area sown more than once	2.47
Area submerged after Post-tsunami	12.79

Source: Department of Economics and Statistics, Andaman & Nicobar Administration.

Agriculture is the mainstay of people in the district although the islands are not self dependent in matters of production of food grains. For this reason, the needful commodities are imported from the mainland. Tsunami and earthquake made a colossal impact on agriculture. Ministry of Agriculture, Govt. of India had taken up Rajiv Gandhi Rehabilitation project for agriculture for helping the affected people and rejuvenation of their agricultural practice. Agriculture is mostly rain fed. In the South Andaman district, agriculture is pivoting on ground water irrigation especially in Neil, Havelock and Little Andaman islands. In these islands vegetables are extensively grown. However, in the current decade irrigation facilities are created tapping groundwater and surface water sources. This has enabled the production of vegetables as also other crops in good quantity. Island wise cropping pattern is presented in **Table-1.6.2**.

Table- 1.6.2 Island wise cropping pattern in South Andaman District

S. N.	Island	Type of Crop
1	**Neil**	Paddy, pulses, oilseeds, vegetables, coconut, arecanut, fruits, spices
2	**Havelock**	Paddy, pulses, oilseeds, vegetables, coconut, arecanut, fruits, root crops
3	**Little Andaman**	Paddy, Red oil palm, vegetables, coconut, arecanut, fruits
4	**Rutland**	Paddy, vegetables, coconut, arecanut, ginger, sugarcane
5	**South Andaman**	Paddy, vegetables, coconut, arecanut, fruits, spices, sugarcane

Source: Department of Economics and Statistics, Andaman & Nicobar Administration.

1.7 Urban areas, Industries and Mining activities

Tehsils of South Andaman District: South Andaman district consists of three tehsils viz., Port Blair, Ferrargunj and Little Andaman.

Ferrargunj Tehsil: Ferrargunj Tehsil comprises of 62 inhabited and 14 uninhabited villages spread over in two Islands viz., South Andaman (Part) and Flat Bay. It also consists of Bambooflat area under Ferrargunj Tehsil, which has been treated as Census Town.

Port Blair Tehsil: Port Blair tehsil consists of 30 inhabited and 3 uninhabited villages spread over in the Islands of South Andaman (Part), Havelock, Neil, Rutland and North Sentinel. The lone statutory town of Port Blair which is the seat of the Andaman & Nicobar Administration is also located in this tehsil and is divided into 18 wards. Apart from this, Garacharma Village has the status of Census Town since 2001. Prothrapur village has also been given the status of Census Town during 2011 Census.

Little Andaman Tehsil: Prior to 2006, it was treated as a part of erstwhile Port Blair tehsil. Little Andaman was declared a separate tehsil by the Andaman & Nicobar Administration vide its Notification No.148/2006 F.No.3-195/2002LSG(Rev) dated 17th August, 2006 with all geographical area comprising of the revenue villages, tribal villages and all the islands falling between 10 degree channel to 11 degree 5' North Latitude and 94 degree 20' to 92 degree East Longitude. Little Andaman Tehsil consists of 16 inhabited and 3 uninhabited villages and is situated around 104 Kms away from the main South Andaman Islands. Hut Bay is the headquarters of Little Andaman.

Inhabited Islands of South Andaman District: - There are 7 inhabited islands in South Andaman district which are as follows (1) South Andaman Island (2) Flat Bay Island (3) Havelock Island (4) Neil Island (5) Rutland Island (6) North Sentinel Island (7) Little Andaman Island The South Andaman Island is the most populated island in the South Andaman district, which is divided into two parts, each falling in Ferrarganj and Port Blair Tehsils respectively. The Flat Bay Island is least populated. The Viper, Cinque and John Lawrence Islands, which were inhabited in 2001 Census became uninhabited during the last decade, as no population was reported in 2011 Census.

Tourism in Andaman and Nicobar Islands is increasing due to popularity of beaches and adventure sports like snorkelling and sea walking.

1.8 Data gap Analysis-Existing Data Base

Because of small areal extent the data gap analysis as it is done in several districts of mainland, analysis cannot be followed in Island. However, depending upon the data availability the data adequacy and data inadequacy has been assorted. The major part of the Island >90% is covered by dense forest hence, the mapable area is inhabited by people and agricultural land are limited. Because of problem in transportation and non availability of suitable drilling Rigs and vendors, since the beginning of ground water exploration both through construction of tube well & geophysical prospective was not carried out in Andaman & Nicobar Islands.

Data gap is based upon the availability of data in several habitations. Data availability pertains to exploration project of CGWB during 1984-90 (Banarjee et.al.) and continues studies undertaken by officers of CGWB S. Banarjee (1997-98), A. Kar (2002-2007, 2011-2014 & 2016-2018) and geophysical studies carried out by S.K Adhikari (2004-2006), A.K Sinha (2017-18).

CHAPTER 2

CLIMATE

2.1 Rainfall:

Rainfall is received through South-West and North-East monsoons from May to December. Average annual rainfall in these Islands is about 3000 mm, while the normal annual rainfall at Port Blair is 3180 mm. The islands in South Andaman district enjoy tropical humid climate because of their location in the equatorial zone surrounded by the Andaman Sea. The islands have only two season's viz. Rainy Season and Summer Season. Winter is virtually absent. The mean relative humidity is 79%.

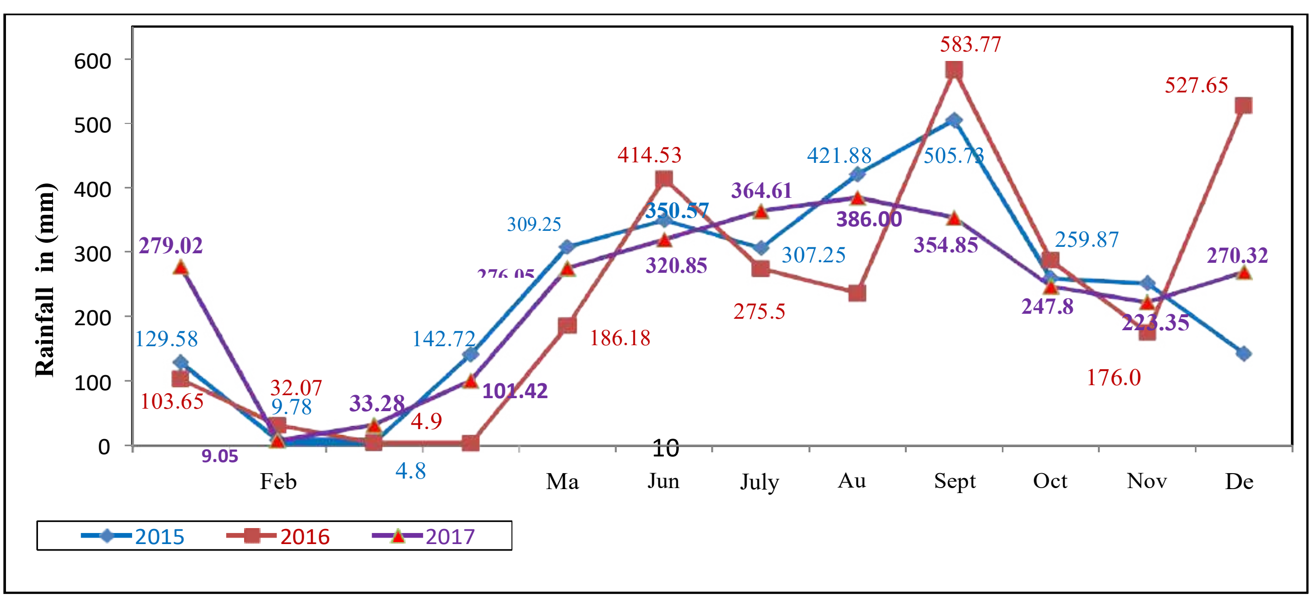
Table-2.1.1 Average rainfall of Andaman & Nicobar Islands

Comparative Statement showing average(total) rainfall (mm) of A&N Islands of last three years								
Month	2015		2016		2017		% Variation in monthly Rainfall of 2017 from 2016	% Variation in cumulative Rainfall of 2017 from 2016
	Monthly	Cumulative	Monthly	Cumulative	Monthl	Cumulative		
January	129.58	129.58	103.65	103.65	279.02	279.02	(+)169.19	(+)169.19
February	9.78	139.36	32.07	135.72	9.05	288.07	(-)71.78	(+)112.25
March	4.80	144.16	4.90	140.62	33.28	321.35	(+)579.18	(+)128.52
April	142.72	286.88	3.37	143.99	101.42	422.77	(+)2909.5	(+)193.61
May	309.25	596.13	186.18	330.17	276.05	698.82	(+) 32.55	(+)111.65
June	350.57	946.70	414.53	744.70	320.85	1019.67	(-)22.59	(+)36.92
July	307.25	1253.95	275.50	1020.20	364.61	1384.28	(+)32.34	(+)38.40
August	421.88	1675.83	237.15	1257.35	386.00	1770.28	(+)62.76	(+)40.79
September	505.73	2181.56	583.77	1841.12	354.85	2125.13	(-)39.21	(+)15.42
October	259.87	2441.43	288.42	2129.54	247.8	2372.93	(-)14.08	(+)11.42
November	252.73	2694.16	176.00	2305.54	223.35	2596.28	(+)26.90	(+)12.61
December	142.97	2837.13	527.65	2833.19	270.32	2866.60	(-)48.77	(+)1.18

- Minimum   - Maximum

Source: Department of Economics and Statistics, Andaman & Nicobar Administration

Figure-2.1.1 Monthly Rainfall in Andaman & Nicobar Islands during 2015, 2016 and 2017



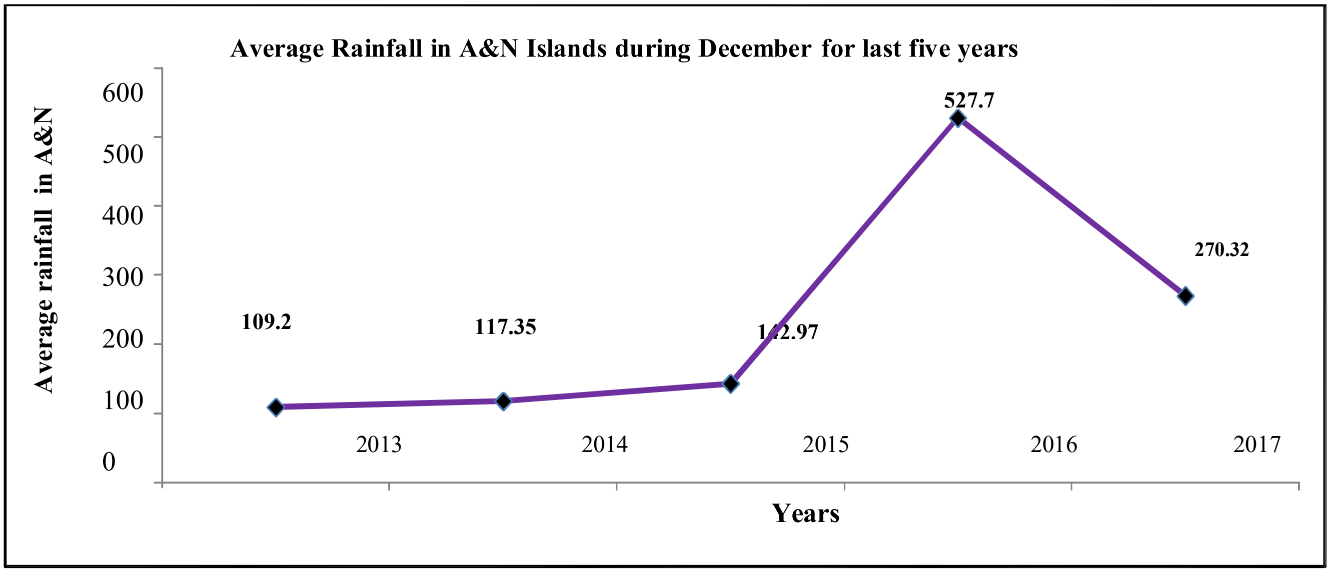


Figure-2.1.2: Average rainfall in Andaman & Nicobar Islands during December (2013-2017)

2.2 Temperature:

The mean maximum temperature is 30.2°C and means minimum temperature is 23.8°C. The relative humidity varies from 79% to 89% and wind speed varies from 7 km/hr. to 10 km/hr. The maximum and minimum temperatures in the islands fluctuate between 27 to 33^{0C} and 21 to 25^{0C}. Daily evaporation rate in the island is fairly high, which cumulatively ranges from 1500 - 1800 mm per annum. The geographical location is responsible for high average evaporation rate to the tune of 1500 - 1800 mm per annum. Climatic aberration is responsible for the availability of surface water and ground water in the islands. In few years in the past decade i.e. in 2008 and 2017 the situation was so worsened that the Andaman and Nicobar administration had to curtail the water supply in Port Blair and it was supplied only once in a week. The Dhanikhari Dam, which is the backbone of water supply to Port Blair, was almost dried up during the years of rainfall aberration.

Table-2.2.1: Weather at Portblair (Temperature & Humidity)

Month/Year	Mean Temperature (*C)										Humidity in (%)									
	Maximum					Minimum					08:30 hrs.					17:30 hrs				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
January	30.4	30.6	30.0	29.9	30.6	23.0	24.0	24.0	23.0	24.0	74	75	66	70	71	77	78	70	73	73
February	31.1	32.0	30.06	30.7	31.0	23.0	25.0	23.0	24.0	24.0	76	74	70	70	69	75	78	73	72	71
March	32.4	33.0	32.5	32.7	32.6	23.0	24.0	24.0	24.0	25.0	72	67	67	68	69	73	71	71	70	74
April	33.6	34.1	34.3	32.7	33.9	25.0	25.0	25.0	25.0	26.0	71	69	64	72	66	77	74	69	76	71
May	31.6	32.2	32.3	32.0	33.3	25.0	25.0	26.0	25.0	27.0	84	81	78	79	73	90	86	82	82	79
June	30.1	29.4	30.6	30.5	30.0	25.0	25.0	26.0	25.0	25.0	84	93	84	87	87	87	91	88	86	88
July	30.6	29.1	29.8	30.6	30.4	25.0	24.0	25.0	26.0	25.0	87	92	88	83	86	88	91	88	86	86
August	30.1	30.3	30.1	30.1	31.0	25.0	25.0	25.0	25.0	25.0	86	88	85	86	84	89	88	87	90	86
September	29.1	29.3	30.0	29.9	29.6	23.0	24.0	24.0	24.0	24.0	94	92	85	88	90	95	93	89	88	93
October	31.1	30.9	30.5	31.0	31.0	24.0	24.0	25.0	25.0	24.0	81	83	82	80	82	88	88	87	88	87
November	31.1	30.8	30.8	30.9	31.0	24.0	25.0	25.0	25.0	25.0	84	78	78	79	78	87	86	83	85	85
December	30.8	29.9	31.0	31.0	30.1	24.0	24.0	26.0	25.0	24.0	77	70	73	75	79	79	74	77	79	84
Average	31.0	31.0	31.0	31.0	31.2	24.1	24.5	24.8	24.7	24.8	81	80	77	78	78	84	83	80	81	81

Source: Department of Economics and Statistics, Andaman & Nicobar Administration

CHAPTER 3

PHYSIOGRAPHY

3.1 Geomorphology

The size, shape and elevation of an islands control the occurrence and movement of both surface and ground water resources to a considerable extent. Either or both types of water resources are likely to be available in larger quantities in wider and larger islands when compared to smaller and narrower islands. The width of a small island has major influence on the occurrence of ground water in basal aquifers.

The islands in South Andaman District have varied topographical features. In general, barring a few small Islands, all the others have undulating terrain with main ridges running North-South. There are also spurs running East – West in between the main ridges. Deep inlets and creeks are formed by the submerged valleys. Flat lands are few. Coral reefs surround most of the Islands.

The islands generally feature a hilly terrain with long ranges of hills and narrow valleys. The maximum altitude of these islands is at Mount Kavab, which is 460m above mean sea level. Mount Ford (435m, amsl) of Rutland Island, and Mount Harriet (365m, amsl) are some of the high peaks in South Andaman district. The peaks i.e. Mount Kavab and Mount Harriet, are formed of marine sedimentary rocks, while Mount ford is made of Ophiolites (igneous). Geomorphology of South Andaman district is controlled by the geology and weathering characteristics of the rock types underlain.

Figure-3.1.1: Moderately high & Steep Hillock

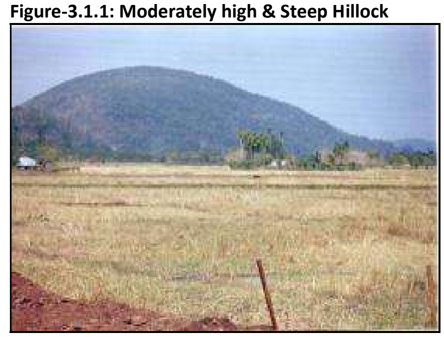


Figure-3.1.2: An intermountain Valley

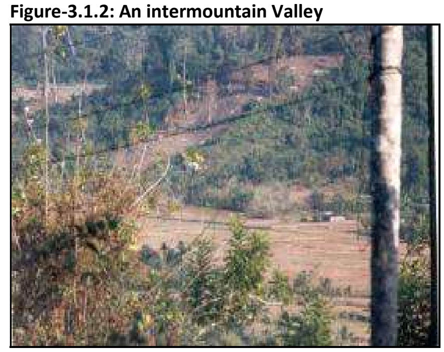


Figure-3.1.3: Gently Sloping Coastal Tract,

Geomorphologically, the South Andaman district can be divided into the following five broad units:

1. Moderate to steep hill ranges having low to moderate heights. This type of geomorphology could be seen in the islands underlain by Marine Sedimentary group of rocks

and Igneous Ophiolites rocks (**Figure-3.1.1**). Examples are South Andaman, Rutland etc. Because of low infiltration capacity of Marine sedimentary rocks, many streams are generated in the tracts underlain by such rocks. While drainage density is high in such areas, ground water potential is low and springs although preponderant lose perenniality in lean periods causing water scarcity in rural areas of South Andaman with recession of monsoon. The islands with Ophiolites i.e. Rutland on the other hand have good ground water potential with perennial springs and drainage.

2. Narrow intermountain valleys (**Figure-3.1.2**). This type of landform is formed in between the hills and could be seen in the aforesaid islands as mentioned under Sl. No. 1. In general the valleys are formed in the structurally weak planes i.e. along the lineaments and may be termed as structural valleys

3. Narrow, gently sloping coastal tracts including swamps (**Figure-3.1.3**). This type of coastal landform could be seen in the islands underlain by Marine Sedimentary, which contain mostly fine sand, silt and clays. Since, the length of the streams from hill to sea is less, the fluvial action on the rocks and sediments in their courses becomes less powerful. Consequently, owing to both the reasons larger clastics (sands, gravels and boulders) are not brought to the coast. Hence, in majority of the cases the beaches in such islands remain swampy and slender with low ground water potential in the low-lying areas. However, in cases where coral reefs are luxuriant around such islands, wide sandy beaches also could be seen. Example the Mahuadera (North Wandoor) beach in the western coast of South Andaman Island etc.

4. Islands basically are made of Coralline material (atoll) or having Clay-mudstone-chalk stone sequence in higher elevations with preponderance of coralline deposit in the low lying areas with very gentle slope and relatively wide coast encircling the islands. The uplifted atolls form low lying islands. Since, the coral reefs are being denudated constantly in the shallower part of the sea because of wave action, huge quantity of coralline sands are produced. They give rise to the formation of wider beaches. Examples of such islands are Neil, Jolly buoy, Havelock etc. In the higher elevations good springs are generated in Chalk stone, which gives rise to few perennial streams as could be seen in Krishnanagar, Radhanagar and Vijay Nagar on the way to Kalapahar village in Havelock Island. The Coralline limestones in the low lying areas form good repositories of ground water.

5. Rugged coast devoid of beaches. This type of coastal landform is visible in the islands or parts of the islands, which are underlain by Ophioliticigneous rocks. Examples are Cinque Island, Rutland Island, Barren (active) and Norcondom (dead) volcanic islands, parts of South Andaman in between Chidiyatapu to Brookshabad. As the Ophiolites are highly fractured having good potential of ground water, highly perennial as also potential springs are generated in such rocks, which finally gives rise to many perennial streams like Burma Nala, Chidiyatapu nala, Lalmitty Nala at Beadnabad, streams of Rutland etc.

3.2 Springs

The characteristic geological and geomorphologic conditions of the island have facilitated the origin of numerous springs in all the three major geological formations (i.e. Marine sedimentary group of rocks, volcanic and other igneous rocks and coralline limestone). The rural water supply in the entire district except Neil Island (Water supply in Neil is done from the wells) is maintained either directly from the springs or spring fed perennial streams. These springs are, in general, formed in high altitudes because of good fracturing in the rocks, hence they also may be termed as fracture springs. The springs are highly yielding and sustainable in igneous rocks and limestone as seen in Rutland (Kalapahar) and Cinque Island underlain by igneous rocks and in Little Andaman and Havelock islands, underlain by limestone.

3.3 Drainage

Because of relatively less areal extent and paucity of catchments, the islands of South Andaman district are devoid of river systems. However, a few perennial streams such as Mithakhari, Portharepore nala*,* Burma nala*,* Pema nala*,* Dhanikhari*,* Chandan nala etc. drain the South Andaman district. All the nalas meet the sea in Bays. The general drainage pattern of the islands varies from dendritic to sub-dendritic. However, land subsidence post-tsunami has facilitated the tidal ingress along the streams of South Andaman Island.

South Andaman district is endowed with sufficient rainfall. However, perennial springs and base flow are facilitating the perennial flow in some of the streams. In many islands, surface runoff occurs rapidly after rainfall and recedes to little or no flow within hours. On low islands (i.e. Neil), surface water resources, if at all present, are likely to be in the form of shallow lakes. In South Andaman district, drainage density is high, while in Havelock, Neil and Little Andaman Islands drainage systems are either absent or poor. However, potential springs are developed in such islands because of cavernous condition in Limestone. At places copious emanation from springs also give rise to potential drainage in Little Andaman Island.

3.4 Soil Characteristics

Soils in South Andaman, Rutland, Cinque, North Sentinel, Viper and Flat Bay Islands are mainly derived from sedimentary and igneous rocks like sandstone, Silt stone, Shale Limestone and Mudstone and Igneous Ophiolite suite of rocks comprising Pillow lava, acid and intermediate volcanic, gabbro, Peridotite, Herzbergite etc. The soils in the islands comprise alluvial soil, Sandy soil, Valley soil and Hilly soil. These soils are mostly deep to very deep, moderately to poorly drained, clay to clayey loam with angular blocky to sub angular blocky structure. Most of the alluvial soil is seen in valleys and used for Paddy in Kharif season, vegetables, pulses and oil seeds in Rabi season. Most of the plantation crops like coconut, arecanut are mostly cultivated in coastal plain and hilly land where slope is less than 10%. The valley land in South Andaman is most fertile as it is enriched in organic matter coming from the hillslope.

The soils of the other islands of South Andaman District like Havelock, Neil, Little Andaman, Strait islands are derived from the sedimentary rocks like Limestone, Coral sand, Mud stone etc. These soils are well drained with rapid permeability and are texturally classified as sandy, loamy sand, sandy loam. Plantation crops like, Coconut, Arecanut, Guava, Mango, banana, sapota etc. are very well grown in such soils. Due to coarse soil structure there is no chance of water logging even during rainy season while high permeability also assures good moisture during dry spells and facilitates luxuriant growth of coconut, arecanut and root crops along the coastal stretches.

CHAPTER 4

GEOLOGY

4.1 General geology & Succession details

The Islands in the South Andaman district are composed mainly of thick Eocene sediments deposited on Pre-Tertiary sandstone, silt stone and shale with intrusions of basic and ultrabasic igneous rocks (Ophiolites). In the geologically Younger Richie's archipelago, calcareous sand stones are more common. The available geological evidence leads us to assume the possibility of a geological period when the Andaman and Nicobar Islands formed a range between Burma and Sumatra. The Andaman and Nicobar Islands with Preparis and Cocos formed a continuous hill connecting this with Burma (Myanmar) through Cape Negrais. The Tertiary sediments classified as the Mithakhari and Andaman Flysh Group comprises thinly bedded alternations of sandstones and siltstones, grit, conglomerate, Limestones, shales, etc., are of Upper Cretaceous to Upper Eocene age. The Tertiary Group is overlain successively by the Archipelago Group, Nicobar Group and the Quaternary Holocene Group, intervening with unconformity. The generalized geological succession is given in **Table-4.1.1**

Marine inorganic sedimentary group of rocks comprising shale, sandstone, grit and conglomerate (Flysch and Mithakhari Groups) and organic sedimentary like Coralline atolls and limestone and extrusive ad intrusive igneous rocks (volcanic and ultramafics) occupy the entire geographical area in **Figure:4.1.1**. Amongst these, the former (inorganic) Sedimentary group is most pervasive and occupy nearly 70% of the entire area of the islands, while the Igneous group covers nearly 15%, while the rest 15% goes to the coralline and limestone formations. All these rock formations are brought under tectonism because of their alignment in a tectonically active zone, evident from the occurrence of shallow and deep focus earthquakes in the islands. The last earthquake and devastation by tsunami were also the effect of tectonic setting of this archipelago in a converging plate margin. Because of tectonism, the igneous and Sedimentary groups of rocks are highly fractured and fissured. The fracturing in hard Rocks forms conduits for movement of ground water in the deeper horizon. The geology of the islands is highly varied and even changes within a small distance**.**

All the above formations except recent to sub recent group have undergone different phase of folding faulting and upliftment documented in the very complicated structural pattern in some exposures **Figure-4.1.2.**

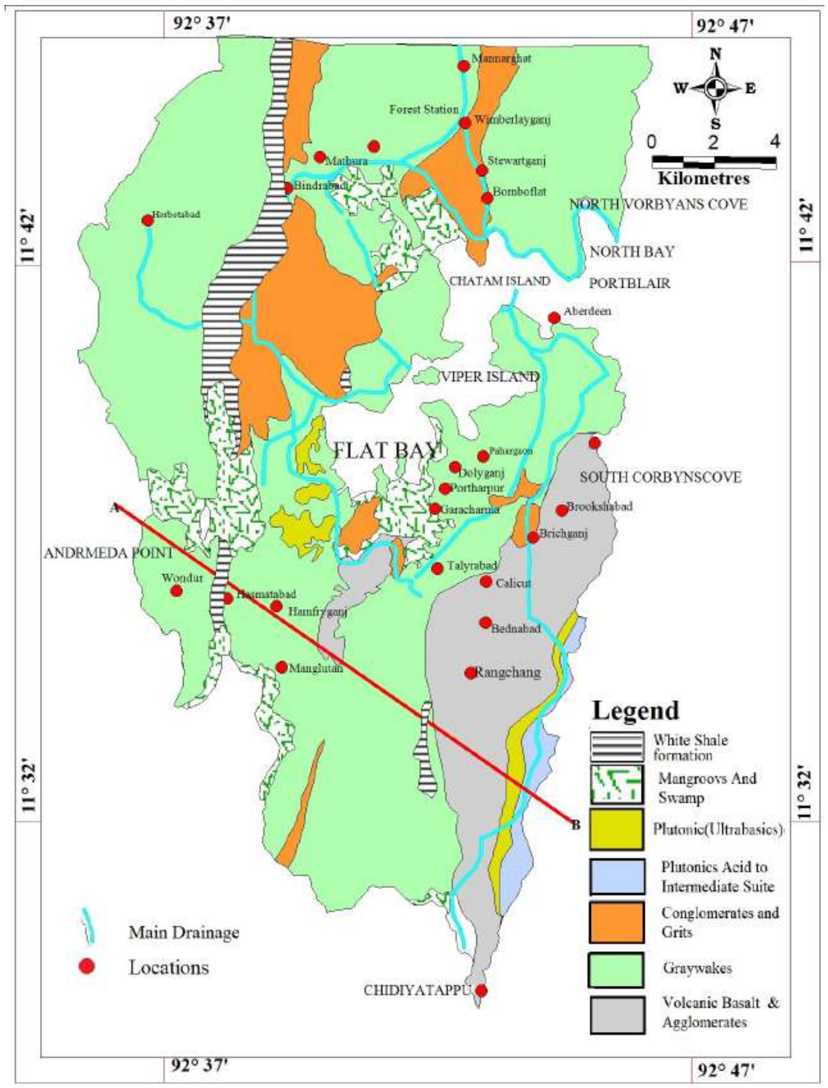


Figure: 4.1.1 Geological Map of the Portblair area South Andaman

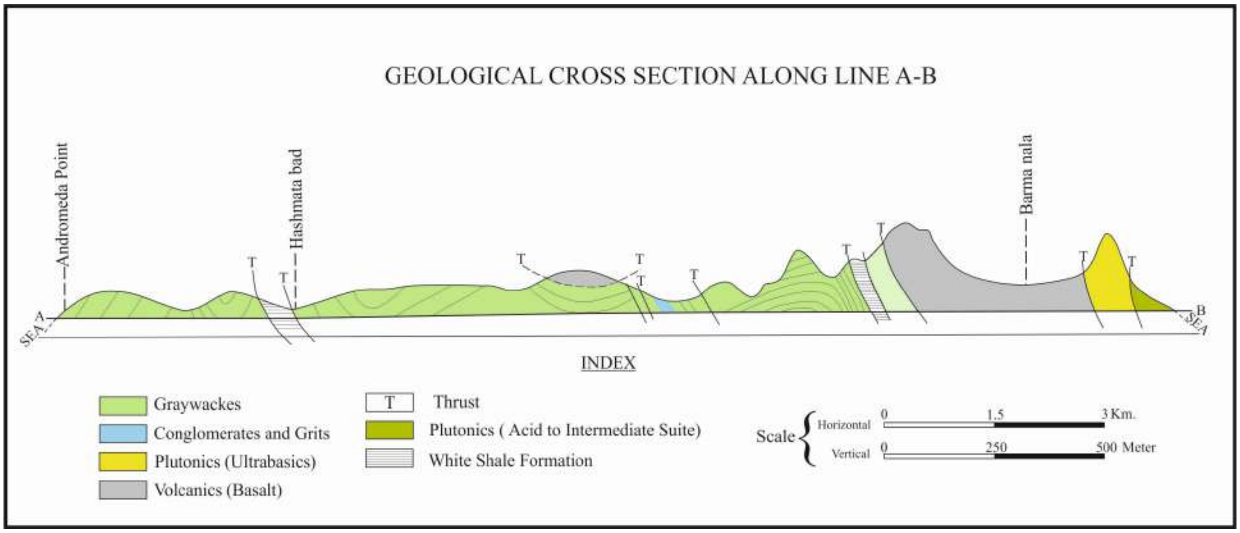


Figure: 4.1.2 Geological Cross section along line AB

Table-4.1.1: Generalized Geological Succession of Andaman & Nicobar Islands

Age	Group	Formation
Recent to sub-Recent	Quaternary Holocene Group	Beach sands, Mangrove clay, Alluvium, Coral rags and Shell limestone, loosely consolidated pebble beds
--	**Unconformity**	--
Pleistocene to Late Pliocene	Nicobar Group	Shell limestone, Sandstone, Claystone, etc.
Miocene	Archipelago Group (Upper)	White claystone, Melville Limestone
--	**Unconformity**	--
Oligocene to Paleocene	Andaman Flysh , Mithakhari Group	Thinly bedded alternations of Sandstones and siltstones, grit, conglomerate, Limestones, black Shales with olistiliths.
--	**Unconformity**	--
Late Cretaceous	Ophiolite Group	Dyke swarms, acidic suite, Pillow lava with radiolarian chert and ultramafic suite.

CHAPTER 5

GEOPHYSICS

5.1 Geophysical Studies

Groundwater resource development needs interdisciplinary approach and geophysics plays a major role particularly in its exploration. Geophysical techniques have been used extensively in almost all the hydrogeological terrain. Two-third part of the country being occupied by hard rocks, surface geophysical techniques particularly resistivity sounding has got wider application in this terrain. The geo-electrical resistivity survey is considered to be the best and most suited for routine ground water investigation both in alluvial and hard rock area because of low operational cost and easy field data interpretational procedure. Geophysical methods use the significant contrasts in resistivity that usually occur between permeable sandy and less permeable clayey formation; consolidated and unconsolidated rocks; dry and water saturated sediments etc. Moreover, it is the only technique that reveals the salinity of formation water. The geo-electrical surveys therefore aim at mapping the aquifer geometry and groundwater salinity. The resistivity of formation water depends on its degree of mineralization and the composition of dissolved salts. Sands saturated with fresh water have a resistivity of 30 to 100 Ohm-m and higher, while in sands saturated with mineralized water, resistivity is reduced to 1 to 0.1 ohm m. It implies that porosity has the major control on resistivity of rocks and the resistivity generally increases as porosity decreases. However, even crystalline rocks with negligible inter-granular porosity are conductive along cracks and fissures.

The role of geophysical methods in groundwater exploration is vital. Its main aim is to understand the hidden subsurface hydrogeological conditions accurately and adequately. Since the base of any geophysical methods is the contrast between the physical properties of the target and the environs, the better the contrast better would be geophysical response/anomaly and hence the identification. So, the efficacy of any geophysical technique lies in its ability to sense and resolve the hidden subsurface hydrogeological heterogeneities or variation. Hence, for groundwater exploration a judicious application or integration of different techniques is most essential to become successful in exploration, technologically as well as economically. It is to be clearly conceptualized that groundwater cannot be detected directly by any one of the geophysical methods and therefore the interpretation is contextual and a broad understanding of the subsurface hydrogeological condition is prerequisite.

In the electrical resistivity method, resistivity of the earth material is measured. This is done by introducing a known amount of current (I) into the ground through two electrodes (A & B) and by measuring the potential difference (V) between another pair of electrodes (M & N). The apparent resistivity is obtained by multiplying the resistance (R) and the geometric factor (K). The readings are taken by increasing the spacing between two current electrodes or potential electrodes or both keeping the centre of the array constant. This method of taking measurements is known as Vertical Electrical Sounding (VES) which reflects vertical distribution of electrical resistivity. In present study geophysical resistivity sounding data were collected in Schlumberger configuration. Schlumberger, in 1930's proposed an electrode arrangement in which the potential electrodes M & N are placed as close as possible (always < 1/5th of AB). This array is also known as gradient array. In this method, the potential electrodes M, N& current electrode B are fixed and only the current electrode A is moved after each measurement. The potential electrodes are shifted only when the change in potential is too small to be measured accurately. This method is very useful for investigating shallow aquifers. Also in this method the effect of in-homogeneities, induction effect and error percentage is minimized.

$$\rho = K \frac{\Delta V}{i}$$

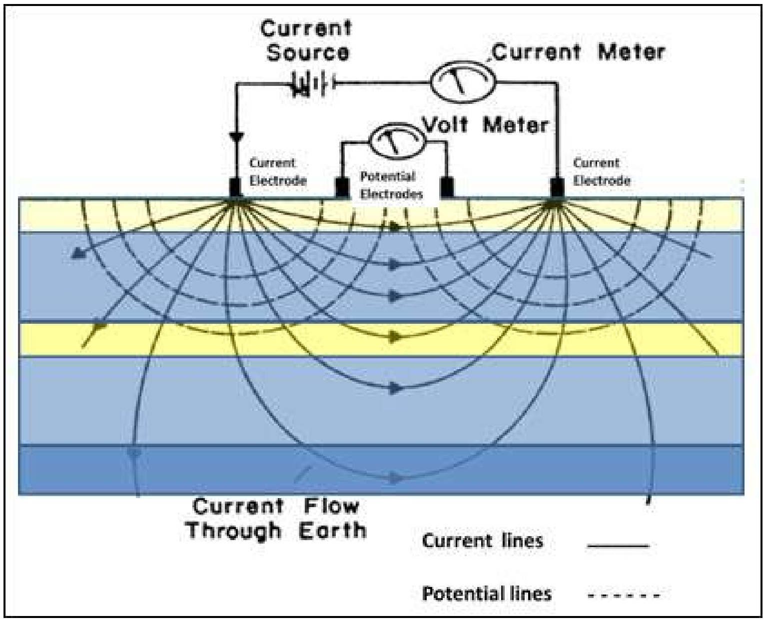
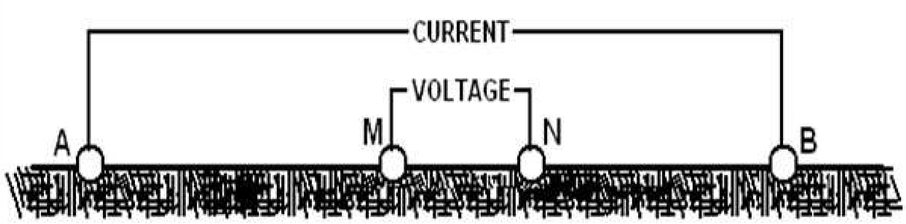


Figure-5.1.1: Schematic view of electrical resistivity method

Based on the detailed hydro-geological studies of the area, Vertical Electrical Sounding (VES) were carried out to find out suitable locations for constructing civil structures to arrest non committed runoff for recharging delineated aquifers. The VES were carried out in Schlumberger Configuration with maximum spread length (AB/2) of 30 to 90 m using CRM AUTO C Resistivity meter. The data is plotted on double logarithmic graph paper and matched with standard curves to know the true resistivity and thickness of various horizons. The data is also interpreted on computer by using IPI2WIN software to verify the results of partial curve matching. The sounding and profiling locations, VES curves, processing, interpretation and its geological inferences in Neil Island, Little Andaman Island and parts of South Andaman Island are given below in the running text.



$$K = \pi\left(\frac{AB}{2}+\frac{MN}{2}\right)\left(\frac{AB}{2}-\frac{MN}{2}\right)/MN$$

Figure-5.1.2: Schlumberger Configuration with Geometrical Factor

5.1.1 Neil Island

To delineate the aquifer geometry one hundred and three (103) Vertical Electrical Sounding (VES) by Schlumberger configuration are conducted to cover the entire area of Neil-Island. Depending upon the objectives the maximum current electrode spacing (AB) was kept 30 m. The spacing of the electrode controls the depth of investigation and the desired spacing facilitates to get the sub-surface information to the depths suitable for facilitating the rainwater harvesting. Further at four areas at 50 m separation the VES were carried out at selected current electrode spacing (2.5, 5.0, 10.0 and 20.0 m) in Schlumberger Configuration in traditional way to realize the concept of resistivity imaging to decipher the sub-surface formations in a precise way. The location of VES and HEP (Horizontal Resistivity Profiling) carried out in Neil Island is shown in **Figure-5.1.1.1**.

The VES curves are interpreted manually by two layer master curves and IPI2WIN, free domain software have been used to check the matching of field and interpreted VES parameter. The 'IPI2WIN' software is based on principal of inversion which takes the geo-electrical parameters as input and the output is in the form of layer parameters in terms of apparent resistivity and thickness. In this computer aided curve matching technique, an initial model is given for which the computer arrives at the theoretical curve and compares with the field data; then it takes difference between the recomputed and field curves and modifies old model parameters to start with a new model for reducing this difference (error). Again computes new theoretical curve and compares with the field curve, and sets another new model to reduce the differences. This process of iteration goes on till the error is minimized and finally displays the match between the field and theoretical curves giving the final model parameters. The final results were corroborated with the known hydro-geological conditions existing in the area. The final interpreted geo-electrical layer parameters of VES (layer resistivity and layer depths) are given in **Table-5.1.1.1**.

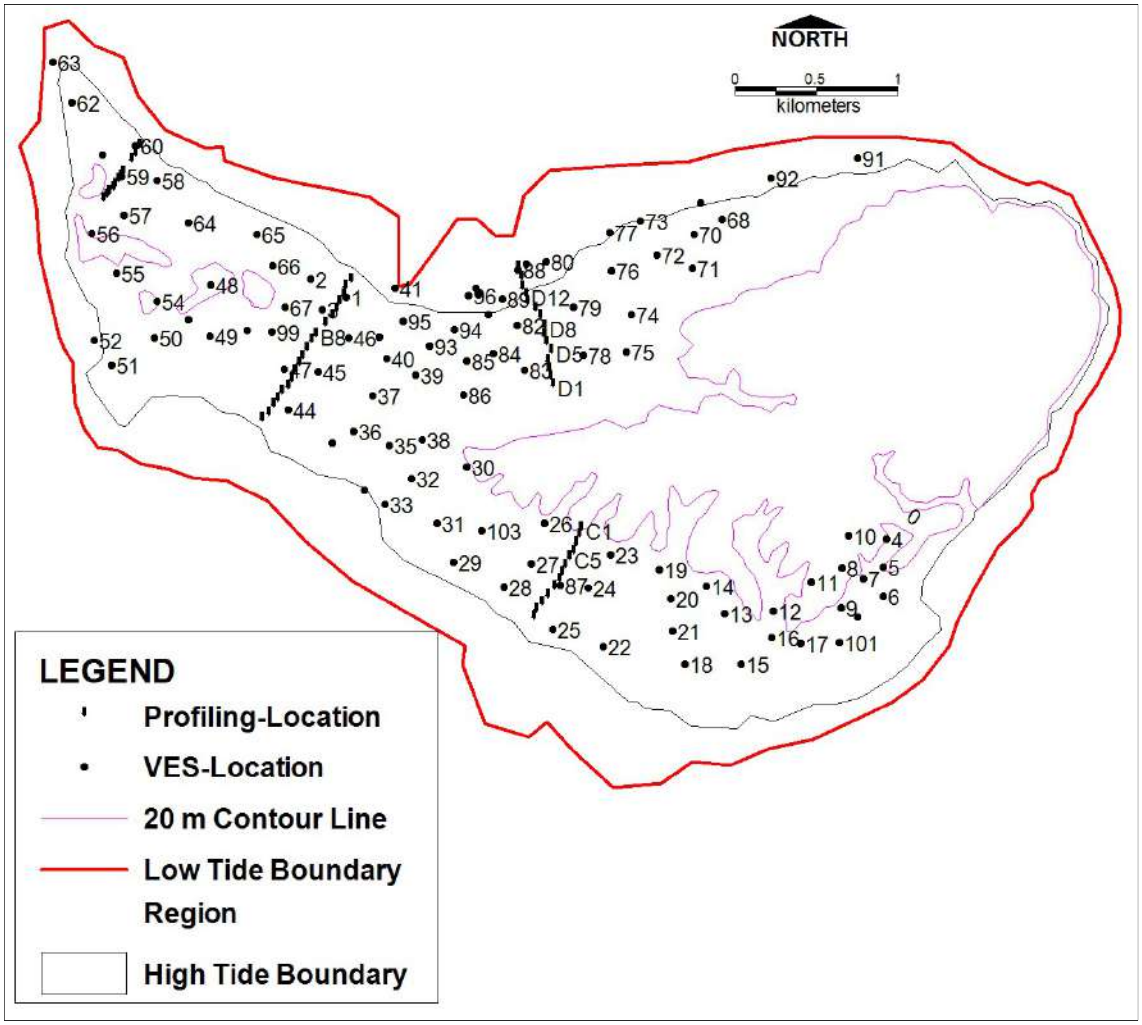


Figure-5.1.1.1 VES and Resistivity Imapging Locations of Neil Island

Table-5.1.1.1: Interpreted layer parameters of VES Curves in Neil Island.

VES No.	espective layer Resistivity (Ohm-m)			Respective layer Depth (m)	
	ρ_1	ρ_2	ρ_3	D_1	D_2
VES-01	48	1.5		2.8	
VES-02	140	570	6	1	3.5
VES-03	182	830	6.5	1	3.2
VES-04	30	930	2.3	1	3.4
VES-05	4	10	1	1	10
VES-06	100	440	5.7	1	3
VES-07	2.9	31	2.6	1	5
VES-08	7	180	1	1	3.9
VES-09	5	35	3	1	4.5
VES-10	4.6	3.5	5.3	1	4.5
VES-11	4.2	52	6	1	4.6
VES-12	150	7.5		4.3	

VES-13	2.7	13	7.5	1	4.5
VES-14	260	2500	4.5	1	3.6
VES-15	145	76	3.3	1.6	4.5
VES-16	5.5	10.5	4.9	1	4.5
VES-17	390	32	7	1.7	7
VES-18	125	56	5.5	1.5	4
VES-19	10.5	71	4.7	1	4.5
VES-20	125	52	6	1	4.5
VES-21	10	21	4.3	1	4.5
VES-22	660	34	2.7	2.3	9
VES-23	4	28	7.4	1	4.5
VES-24	103	3.3		4.5	
VES-25	800	65	1.7	2.1	7.8
VES-26	460	1200	14	1	4.5
VES-27	22	60	6	1	4.5
VES-28	1200	85	2	1.8	5.2
VES-29	615	82	2.6	1.5	2.7
VES-30	26	330	1	1	4
VES-31	38	4.5		4.4	
VES-32	108	33.5	2.9	1.8	8
VES-33	300	37	2.8	1.2	5.2
VES-34	320	48	2	1.3	7.5
VES-35	430	130	3.5	2	3.8
VES-36	540	38.5	2.9	2	6.7
VES-37	160	4.8		4	
VES-38	385	760	8.4	1	4.5
VES-39	800	147	3	1	4.8
VES-40	600	114	1.9	1	4.4
VES-41	240	1.2		1.9	
VES-42	50	2.2		3.7	
VES-43	500	19	2.1	1.3	4.7
VES-44	460	31	2.3	1.6	6.7
VES-45	400	2.7		2.7	
VES-46	360	17	3	1.7	5.8
VES-47	47	23	2	1.3	3.5
VES-48	240	5.7		3.3	
VES-49	600	30	3.4	1.8	5.9
VES-50	49	2.7		2.5	
VES-51	410	28	1.6	1.3	5.5
VES-52	5.8	3	1.5	1.1	5.6
VES-53	132	42.5	3.2	1.2	4.2
VES-54	125	3.7		4.5	
VES-55	1.9	2.5	2	1	3.5
VES-56	6.5	4.5	2.5	1	21
VES-57	17	115	3	1	2.7
VES-58	325	1500	6	1	4.5
VES-59	180	700	1	1	4
VES-60	500	125	3.6	1.9	3

VES-61	65	380	1.3	1	3.3
VES-62	2100	14		5.6	
VES-63	950	360	1.8	2	3.8
VES-64	140	7.4		4.6	
VES-65	220	66	7.4	2.2	5
VES-66	75	440	3.2	1	4.5
VES-67	90	1500	3	1	3.5
VES-68	500	160	3.7	1.8	3.5
VES-69	1250	170	2.7	1.7	3
VES-70	560	870	5.1	1	2.6
VES-71	5	17	11	1	4.3
VES-72	88	22	6.8	2	7
VES-73	2000	500	2.5	2	3
VES-74	58	26	7.2	1.8	3.2
VES-75	3.1	17.8	5.5	1	4.6
VES-76	12	19	2.8	1	5.5
VES-77	490	18	1.6	1.4	4.5
VES-78	3	32	2.2	1	4.5
VES-79	3.8	22	3.7	1	4.5
VES-80	120	35	1	1	6.5
VES-81	35	1.5		6	
VES-82	850	520	1.8	2.5	3.4
VES-83	57	21	2	4	10
VES-84	280	62	3.7	1.2	5
VES-85	60	86	1.4	1	4.5
VES-86	32	75	5.8	1	4.5
VES-87	7.8	57	2.2	1	3.8
VES-88	12	47	2.8	1.1	4
VES-89	186	20	2.5	1.1	5.2
VES-90	44	18	2.8	1	2.6
VES-91	66	35	2.4	1	3.9
VES-92	45	20	2.3	1.1	3
VES-93	70	56	1.8	1	4.5
VES-94	90	43	1.3	1	3.7
VES-95	65	1.7		3.3	
VES-96	1	0.9		1.2	
VES-97	0.8	1		7.7	
VES-98	0.9				
VES-99	520	4.5		3.2	
VES-100	300	20	3	1.1	4
VES-101	400	48	3.8	1.6	6.2
VES-102	4	37	4.2	1	4.6
VES-103	4.6	30	3	1	4.4

After the close observation of all VES curves and its interpretation it is very clear that the study area is having two to three layers earth model up-to depth of investigation. The thickness of first layer is varying between 1.0 to 6.0 m with resistivity value 1to 2000 Ohm-m indicative of saline/clayey to unsaturated nature of soil. The value of resistivity (0.8 - < 2 Ohm-m) indicates saline nature of soil, (2 – 10 Ohm-m) indicates mud rock, (10 – 200 Ohm-m) is weathered coral, (200 – 500 Ohm-m) is hard coral formation saturated with fresh ground water and resistivity (> 500 Ohm-m) values indicate unsaturated nature of soil. Similarly the second layer at these locations is showing mixed nature of hydrogeological condition with depth range between 2.6 to 10.0 m and resistivity range between 1 Ohm-m to 2500 Ohm-m. The third layer at various locations is indicating mud rock to formation saturated with saline water upto depth of investigation which is 10.0 m in this terrain with resistivity range between 1.9Ohm-m to 14 Ohm-m. This layer is extended up to depth of investigation in almost entire study area. The fresh ground water zone in entire study area is occurring within depth range from 1.0 to 9.0 m.

To establish the subsurface aquifer configuration as well as feasibility of recharge through the proposed structure the interpreted layer parameters in the proposed area is much useful. The generalized litho-succession occurring at the proposed recharge site as inferred from Vertical Electrical Sounding (VES) and hydrogeological data is given in **Table-5.1.1.2**. This Table is showing depth and resistivity range with inferred hydrogeology of the study area.

Table-5.1.1.2: Depth and Resistivity range with inferred Hydrogeology of the Neil Island

S. N.	Depth in meters		Resistivity Range (Ohm-m)		Lithology
	From	To	From	To	
1	1	6	1	2000	>0 – 2 Ohm-m Formation saturated with saline water 2 – 10 Ohm-m Mud rock 10 – 200 Ohm-m Weathered coral l200 – 500 Ohm-m) Hard coral > 500 Ohm-m Unsaturated nature of formation
2	2.6	10	1	2500	
3	1.9	10	1.9	14	

From the inversion of resistivity data and correlation of prevailing hydrogeological conditions in the area it can be inferred that the area is having unconfined aquifer zone within a depth range of 1 and 9 mbgl. The depth of aquifer deposition is shown in **Figure-5.1.1.2**.

In this figure the depth of aquifer is 6 to 10 m in the southern part of Island along the coast in Sitapur, Ramnagar and Neil Kendra and central part of Bharatpur village. This depth reduces gradually towards northern coast where it occurs between 2 to 4 m. In central part of Island and Lakshmanpur village about half of the area the depth of aquifer lies between 4 to 6 m.

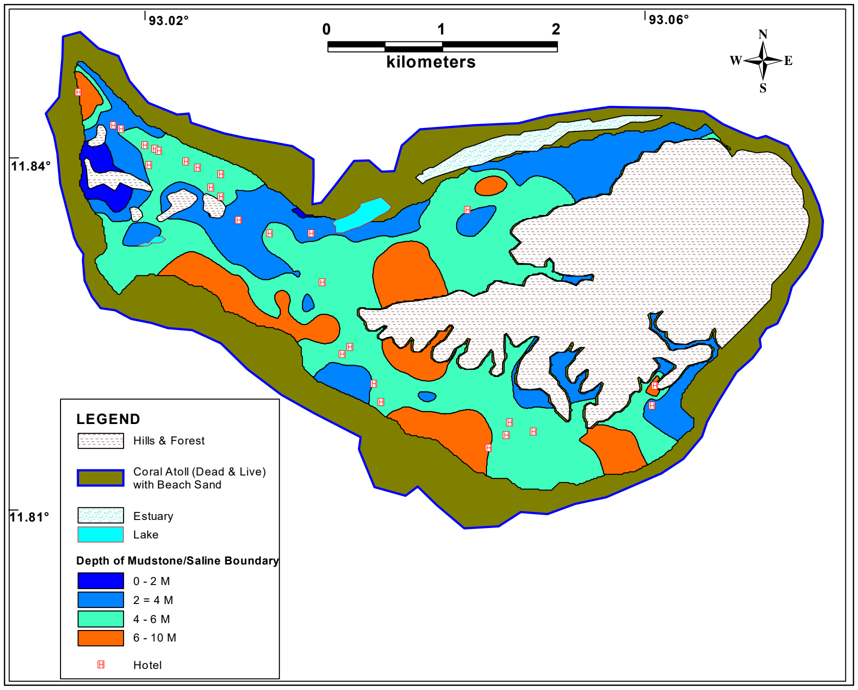


Figure-5.1.1.2: Depth of Aquifer deposition in Neil Island

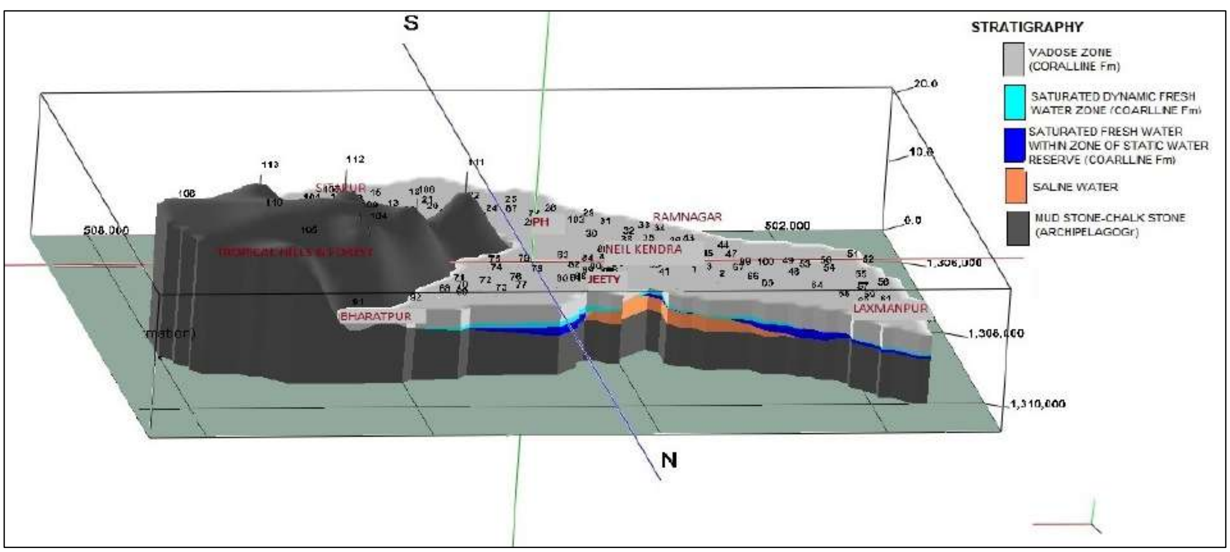


Figure - 5.1.1.3: 3D view of Aquifer Deposition towards Northern Coast of Neil Island

The 3D view of aquifer deposition towards northern and southern coast is shown in **Figure-5.1.1.3 and Figure-5.1.1.4** respectively**.** In northern view the salinity is replacing the fresh water zone near Jetty area of Neil Kendra village. As we move towards Lakshmanpur and Bharatpur villages the fresh ground water zones throughout the northern coast. In southern view the salinity is replacing the fresh water zone near Sitapur and Neil Kendra villages. At Ramnagar village area the fresh ground water zones throughout the southern coast. In this area as the depth of aquifer is more in comparison to the remaining part of the Island, suitable for ground water development.

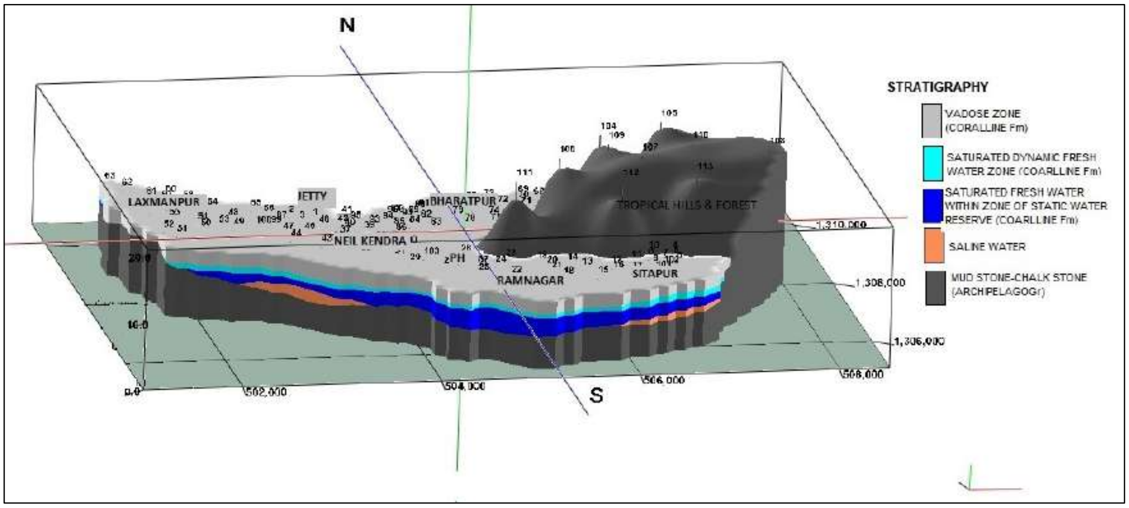


Figure-5.1.1.4: 3D view of Aquifer Deposition towards Southern Coast of Neil Island

Locations Required Dug-wells For Development:

1. The Burning Place

The VES-34 has been carried out at entrance of burning place which is located in Ramnagar village of Neil-Island. The observed VES curve is showing three layers earth model. The first layer is having resistivity value 320 Ohm-m and thickness of 1.3 m is unsaturated zone of top-soil. The second layer with resistivity value 48 Ohm-m and up to depth of 7.5 m is indicative of weathered coral formation. This layer is contributing as aquifer at this location. The last layer with resistivity value 2 Ohm-m is mud rock saturated with saline water. The interpretation of VES-34 is shown in **Figure-5.1.1.5**.

At this location a dug well may be constructed up to depth of 7 m for tapping ground water.

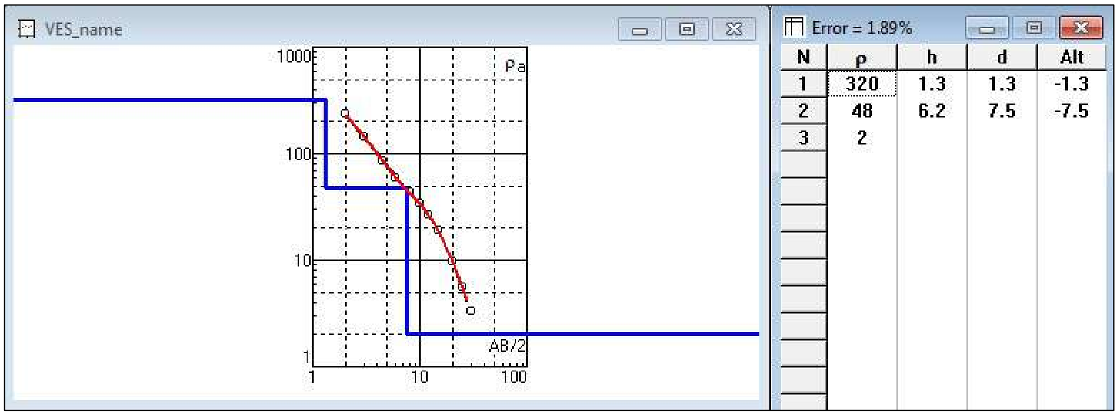


Figure-5.1.1.5: Interpretation of VES-34 at the burning place in Neil Island

2. Ground Near Bharatpur Lake

The VES-93 has been carried out near house of Shri British Roy at open ground close to Bharatpur Lake which is located in Bharatpur village of Neil-Island. The observed VES curve is showing three layers earth model. The first layer is having resistivity value 70 Ohm-m and thickness of 1.0 m is top-soil. The second layer with resistivity value 56 Ohm-m and upto depth of 4.5 m is indicative of weathered coral formation. This layer is contributing as aquifer at this location. The last layer with resistivity value 1.8 Ohm-m is mud rock saturated with saline water. The interpretation of VES-93 is shown in **Figure-5.1.1.6**.

At this location a dug well may be constructed up to depth of 4.5 m for tapping ground water.

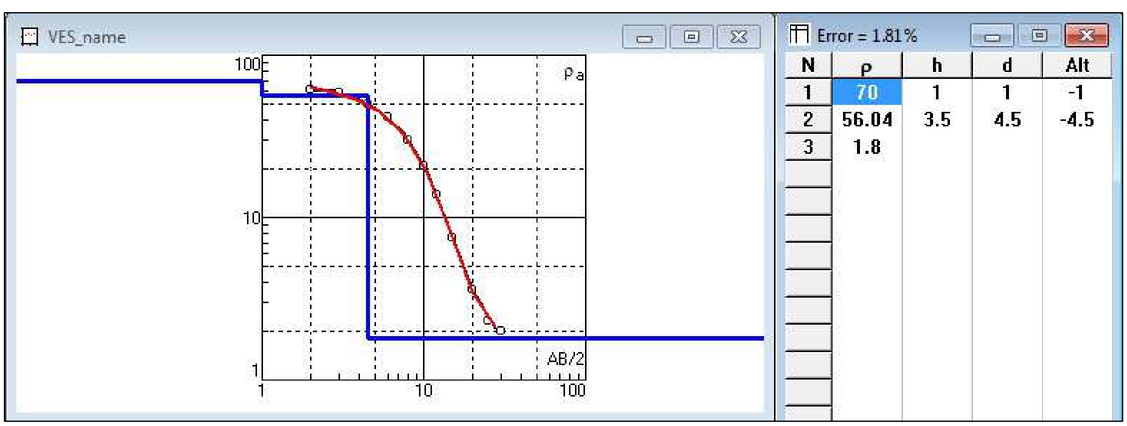


Figure 5.1.1.6: Interpretation of VES-93 near Bharatpur Lake in Neil Island

3. Near Fish Market:

The VES-01 has been carried out close to Fish Market which is located in Neil Kendra village of Neil-Island. The observed VES curve is showing two layers earth model. The first layer with resistivity value 48 Ohm-m and up to depth of 2.8 m is indicative of weathered coral formation. This layer is contributing as aquifer at this location. The last layer with resistivity value 1.5 Ohm-m is mud rock saturated with saline water. The interpretation of VES-01 is shown in **Figure-5.1.1.7**.

At this location a dug well may be constructed up to depth of 2.8 m for tapping ground water.

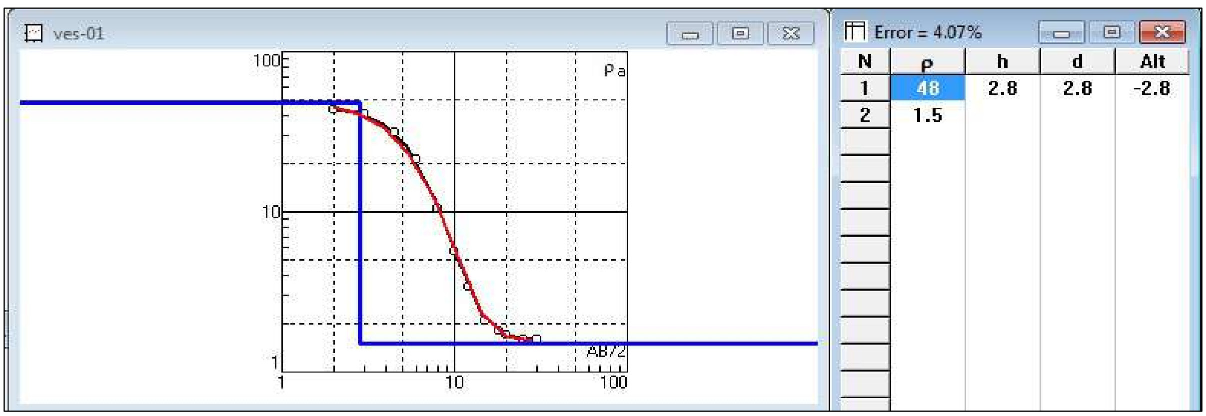


Figure-5.1.1.7: Interpretation of VES-01 near Fish market, Neil Kendra in Neil Island

4. Lakshmanpur Lake:

The VES-47 has been carried out close to Lakshmanpur Lake which is located in Lakshmanpur Village of Neil Island. The observed VES curve is showing three layers earth model. The first layer is having resistivity value 47 Ohm-m and thickness of 1.3 m is top-soil. The second layer with resistivity value 23 Ohm-m and up to depth of 3.5 m is indicative of weathered coral formation. This layer is contributing as aquifer at this location. The last layer with resistivity value 2 Ohm-m is mud rock saturated with saline water. The interpretation of VES-47 is shown in **Figure 5.1.1.8**.

At this location a dug well may be constructed up to depth of 3.5 m for tapping ground water.

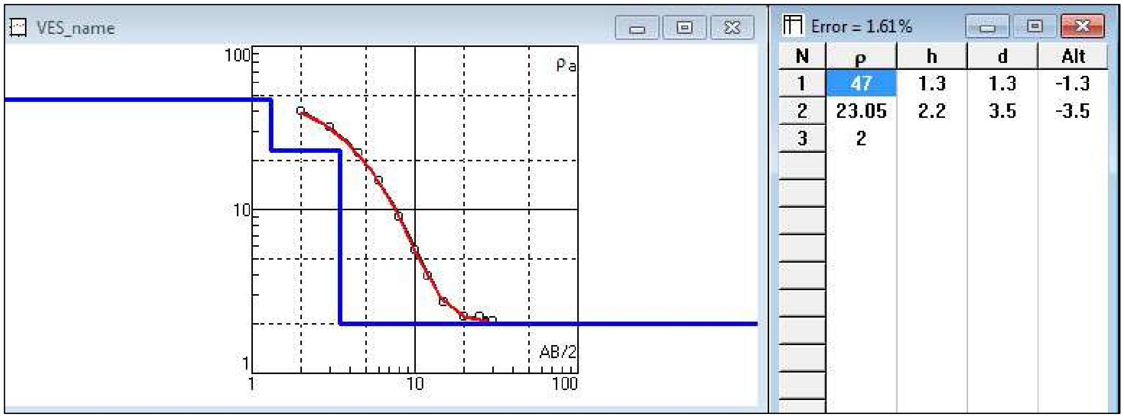


Figure 5.1.1.8: Interpretation of VES-47 near Lakshmanpur Lake in Neil Island

5. **Near Parimal Das House:**

The VES-87 has been carried out in agriculture land of Shri Parimal Das house which is located in Ramnagar Village of Neil Island. The observed VES curve is showing three layers earth model. The first layer is having resistivity value 7.8 Ohm-m and thickness of 1.0 m is clayey top-soil. The second layer with resistivity value 57 Ohm-m and up to depth of 3.8 m is indicative of weathered coral formation. This layer is contributing as aquifer at this location. The last layer with resistivity value 2.2 Ohm-m is mud rock saturated with saline water. The interpretation of VES-87 is shown in **Figure-5.1.1.9**.

At this location a dug well may be constructed up to depth of 3.8 m for tapping ground water.

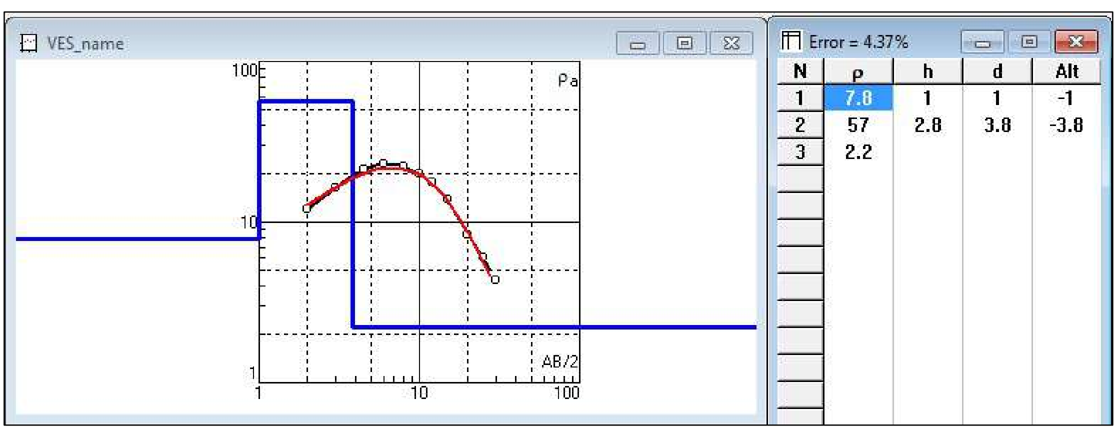


Figure-5.1.1.9: Interpretation of VES-87 near Parimal Das House in Neil Island

5.1.2 Little Andaman Island

With reference to the devastating Tsunami and Earthquake calamities occurred on 26/12/2004, detailed hydrogeological studies were carried out in the inhabited areas of Little Andaman Island. In addition to this, geophysical resistivity surveys were also carried out in the Island to assess the feasibilities of ground water exploration. The Geophysical Survey was carried out mainly to adjudge the affect of Tsunami and earthquake on water resources of the Island in view of quantity as well as quality. Further to decipher the disposition of saline and fresh water with a perspective to carryout ground water exploration (drilling) in the Islands to mitigate the water supply problem through construction of the bore wells as also by dug wells. The necessity of fresh water conservation adopting rooftop rainwater harvesting and recharge, construction of check dam, subsurface dam, collector well, pond etc.

The Island is underlain by extensive Miocene limestone and in the low lying areas Recent to Sub-Recent coralline sands with coral rags are observed. In the core of the Island at places small ultramafic bodies were observed. The lime stones are highly cavernous and occasionally fractured. Coralline sands are highly friable and highly porous. In the area Recent to Sub-Recent coralline sands form potential aquifer in the shallow horizons. These aquifers are mostly developed by dug wells. The areas where such type of formations crop out are Harminder Bay, Netaji Nagar, Hut Bay, Dugong Creek and South Bay (Onge settlement) areas. The pervasive and vast limestone terrain form potential reserve of Ground water. Good high yielding springs, waterfalls and highly flowing streams are developed in this formation. Characteristically this limestone is highly cavernous and in V.K. Pur, R.K. Pur, Ravindra Nagar settlement areas these aquifers are tapped through numerous dug wells fitted with pump available in the house of each settler.

A total number of seventy five (75) Vertical Electrical Sounding (VES) were carried out at different parts of the Little Andaman Island i.e. around Hut Bay, Harminder Bay, Vivekanandapur, Rabindranagar, Ramkrishnapur, Netajinagar and Dugang Creek area (Figure-5.1.2.1) to find out the fresh drinking water sources as well as to assess the feasibility of ground water exploration through drilling in the areas after the effect of tsunami and earth quake in connection with relief and rehabilitation work for victims. The electrical resistivity surveys were conducted by deploying an AC resistivity meter, ABEM Terrameter (SAS300B), Sweeden. During the survey maximum current electrode separation was kept as 400m (AB). Plotting the apparent resistivity values against half electrode separation in double log paper, VES curves were generated and these curves were interpreted with the help of standard master curves by partial curve machine technique. The curve types obtained in Little Andaman were K, A, Q, HA, KQ, KH, H type. These results are standardized with the known litho-logy of the nearby tube wells/dug wells and the resistivity values for different formations are furnished in **Table-5.1.2.1**.

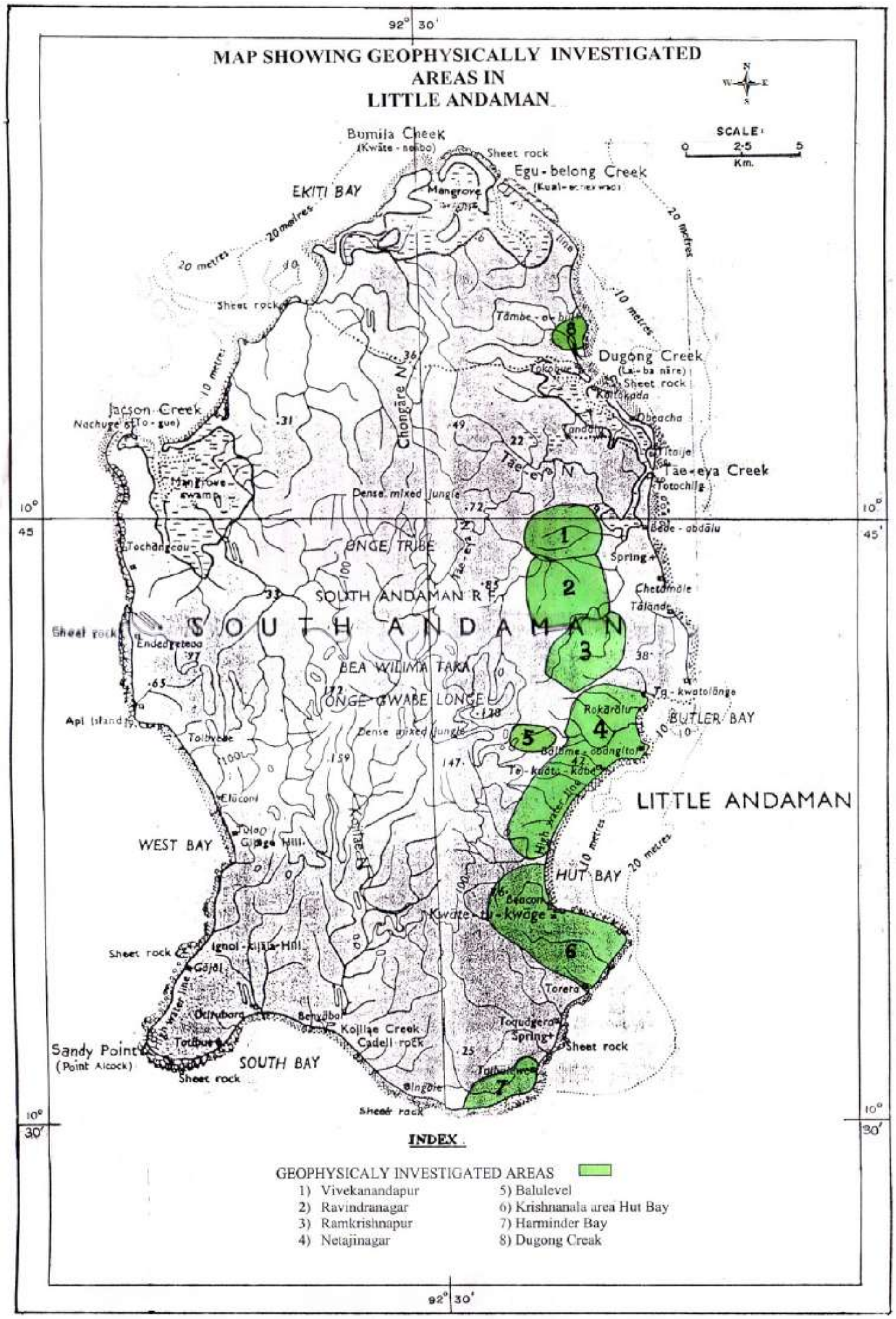


Figure-5.1.2.1: Map showing area covered with Geophysical survey in Little Andaman Island

Table-5.1.2.1: Standardized resistivity for different geological formations in Little Andaman Island

S. No.	Formation	Resistivity (Ohm-m)
I	Top soil	4 - 1250
II	Fresh water in cavernous limestone/coralline sand.	30 - 480
III	Brackish water in cavernous limestone/ coralline sand	8 - 18
IV	Brackish to fresh water in cavernous limestone/coralline sand	20 - 29
V	Highly weathered formation/ clay	12 - 14
VI	Saline formation water /clay	0 - 7
VII	Hard formation (dry)	560 - 3075

Hut Bay and Harminder Bay area:

A total number of twenty four (24) Vertical Electrical Sounding (VES) were carried out in the area (Figure-5.1.2.2). Sub surface water was contaminated with the invading saline water during Tsunami in Hutbay and Harminder bay area due to proximity of the coast lines. On the spot observation of the Electrical Conductivity of dug well and the resistivity results corroborate the same. The different characteristics of the aquifers at various depths are analyzed in the following sections along EF on the basis of the resistivity results.

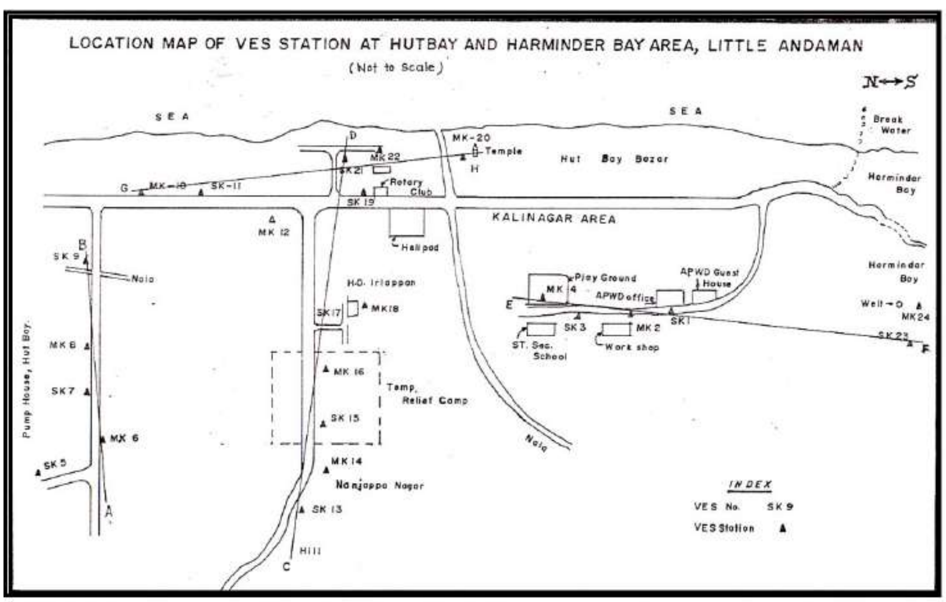


Figure-5.1.2.2: Location Map of VES at Hut Bay and Harminder Bay in Little Andaman Island

Geoelectric cross-section along E - F:

The section E-F passes through the VES MK4, SK3, MK2, SK1 and SK23 (**Figure-5.1.2.2**). It is observed that except VES SK23, located at Harminder bay, all the VES at northern part are showing a thin layer of fresh and brackish water (thickness 0.2m to 1.6m) are floating over saline water. The resistivity range of this thin layer is 8 ohm-m to 74 ohm-m. As these VES were close to the sea and the resistivity order is lower, the formation is predicted to be coralline sand. VES 23 is located at little distance from the sea shore and the fresh water pocket of resistivity 46 ohm-m is found to be sandwiched between upper dry limestone (resistivity 555 ohm-m) and lower brackish formation of resistivity 8 ohm-m, it is inferred that the fresh water is lying within limestone cavity. VES curves obtained in tsunami affected areas of Little Andaman Island is shown in **Figure-5.1.2.4**.

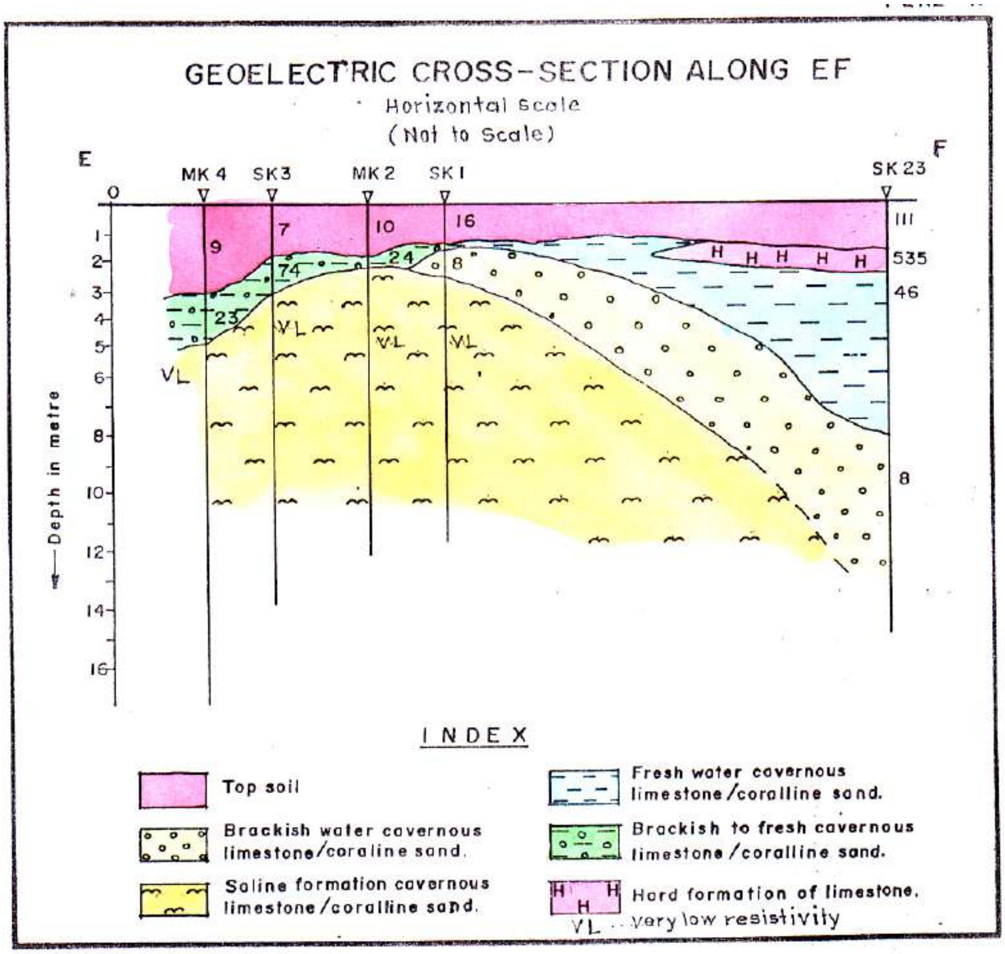


Figure-5.1.2.3: Geoelectric cross-section along E-F

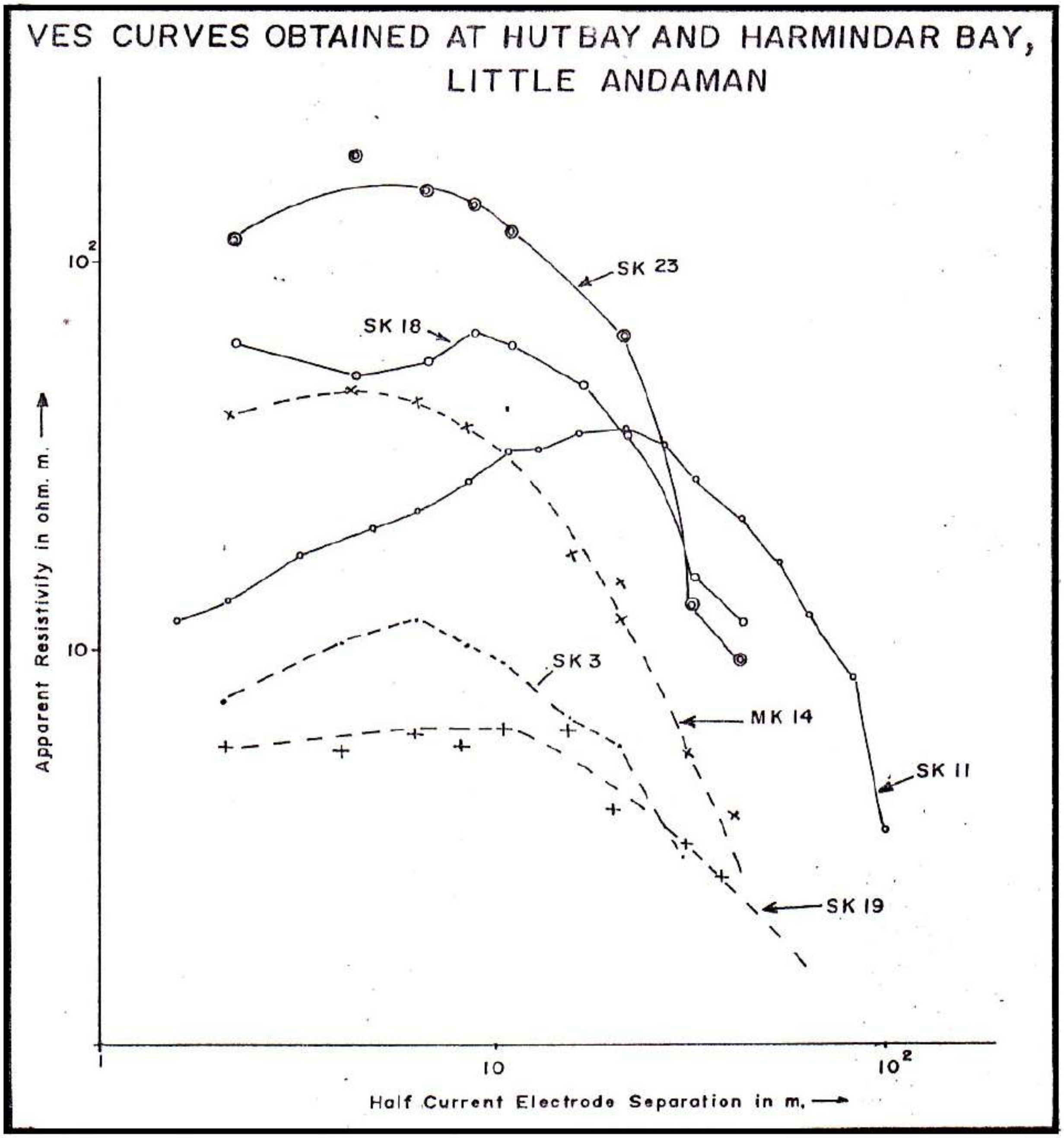


Figure-5.1.2.4: VES curves obtained at Hut Bay and Harmindar Bay in Little Andaman Island

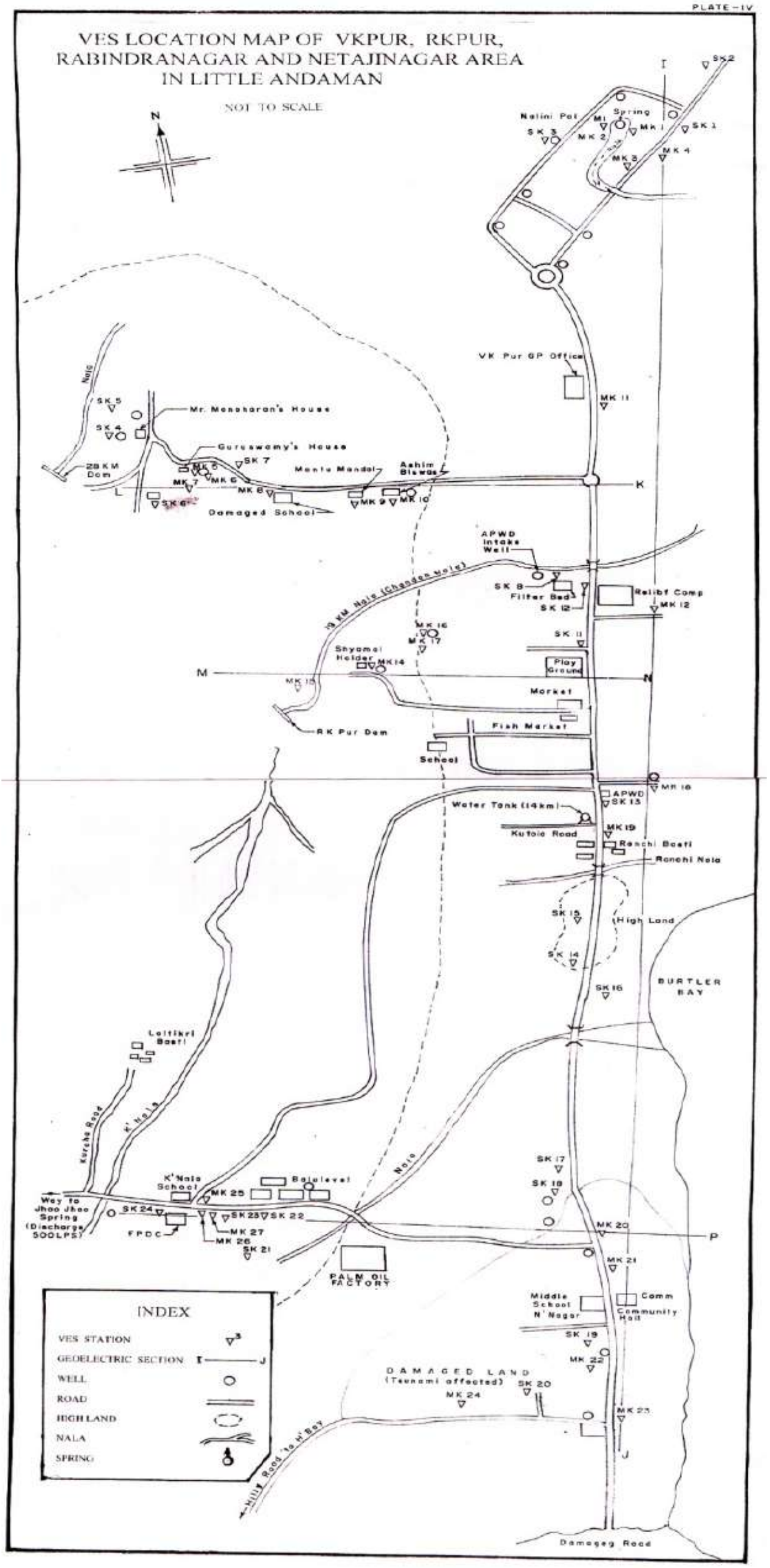


Figure-5.1.2.5: Location Map of VES Station at R.K. Pur, V. K. Pur, Ravindra Nagar and Netaji Nagar area, Little Andaman Island

A total number of fifty one (51) VES were conducted at V K Pur, Rabindranagr, RK Pur, and Netajinagar (Figure-5.1.2.4). Among these areas Netajinagar being low lying area, badly affected by Tsunami, Rabindranagr and R. K. Pur area are partly affected by earth quake and tsunami but V.K. Pur area is completely saved by Tsunami but little affected by earth quake. Different sections are drawn in different orientations over these areas on the basis of interpreted VES data and from the analysis of these sections attempt has been made to delineate fresh water boundaries within the areas of salinity, developed due to Tsunami and earth quake. A geo-electric cross-section I-J is drawn and explained below.

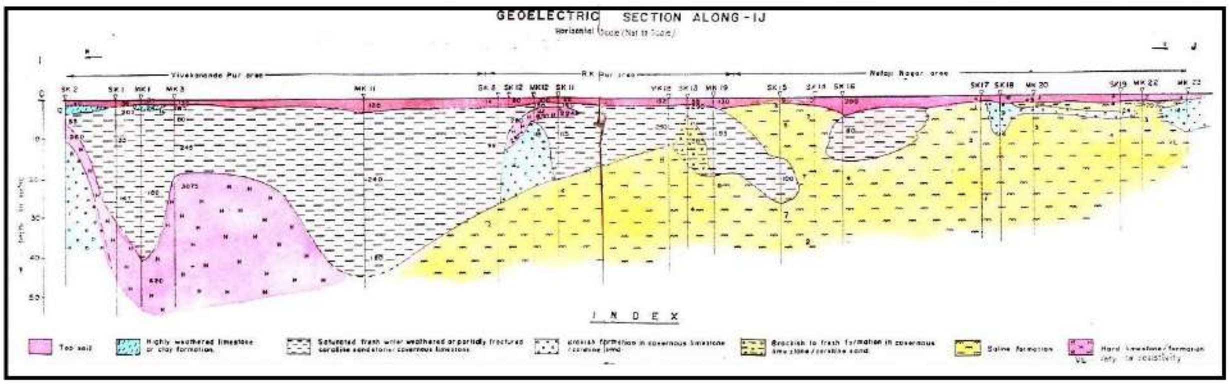


Figure-5.1.2.6: Geoelectric cross-section along I-J

This section is elongated along North to South orientation and passes through the villages Vivekanandpur, Rabindranagr, Ramakrishnapur and Netajinagar. From the section it is observed that VK Pur is almost safe from salinity hazard by Tsunami, R K Pur and Rabindranagr is less affected but Netajinagar is completely damaged by Tsunami saline water except at one place which is showing little thickness of fresh water at VES SK16. From the knowledge of geology and higher order of resistivity values it may presumed that V K Pur, Rabindranagr and Ramkrishnapur etc. are falling under the cavernous limestone area and the Netajinagar area is underlain by coralline sands.

VK Pur in the section shows 3 to 5 layers namely top soil, highly weathered limestone, saturated (fresh water) weathered limestone within the limestone cavity, brackish water within the limestone cavity and massive limestone formation. It is observed from the section that the thickness of saturated fresh water column having resistivity range 53 ohm-m to 245 ohm-m varies from 3.2 m to 38 m. The hard and dry massive limestone shows the resistivity range 560 ohm-m to 3075 ohm-m below the fresh water column. Fractures are also encountered at the V.K. Pur area within the depth ranges 20-30 mbgl, 60-70 mbgl, 80-110 mbgl at VES SK1, MK3 and MK11.

At Rabindranagr and R.K. pur area the thickness range of the saturated fresh water column is 3-25 m is detected within the cavernous lime stone. A dry and hard limestone of resistivity range 650 ohm-m to 2825 ohm-m is interpreted within the cavity at VES SK12, MK12 and SK11. Below this hard formation brackish water within the cavity is established and it shows the resistivity range 14-18 ohm -m. below the fresh or brackish water a low resistive layer i.e. 2 to 6 ohm-m reveals the presence of saline aquifer.

At Netajinagar area i.e., from VES SK15 towards south it is clearly visible from the section that the fresh water column is only observed at VES SK16. It shows the resistivity of 80 ohm-m and the thickness 10.78 m. Due to pronounced withdrawal of water, the water quality might have been improved. At VES, MK20 and MK22 a very thin layer i.e. 0.595 m and 0.798 m of fresh water column of resistivity range 45 ohm-m and 70 ohm-m are observed to be floating over brackish and saline water respectively. At VES, SK18 and MK23 a brackish water column is developed the top soil at the thickness range 7.4 m to 7.58 m. Due to continuous withdrawal of the villagers the quality of the water is improving day by day. These places may be developed for the construction of wells.

Gist of geophysical findings:

From the study of geo electric sections it is clearly understood that the ground water is almost fully contaminated by saline water in Hut bay and Netajinagar area during Tsunami. Rabindranagr and RK Pur areas are less affected by Tsunami and earth quake. V.K. Pur is almost spared from the devastation by Tsunami and the effect of earth quake on ground aquifer system had also been minimal with respect to the other villages.

5.1.3 South Andaman Island

Geophysical survey has been carried out in parts of South Andaman Island of South Andaman district namely area of Airport Authority of India (AAI), Coast Guard premises at Namunaghar, IRBN premises at Port Mount, DBRAIT Premises at Chouldari and around Calicut area of Port Blair. In this regard, a total forty five (45) Nos of Vertical Electrical Soundings (VES) have been carried out to in Sclumberger Configuration to delineate the sub-surface formations for constructing ground water abstraction structures as well as pin point location for artificial recharge structures. The location, interpreted VES curve and recommendation of area wise Geophysical studies are given below in the running text.

1. Airport Authority of India (AAI), Port Blair:

Based on the detailed hydro-geological studies of the area, Vertical Electrical Sounding (VES) were carried out to find out suitable locations for tapping ground water and constructing civil structures to arrest non committed runoff for recharging delineated aquifers. To delineate the sub-surface formations the total three (3) number of VES were carried out in Schlumberger configuration with maximum spread length (AB/2) of 80 m using SSR-MP-AT Resistivity meter to cover the study area in the premises of Port Blair Airport of South Andaman district for Airport Authority of India (AAI). The sounding locations are shown in **Figure-5.1.3.1**.

Figure-5.1.3.1: VES location in the premises of AAI, Port Blair

The final interpreted geo-electrical layer parameters of VES's (layer resistivity and layer depths) are given in **Table-5.1.3.1**.

Table-5.1.3.1: Interpreted layer parameters of VES Curves in AAI, Port Blair.

VES No.	Respective layer Resistivity in (Ohm-m)				Respective layer Depth in (m)		
	ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
VES-01	27	3	13	-	1	5.2	-
VES-02	11	5.5	3	400	1	4.8	29
VES-03	8.5	3.5	600	-	3	29	-

The VES-03 has been carried out close to runway in the premises of port Blair Airport. The observed VES curve is showing three layers earth model. The first layer is having resistivity value 8.5 Ohm-m and thickness of 3 m is top soil. The second layer with resistivity value 3.5 Ohm-m and depth upto 29 m is indicative of clay/mudstone formation. The third and last layer is having resistivity value 600 Ohm-m upto depth of investigation i.e. 50 m is indicative of fractured hard rock formation. This location is suitable for tapping fresh ground water between depth ranges of 29 to 50 m.

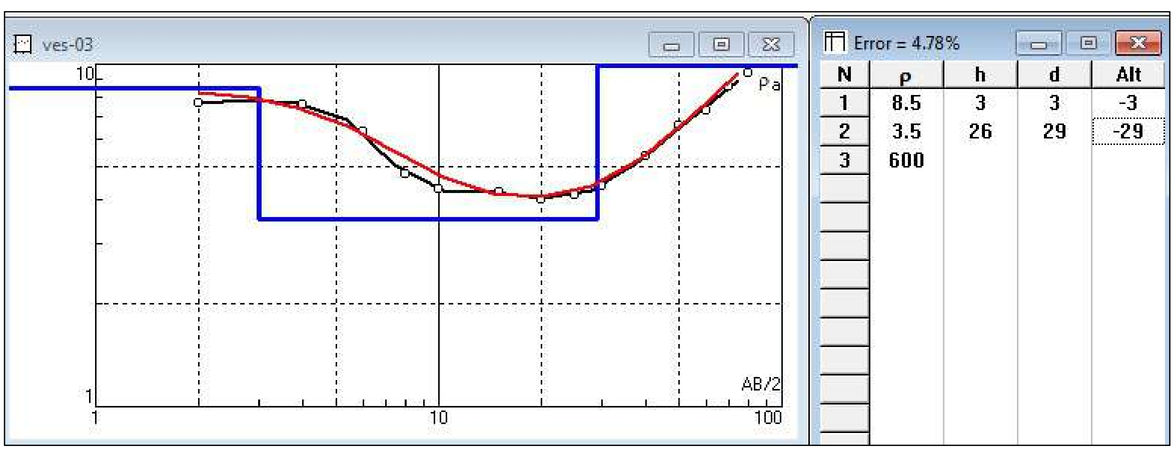


Figure-5.1.3.2: Interpretation of VES-03 at AAI, Port Blair in South Andaman Island

2. Coast Guard Premises, Namunaghar:

Based on the detailed hydro-geological studies of the area, Vertical Electrical Sounding (VES) were carried out to find out suitable locations for tapping ground water and constructing civil structures to arrest non committed runoff for recharging delineated aquifers. To delineate the sub-surface formations the total one (1) number of VES were carried out in Schlumberger configuration with maximum spread length (AB/2) of 100 m using SSR-MP-AT Resistivity meter to cover the study area in the new premises of Coast Guard near village Namunaghar in South Andaman island of South Andaman district. The sounding locations are shown in **Figure-5.1.3.3**.

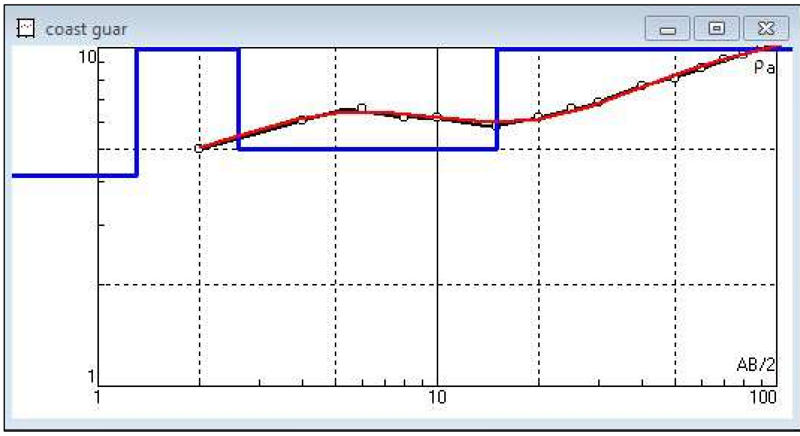
Figure-5.1.3.3: VES location in the premises of the Coast Guard, Namunaghar

The final interpreted geo-electrical layer parameters of VES's (layer resistivity and layer depths) are given in **Table-1**.

Table-5.1.3.2: Interpreted layer parameters of VES Curve in Coast Guard premises, Namunaghar

VES No.	Respective layer Resistivity in (Ohm-m)				Respective layer Depth in (m)		
	ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
VES-01	4.2	12	5	12	1.3	2.6	15

The VES-01 has been carried out in the new premises of Coast Guard near village Namunaghar in South Andaman district. The observed VES curve is showing four layers earth model. The first layer is having resistivity value 4.2 Ohm-m and thickness of 1.3 m is top soil. The second layer with resistivity value 12 Ohm-m and depth upto 2.6 m is indicative of clay/mudstone formation mixed with Kankar. The third layer with resistivity value 5 Ohm-m and depth upto 15 m is indicative of clay/mudstone formation saturated with water. The fourth and last layer is having resistivity value 12 Ohm-m upto depth of investigation i.e. 50 m is indicative of mud rock formation with Kankar. This location is not suitable for tapping fresh ground water upto depth of 50 m.



N	ρ	h	d	Alt
1	4.2	1.3	1.3	-1.3
2	12	1.3	2.6	-2.6
3	5	12.4	15	-15
4	12			

Figure-5.1.3.4: Interpretation of VES-01 at Namunaghar, Port Blair in South Andaman Island

3. IRBN, Port Mount, Port Blair:

The purpose of the present investigation was mainly to study the hydrological properties of the underlying geological formation in the reservoir for de-siltation as also to study the hydrogeology of the area to find out the feasibility of locating viable water supply sources through rainwater harvesting for augmentation of water supply inside the IRBN campus as also to suggest the remedial measures to lessen the siltation in the reservoir to augment the water supply. The hydro geological investigation in the area includes the study and analysis of data in and around the campus area and to assess the feasibility of rainwater harvesting To delineate the sub-surface formations the total three (3) number of VES were carried out in Schlumberger configuration with maximum spread length (AB/2) of 90 m using SSR-MP-AT Resistivity meter to cover the particular study area in IRBN campus near village Mount Port in South Andaman Island of South Andaman district. The sounding locations are shown in **Figure-5.1.3.5**.

The final interpreted geo-electrical layer parameters of VES's (layer resistivity and layer depths) are given in Table-1.

Table-5.1.3.3: Interpreted layer parameters of VES Curves in IRBN, Port Mount, Port Blair

VES No.	Respective layer Resistivity in (Ohm-m)				Respective layer Depth in (m)		
	ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
VES-01	80	40	17	32	1.2	5.5	15
VES-02	178	48	5		3.1	34.5	
VES-03	45	117	38	14.5	1	2	8.5

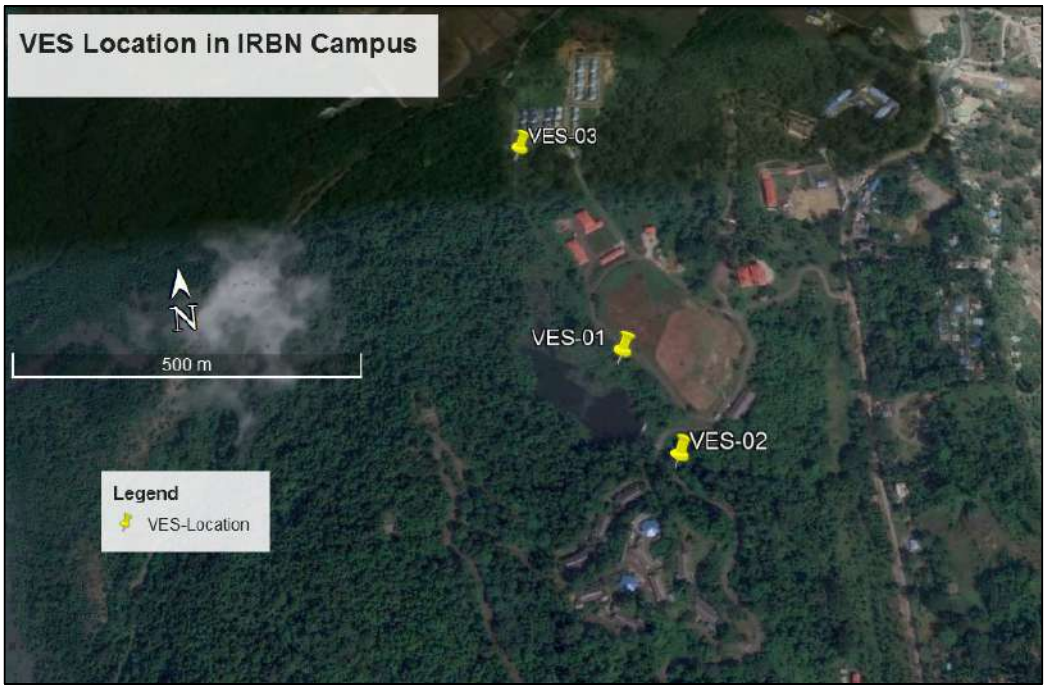


Figure-5.1.3.5: VES location in the premises of IRBN, Port Mount, Port Blair

The VES-01 has been carried out adjacent to reservoir area in IRBN campus. The observed VES curve is showing four layers earth model. The first layer is having resistivity value 80 Ohm-m and thickness of 1.2 m is top soil. The second layer with resistivity value 40 Ohm-m and depth upto 5.5 m is indicative of weathered sandstone. The third layer with resistivity value 17 Ohm-m and depth upto 15 m is indicative of shale formation. The fourth and last layer is having resistivity value 32 Ohm-m upto depth of investigation i.e. 35 m is indicative of fractured fine grained sandstone. Possibility of occurrence of fresh ground water is envisaged upto a depth of 15 m.

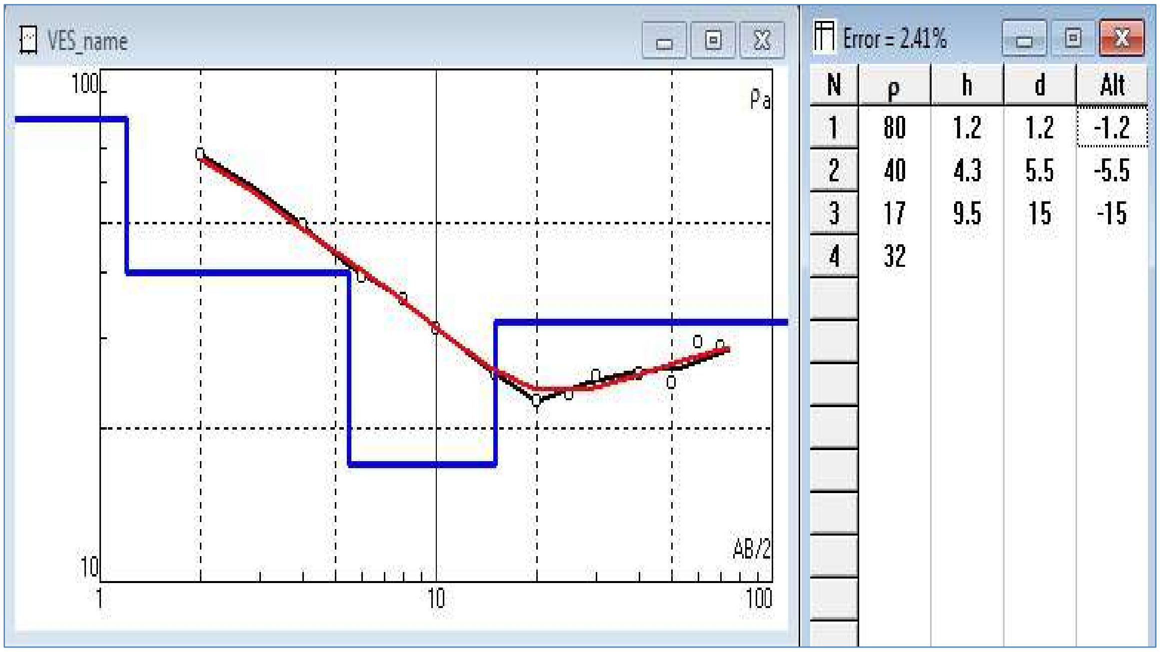


Figure-5.1.3.6: Interpretation of VES-01 at IRBN, Port Mount, Port Blair

To adjudge the actual depth of silt deposition application of ERT (Electrical resistivity tomography technique) is the best option which can also unravel the structural weakness like cracks and fissures in the underlying rock formation. In absence of ERT instrument in CGWB, Eastern Region, and the desired study could not be taken up in the reservoir. For this the electrical resistivity sounding studies were taken in and around the reservoir to adjudge the subsurface hydrogeological properties of the rock formation. From the obtained results of geophysical studies as also from the in depth hydrogeological studies on the rock formations in the entire Islands including the surroundings, it may be opined that the underlying rock formations possess occasional fracture and fissures and it can also be generated easily from the minor tremors even which are very common in the tectonically active A&N Islands. However, the fractures are generally clogged with in short period due to preponderance of easily derived clay and silt from the parent rock.

4. DBRAIT, Chouldari, Port Blair:

To delineate the sub-surface formations the total four (4) number of VES were carried out in Schlumberger configuration with maximum spread length (AB/2) of 90 m using SSR-MP-AT Resistivity meter to cover the particular study area in DBRAIT campus near village Chouldari of South Andaman district. The sounding locations are shown in **Figure-5.1.3.7**.

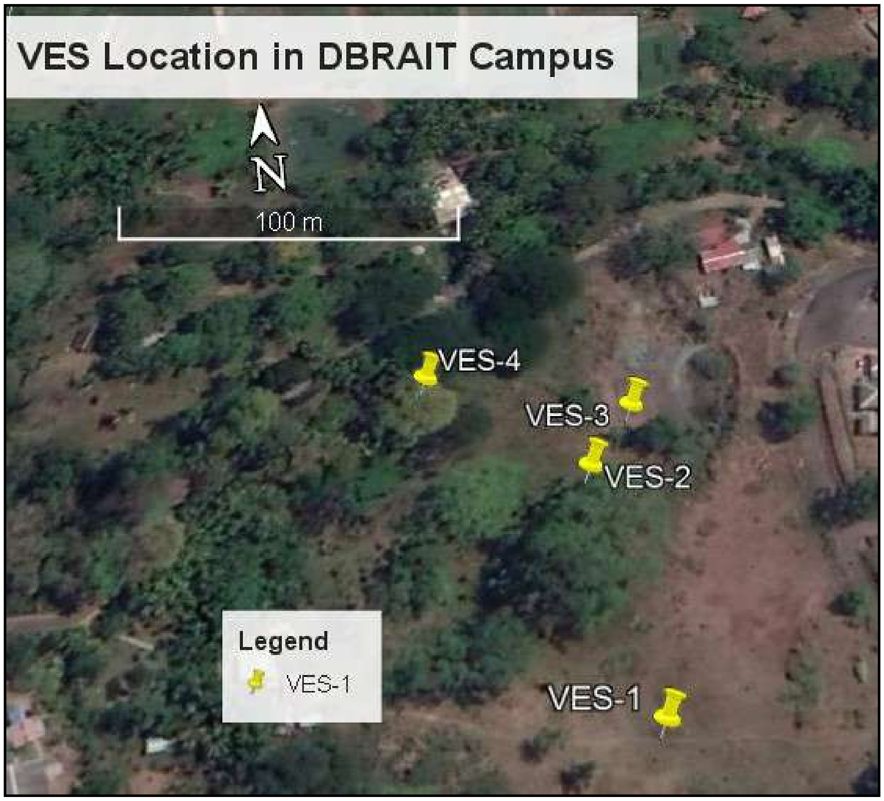


Figure-5.1.3.7: VES location in the premises of DBRAIT, Chouldari, Port Blair

The final results were corroborated with the known hydro-geological conditions existing in the area. The final interpreted geo-electrical layer parameters of VES's (layer resistivity and layer depths) are given in **Table-5.1.3.4**.

Table-5.1.3.4: Interpreted layer parameters of VES Curves in DBRAIT, premises Chouldari.

VES No.	**Respective layer Resistivity in (Ohm-m)**				**Respective layer Depth in (m)**		
	ρ_1	ρ_2	ρ_3	ρ_4	**D_1**	**D_2**	**D_3**
VES-1	3.2	32	1	36	0.6	2.3	4.6
VES-2	8.5	6.2	-	-	2.5	-	-
VES-3	136	31	1.8	1000	0.7	5.4	10.4
VES-4	5.6	9	1080	-	4.5	22	-

The VES-01 has been carried out at highest location of the DBRAIT campus. The observed VES curve is showing four layers earth model. The first layer is having resistivity value 3.2 Ohm-m and thickness of 0.6 m is top clayey soil. The second layer with resistivity value 32 Ohm-m and depth upto 2.3 m is indicative of clay mixed with Kankar. The third layer with resistivity value 1 Ohm-m and depth upto 4.6 m is indicative of saline formation. The fourth and last layer is having resistivity value 36 Ohm-m upto depth of investigation i.e. 40 m is indicative of clay mixed with Kankar.

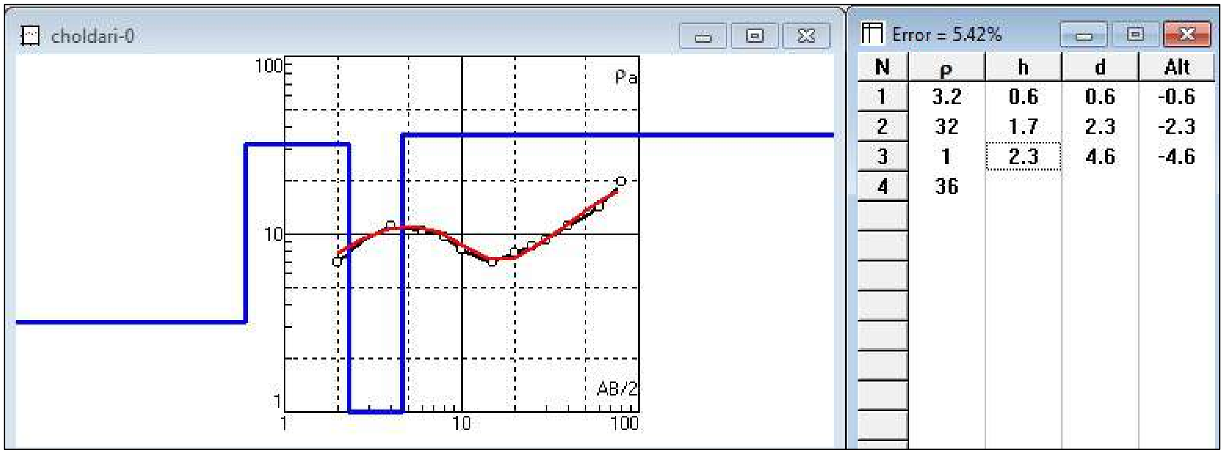


Figure-5.1.3.8: Interpretation of VES-01 at DBRAIT, Chouldari, Port Blair

- The VES locations VES-1 and VES-2 are not suitable for drilling purposes as the occurrence of clay is there upto depth of 40 m bgl.
- The VES locations VES-3 and VES-4 are suitable for drilling purposes as the occurrence of fractured hard rock is there upto depth of 40 m bgl.

5. Calicut Area:

To delineate the sub-surface formations the total thirteen (13) number of VES were carried out in Schlumberger configuration with maximum spread length (AB/2) of 90 m using SSR-MP-AT Resistivity meter to cover the study area around Calicut of South Andaman district in Andaman & Nicobar Islands. The sounding locations are shown in **Figure-5.1.3.9**.

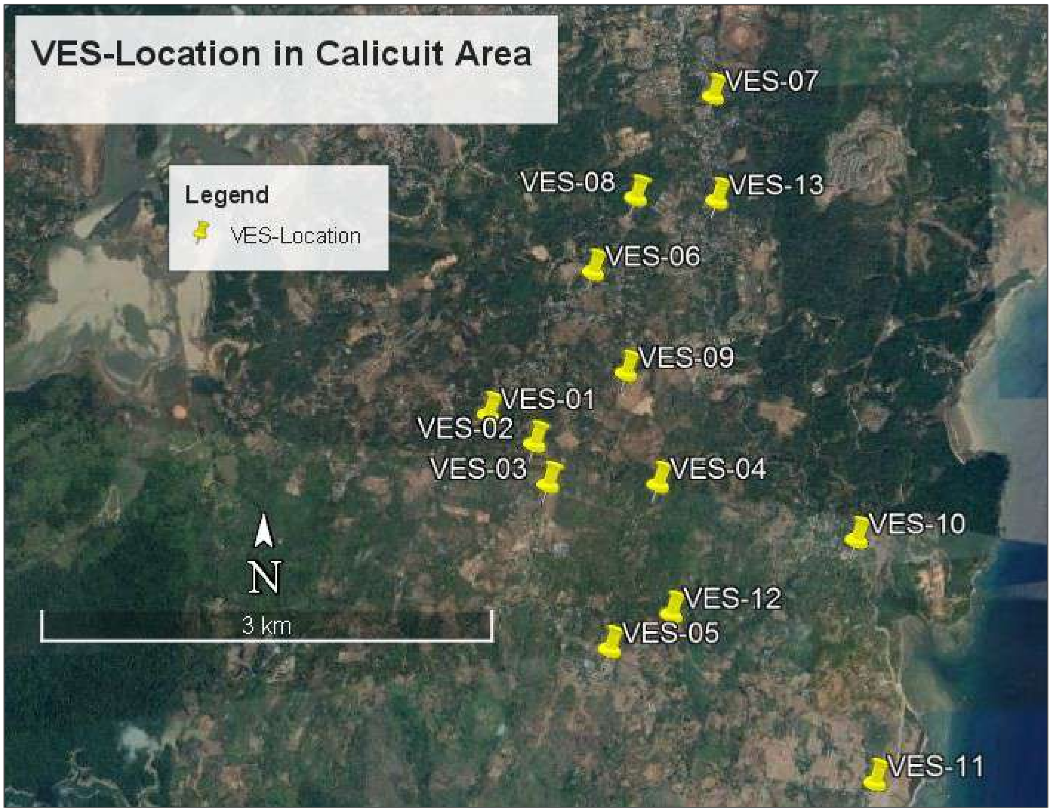


Figure-5.1.3.9: VES location around Calicut area, Port Blair

The final results were corroborated with the known hydro-geological conditions existing in the area. The final interpreted geo-electrical layer parameters of VES's (layer resistivity and layer depths) are given in **Table-5.1.3.5**.

The Igneous suite of rocks (Ophiolites) sustain good amount of water both in shallow and deeper horizons. Bore wells were being successfully constructed in these formations. A dug well 5m diameter and 6m depth used to yield to the tune of 15,000 to 30,000 liters/day, while a bore well 60m deep and 6" diameter yields 50,000 to 80,000 litres /day. The interpretation of fourteen (14) VES around Calicut area infers that the existing hard rock consists of two fracture zones, 14-20 m bgl and 45-50 m bgl having potential ground water zones in the area.

Table-5.1.3.5: Interpreted layer parameters of VES Curves in in Calicut area, Port Blair

VES No.	Respective layer Resistivity				Respective layer Depth		
	ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
VES-01	26	11	1100	25	1	3.5	12
VES-02	29	21	950	15	1	5	13
VES-03	36	18	116	40	1.2	3.2	40
VES-04	7.8	120	15	-	6	28	-
VES-05	12	59	15	-	3.5	18	-
VES-06	12	95	44	-	1.8	28	-
VES-07	12	5.5	1100	-	2.7	20	-
VES-08	44	62	220	-	2.7	19	-
VES-09	10	22	260	15	1	6.5	15
VES-10	24	8.5	92	-	1	2.8	-
VES-11	13	5.5	430	1	2.4	5	14.5
VES-12	18	38	500	15	2.3	12	36
VES-13	43	34	3000	-	4.7	31	-

The VES-12 has been carried out at Beadnabad basti in Calicut area. The observed VES curve is showing four layers earth model. The first layer is having resistivity value 18 Ohm-m and thickness of 2.4 m is top sandy soil. The second layer with resistivity value 37 Ohm-m and depth upto 11 m is indicative of weathered rock formation. The third layer with resistivity value 300 Ohm-m and depth upto 45 m is indicative of fractured hard rock formation. The fourth and last layer is having resistivity value 45 Ohm-m upto depth of investigation i.e. 60 m is indicative of highly fractured rock formation. This location is suitable for exploration upto 80 m to tape ground water zones.

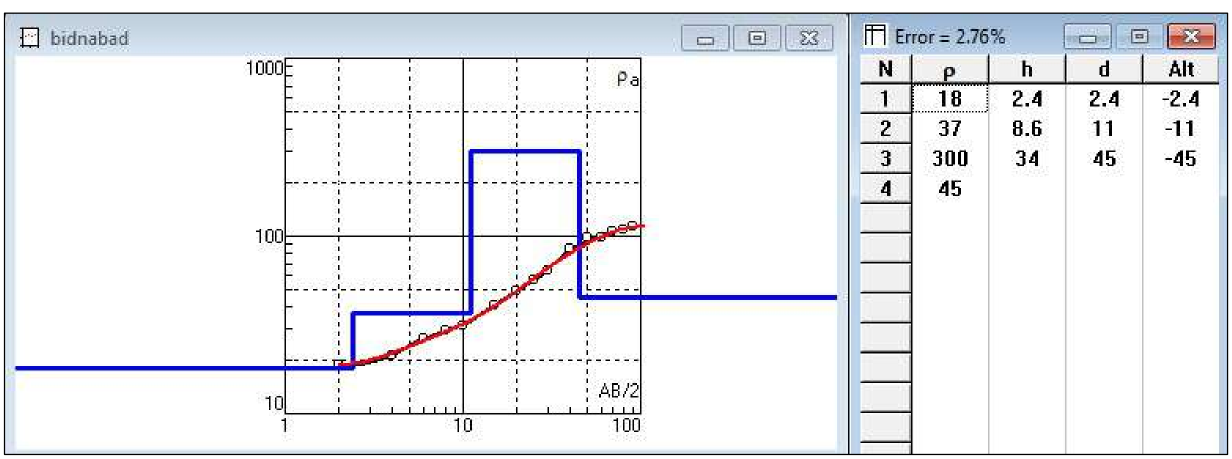


Figure-5.1.3.10 Interpretation of VES-12 at Beadnabad around Calicut area, Port Blair

Chapter 6

HYDROGEOLOGY

The Study area of South Andaman district is Hydrogeologically the Quaternary formations represented by Beach sand, Corals rags, thin alluvium cover, restricted in distribution as narrow linear tract along the coast, and intermontane valleys constitute the unconsolidated group. The marine sedimentary rocks comprising the Andaman flysh and the Mithakhari sandstone characterised by hard and compact nature, warrant grouping under semi-consolidated sedimentary formations, and the volcanic suits of rocks characterised by fracture porosity fall under the group of fissured formation. Ophiolite suite marine sedimentary rocks of Palaeocene to Oligocene age and recent to sub recent beach sand, Mangroves clay, alluvium and coral rags are exposed in the South Andaman. The marine sedimentary rocks occupy more than 80% of the area **Figure-6.**

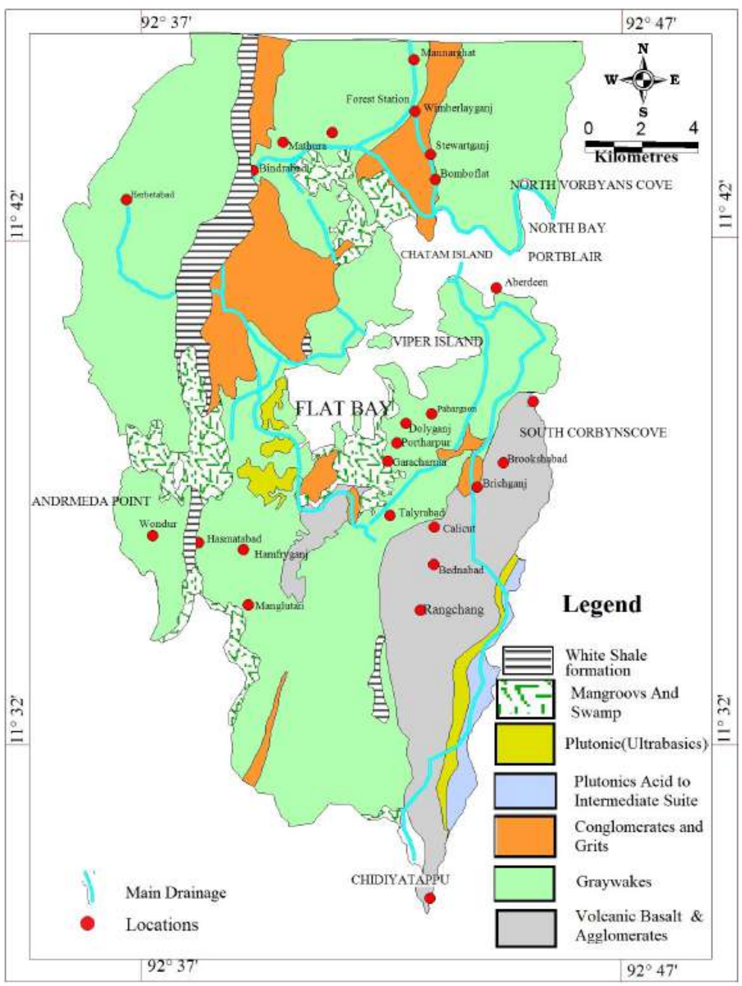


Figure: 6: Geological map of the Portblair area of South Andaman Island

6.1 Water bearing Formation:

In the study area the shallow Aquifers occur in different formation, viz. beach sand with coral rags and shells, alluvium cover in the valleys and colluviums in the intermontane valleys. These constitute the shallow water table aquifers. Maximum thickness of sediments is up to 9.0 mbgl. Structural thickness of the aquifer varies from 1.5 m in summer to 6m in rainy season. Generally ground water occurs as fresh water lens over saline water, as is characteristic of hydrogeological situation of all Islands.

6.2 Aquifer characteristics, groundwater regime, depth to water levels, wells, hydrograph analysis and Pre & Post - monsoon long term trend analysis

The shallow aquifer in the weathered sandstone intercalated with shales gives a unit specific capacity value of 1.1.2 lpm/m. Weathered residuum is encountered up to 6 mbgl; yield from dug wells tapping this aquifer as near Carbyons Coves is in the order of 15 – 20,000 litres per day (lpd) in post monsoon period. The thickness of weathered residuum in volcanic rocks varies from 3 – 6 mbgl. Dug wells in weathered volcanic rocks as near Chidiyatapu is capable of yielding up to 30,000 lpd over duration of 3 cycle of pumping.

Springs and their role in water supply: There are small numbers of small springs originating from the forest-clad hills in both the Igneous and sedimentary rocks area, which is being utilised by PHED for pipeline water supply in rural areas. In fact the major streams are mostly spring-fed and they retain some amount of base flow in the lean month, however measurement of base flow in different streams has not been conducted so far.

Most of the stream channel has been bounded at higher altitude to create small reservoir from which water flows down by gravity through pipelines to the door step of users in village along the foothills. With the recession of ground water table in lean month majority of springs dry up.

6.2.1 Neil Island

The Neil Island is a picturesque tiny island of South Andaman district. Population of the Island as per 2011 census is 6931. Total geographical area of the Island is 18 Sq. Km. the Island enjoys tropical monsoon climate and the average annual rainfall is about 3000mm. The Island is situated about 36 Km northeast of Port Blair city, the capital of Union Territory of Andaman & Nicobar Islands. Post-tsunami the Island has been projected as an important tourist destination. Consequently day by day the influx of tourists is increasing by leaps and bounds. The Island is also an important producer of vegetables, which is transported everyday to Port Blair. In the absence of surface water resources, the Island is totally dependent on ground water resources. The Island is underlain by Silt stone-Mud stone-Chalk stone sequence of Archipelago group, which is overlain by coralline limestone of variable thickness, which forms the major repository of ground water (**Figure-6.2.1.1**). At places where the thickness of coralline formation is thin or negligible, brackish/saline water is generally encountered. So far there is no detailed study carried out by any Govt. Department as also research organization except CGWB on aquifer mapping studies and management of ground water resources. In 2016 a Task force on Water supply was constituted at the Secretariat of Andaman & Nicobar Administration under the Chairmanship of Chief Secretary, A&N Administration, where the expert scientist of CGWB was inducted as a member. As per the decision of Task Force as also on demand of Head of PRI (Pradhan) of Neil Island, the detailed works were undertaken.

Ground water in Marine sedimentary formation occurs under unconfined condition in weathered residuum. Preponderance of clayey mineral renders groundwater development possibility very low. Yield of dug well (5- 6m dia, 6 m depth) in Marine sedimentary group varies from 4000 - 5000 liters/day. Ground water in Ophiolites occurs under unconfined to semi-confined condition in weathered residuum, while in fractured hard rock in deeper horizon in confined condition. Yield of dug well (5 - 6m dia, 6m depth) in Marine sedimentary group varies from 40,000-50,000 liters/day. In case of bore well ($6^{//}$dia, 80m deep) yield varies from 80,000-1, 00,000 liters per day. In Coralline limestone of archipelago group yield of dug well (5 - 6m dia, 4 - 5 m depth) varies from 80,000-1,00,000 liters/day. Springs are profuse in all the geological formations. However, springs are sustainable in Ophiolites and archipelago group.

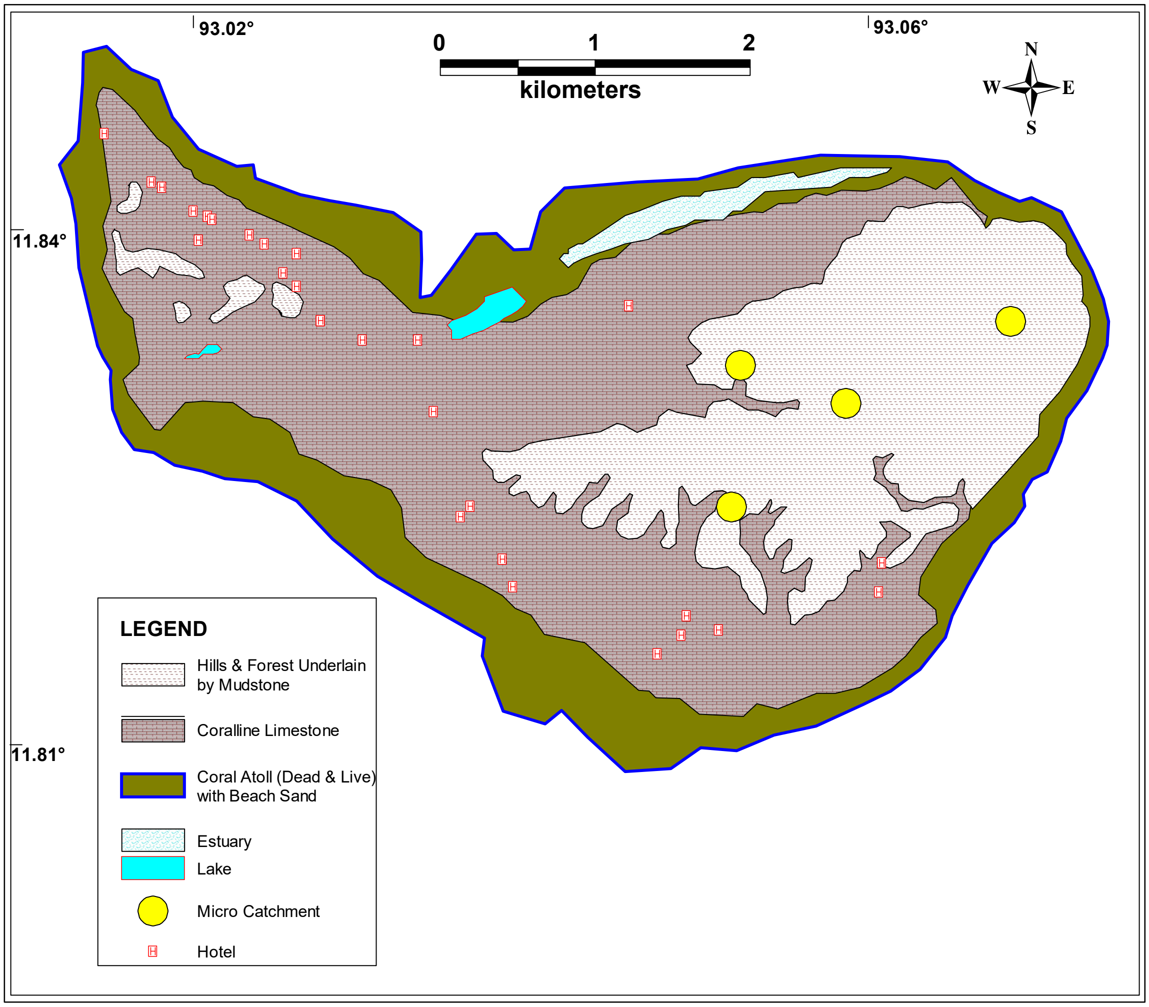


Figure-6.2.1.1: Geological map of Neil Island

Around 35% of area in eastern part of Neil Island is covered with hills and forest underlain by Mudstone. This area is suitable for constructing water conservation structures by considering micro catchments. Remaining part of the Island is covered with coralline limestone of variable thickness surrounded by coral atoll (dead & live) with beach sand. This area mainly constitutes the aquifer system in the Island and is exploited through dug-wells.

The pre monsoon water level map, post monsoon water level map and water level fluctuation for the year 2017 in Neil Island are shown in **Figure-6.2.1.2**, **Figure-6.2.1.3** and **Figure-6.2.1.4** respectively. Further a hydrograph of Pearl Park Hotel, Laxmanpur Village in Neil Island is shown in **Figure-6.2.1.5.**

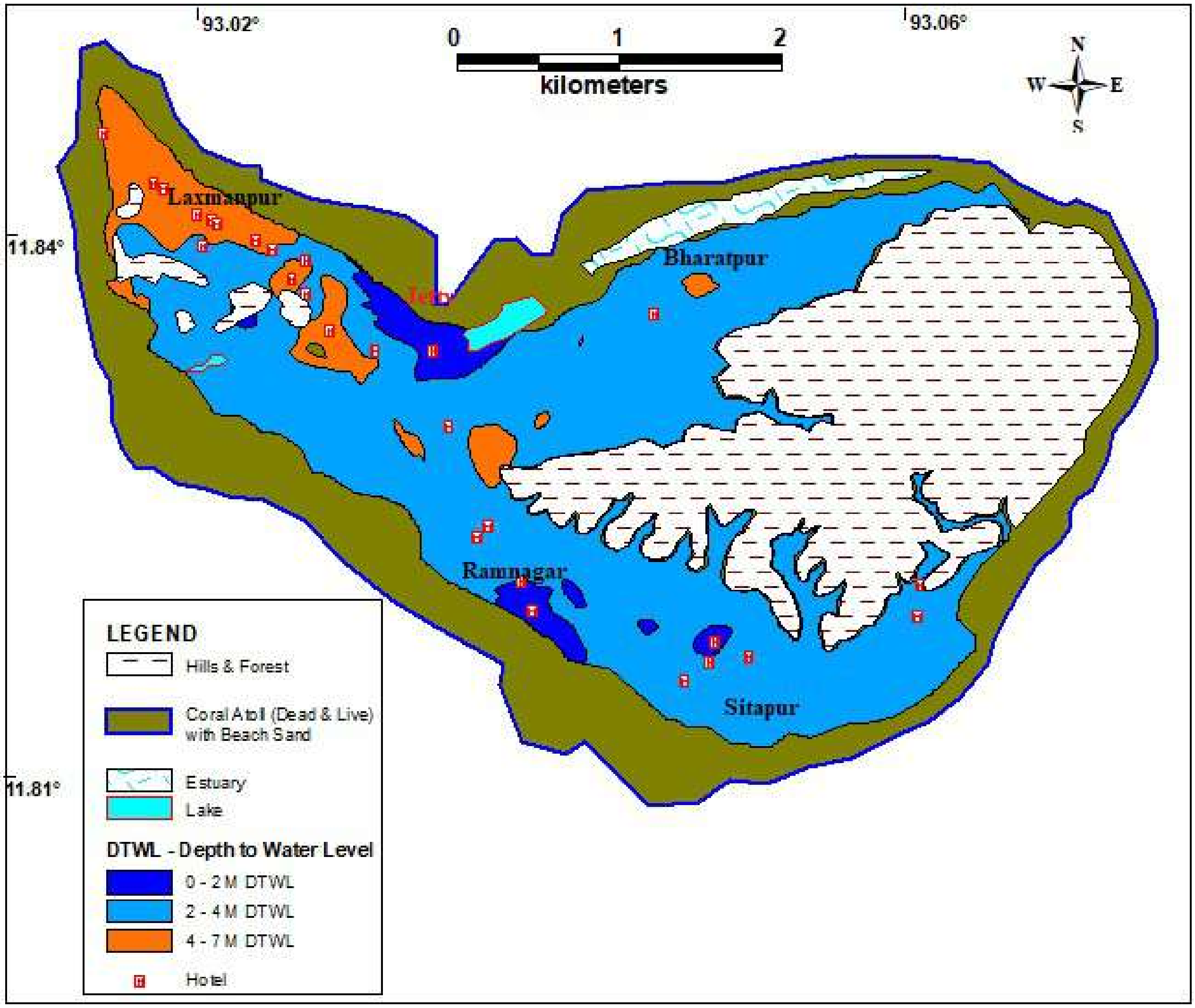


Figure-6.2.1 .2 Pre-monsoon water level map in Neil Island (2017)

In pre-monsoon the water level 0 - 2 mbgl is near Neil Jetty area in Neil kendra Village and southern part of Ramnagar village along the coast. The pre-monsoon water level range between 2 to 4 mbgl has been noticed predominantly spread over the entire Island. The area of Laxmanpur village, central Neil Kendra village & some part of Bharatpur village is showing Pre-monsoon water level range between 4-7 mbgl.

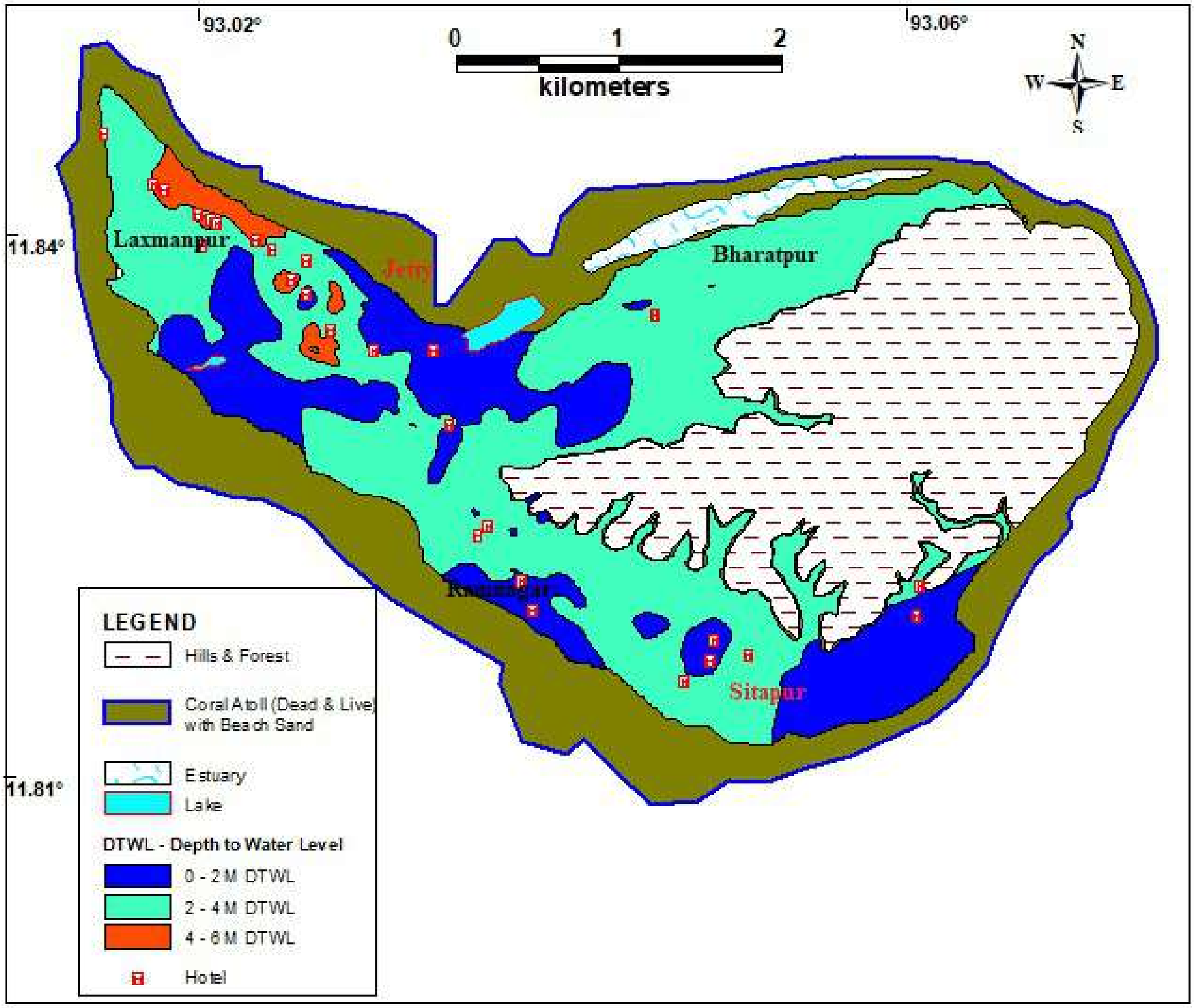


Figure-6.2.1 .3 Post-monsoon water level map in Neil Island (2017)

In post-monsoon the water level 0 - 2 mbgl is near Neil Jetty area in Neil kendra Village and southern part of Ramnagar village, Laxmanpur village along the coast and entire part of Sitapur village. The post-monsoon water level range between 2 - 4 mbgl is spread over the entire Island. The area of Northern Laxmanpur village along the coast & central Neil Kendra village is showing Post-monsoon water level range between 4 - 6 mbgl.

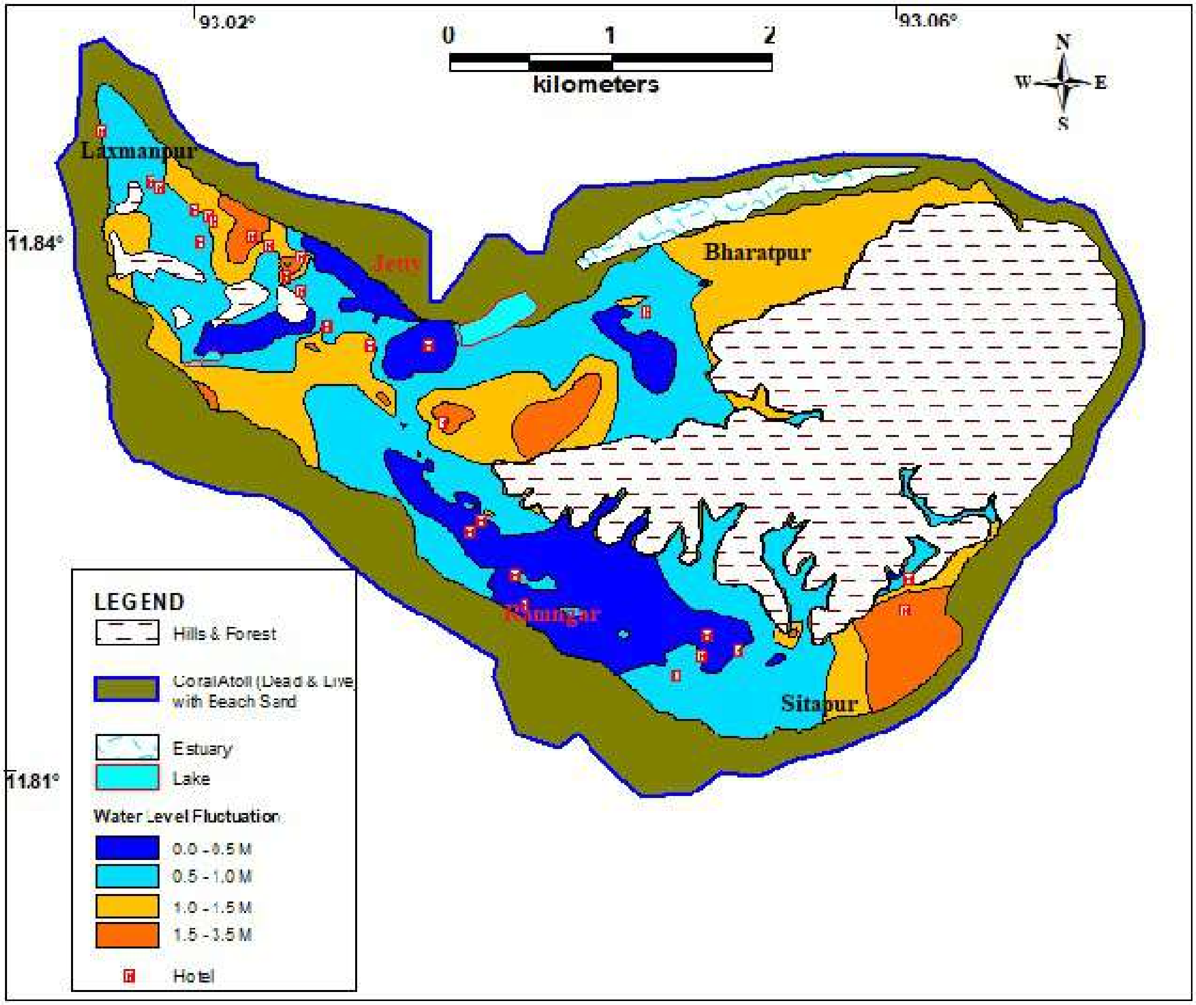


Figure-6.2.1 .4 water level Fluctuation Map in Neil Island (2017)

Water level fluctuation range between 0.0 - 5 m is in Ramnagar village and Northern Part of Neil kendar, central part of Bharatpur and Laxmanpur villages. The Fluctuation range between 0.5 -1.0 m is in the area of Bharatpur village, Laxmanpur Village and some part of Neil Kendra and Ramnagar villages, the fluctuation range between 1.0 – 1.5 m is spread over the eastern Bahratpur, Western part of Sitapur and Suthern Laxmanpur. The Maximum fluctuation range 1.5 – 3.5 m is spread over Sitapur Village Central Bharatpur village and parts of northern Laxmanpur village.

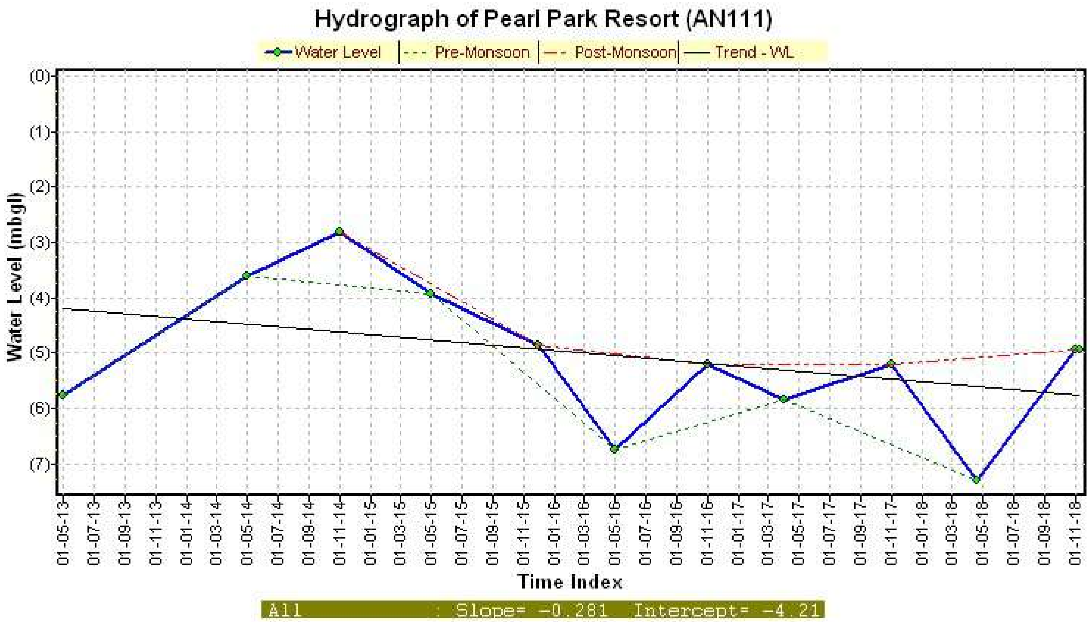


Figure-6.2.1.5 Hydrographs at **site Pearl Park Hotel, Laxmanpur Village in Neil Island**

The long term trend analysis reveals that there is a falling trend at two Locations during Pre-monsoon and two locations during Post-monsoon periods. The Pre-monsoon falling trend varies from 0.492 m/year (in Pearl Park Resort) to 0.012 m/year (in Sitapur). The Post-monsoon falling trend varies from 0.051 m/year (in Neil Kendra) to 0.458 m/year (in Pearl Park Resort). Details of pre-monsoon and post-monsoon water level trend (from 2009 to 2018) in cm/year for individual village is given in **Table- 6.2.1.1,** this is due to heavy exploitation of ground water by the new hotels constructed to cater the need of increasing tourism in Neil Island.

Table- 6.2.1.1 Trend ground water Level District South Andaman, Neil Island (2009-2018)

Tehsil /Taluk/ Island	**Location**	**Well No**	**Pre- Monsoon**		**Post- Monsoon**	
			Rise (meter/yr)	**Fall** (meter/yr)	**Rise (meter/yr)**	**Fall** (meter/yr)
Neil Island	**Bharatpur - 1**	AN060	0.006	-	0.107	-
Neil Island	**Bharatpur - 2**	AN061	0.002	-	0.092	-
Neil Island	**Laxmanpur**	AN063	0.012	-	0.055	-
Neil Island	**Neil Kendra**	AN110	0.073	-	-	0.051

Neil Island	**Pearl Park Resort**	AN111	-	0.492	-	0.458
Neil Island	**Sitapur**	AN062	-	0.012	0.028	-

6.2.2 Havelock Island

Havelock Island is one of the largest islands of South Andaman district. Population of the Island as per 2011 census is 6331. Total geographical area of the Island is 114 Sq. Km. The Island enjoys tropical monsoon climate and the average annual rainfall is about 3000 mm. The Island is situated about 41 Km northeast of Port Blair city, the capital of Union Territory of Andaman & Nicobar Islands. Post-tsunami the Island has been projected as an important tourist destination. Consequently day by day the influx of tourists is increasing by leaps and bounds. The Island is also an important producer of vegetables which is transported everyday to Port Blair. In the absence of surface water resources, the Island is totally dependent on ground water resources. The Island is underlain by Silt stone - Mud stone - Chalk stone sequence of Archipelago group, which is overlain by coralline limestone of variable thickness, which forms the major repository of ground water (**Figure-6.2.2.1**)

Havelock is one of the few places that the administration of the Union Territory of Andaman and Nicobar Islands, has permitted and encouraged development of tourism, with a focus on promoting eco-tourism. Havelock Island avoided much of the devastation by the 2004 Indian Ocean earthquake and its resulting tsunami, as there were no documented casualties. There is a lighthouse at the northern point of the island, near Govind Nagar, established in 2005. The geological map of Havelock Island is shown in **Figure-6.2.2.2**.

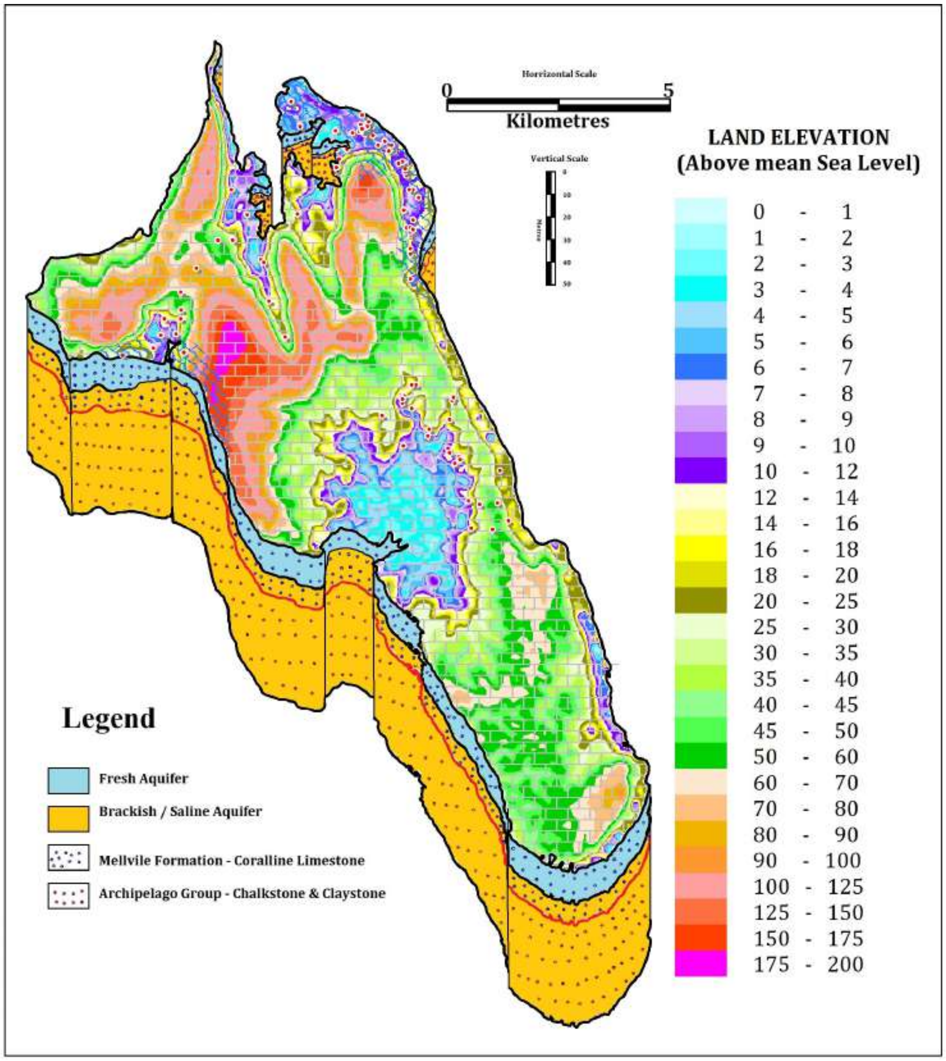


Figure-6.2.2.1: Aquifer Disposition in Havelock Island with Land elevation.

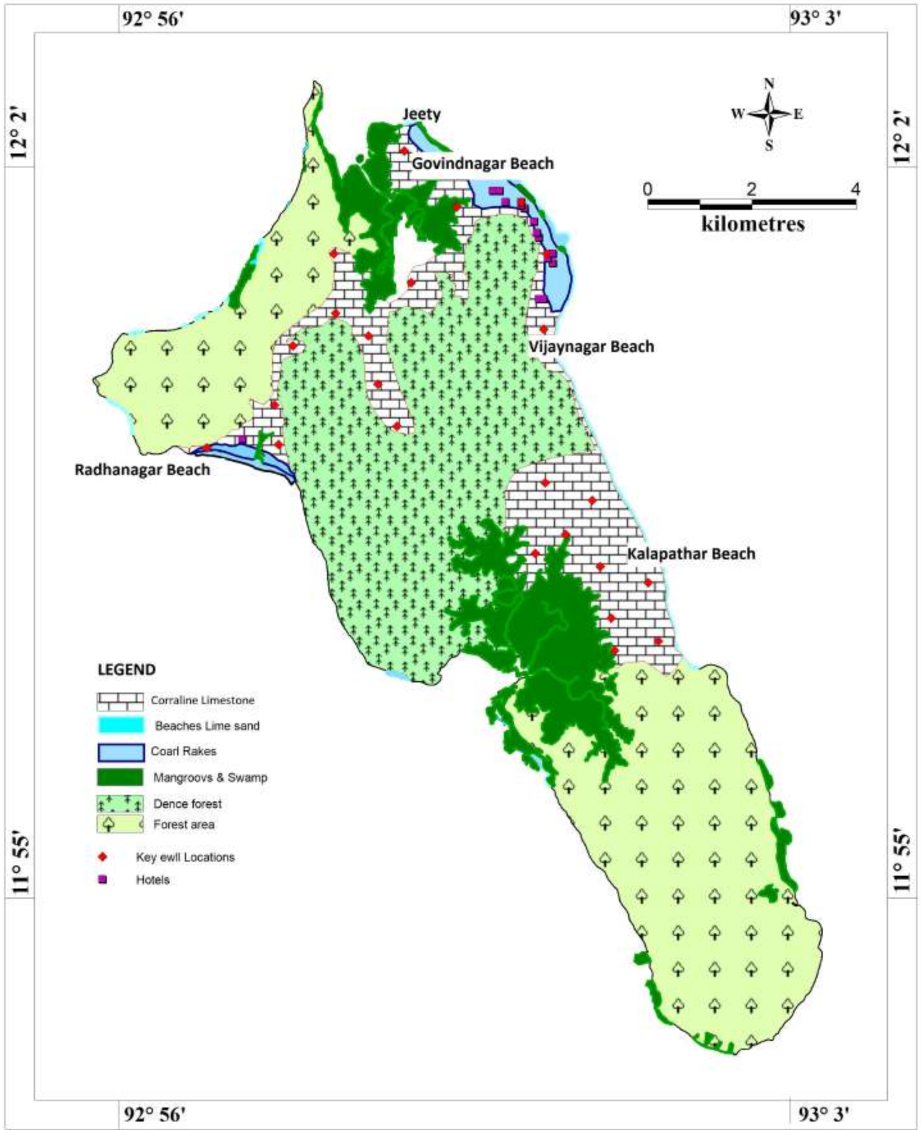


Figure-6.2.2.2: Geological map of Havelock Island

The pre monsoon water level map, post monsoon water level map and water level fluctuation for the year 2017 in Havelock Island are shown in **Figure-6.2.2.3**, **Figure-6.2.2.4** and **Figure-6.2.2.5** respectively. Further a hydrograph near Havelock Jetty in Havelock Island is shown in **Figure-6.2.2.6.**

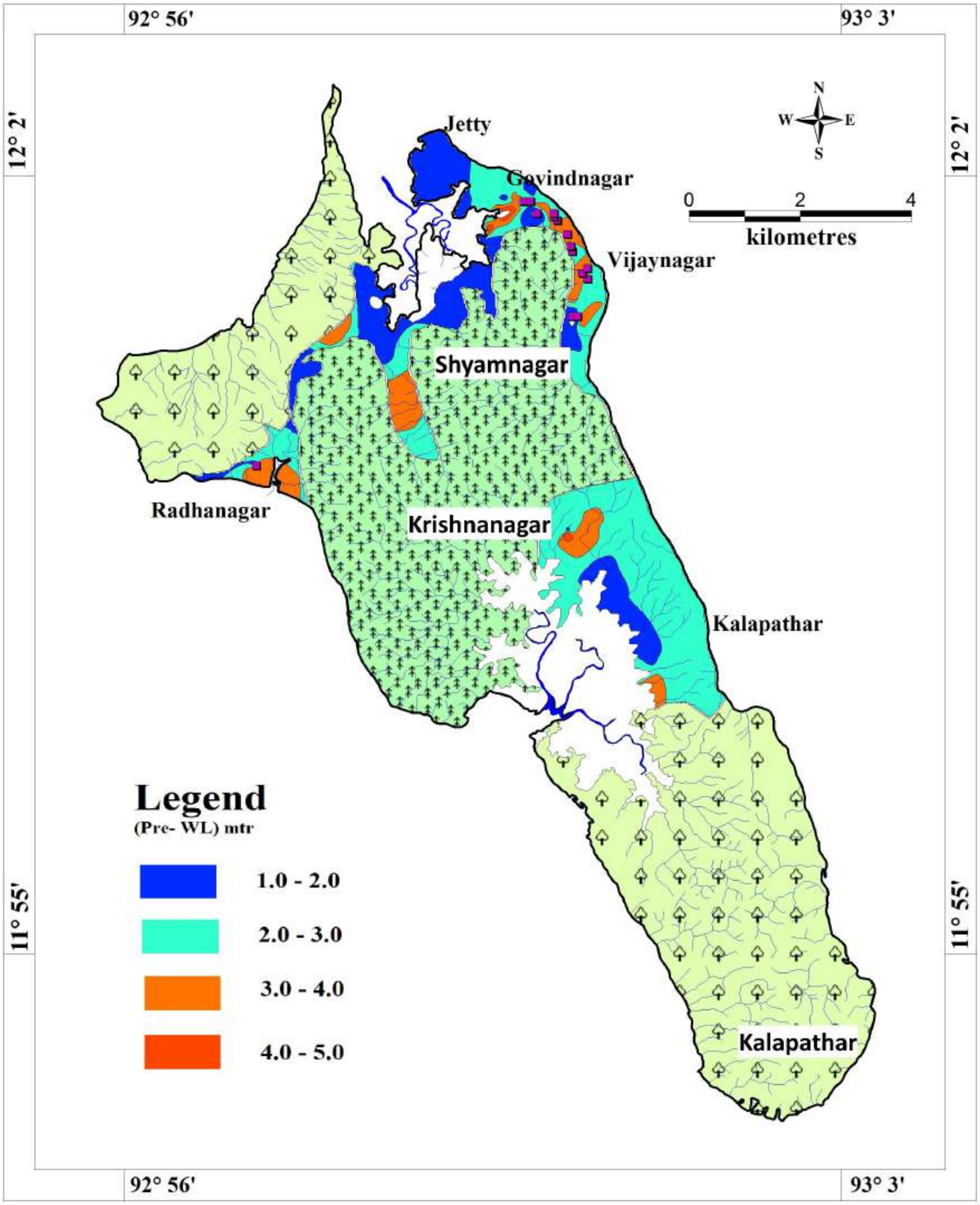


Figure-6.2.2.3 Pre-monsoon water level map in Havelock Island (2017)

In pre-monsoon the water level ranges between 0 - 2 m is near Shyamnagar village area in Havelock Island and southern part of Kalapthar village along the coast. The pre-monsoon water level range between 2 to 3 mbgl has been noticed predominantly spread over the entire Island more than 80%. The area of Krisnanagr village, central Havelock island & some part of Vijaynagar village is showing Pre-monsoon water level range between 4 - 5 mtrs.

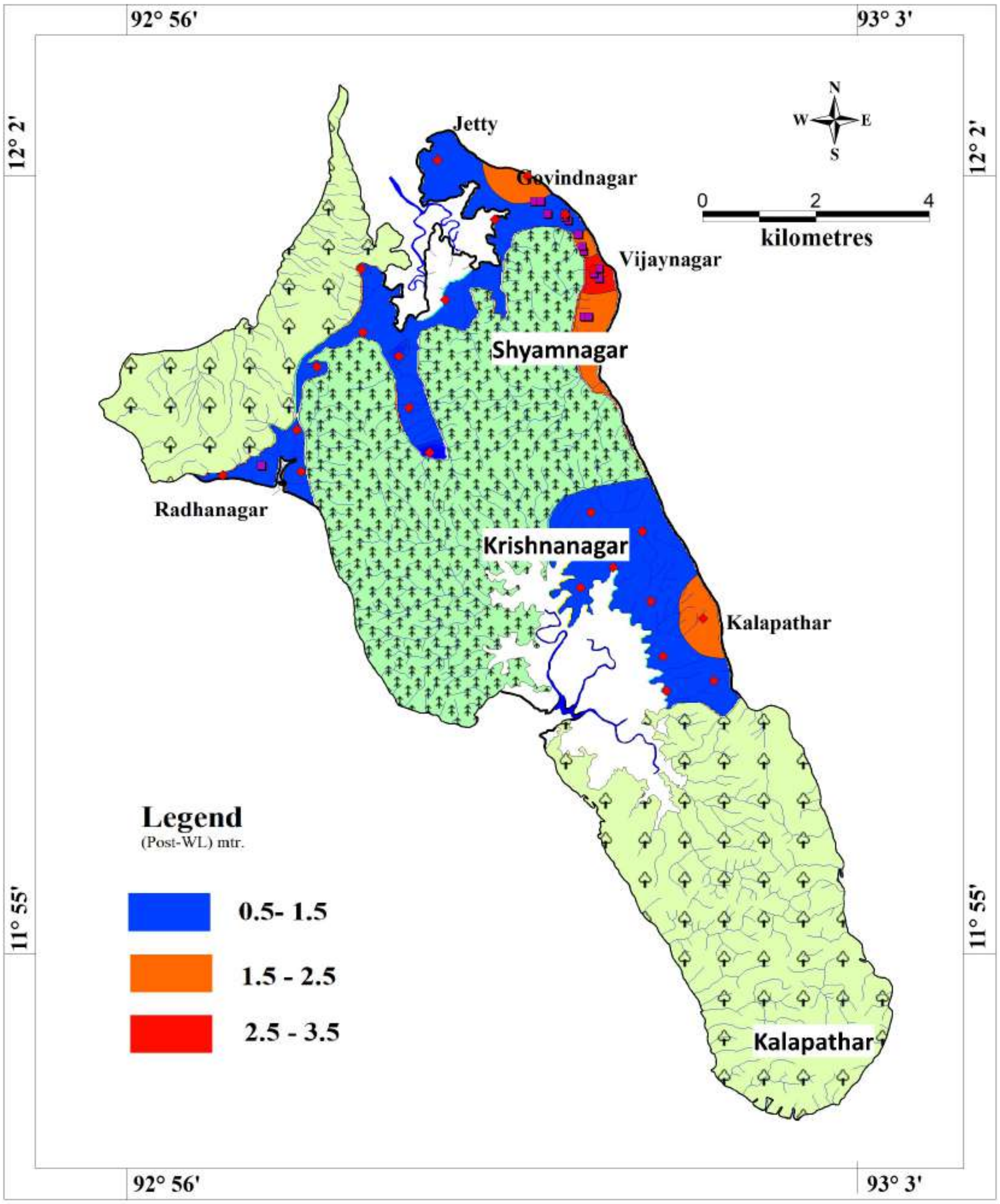


Figure-6.2.2.4 Post-monsoon water level map in Havelock Island (2017)

In post-monsoon the water level ranges between 0.5 - 1.5 m is near Radhanagar viilage and Havelock Jetty area. The range 0.5 - 1.5 m is spread over the entire Island. Southern part of

Shyamnagar village, Kalapathar village along the coast and entire part of Govindnagar village is showing the range of post monsoon water level 1.5 – 2.5 m. The Northen part of Vijaynagar area is showing the post - monsoon water level as 2.5 – 3.5m.

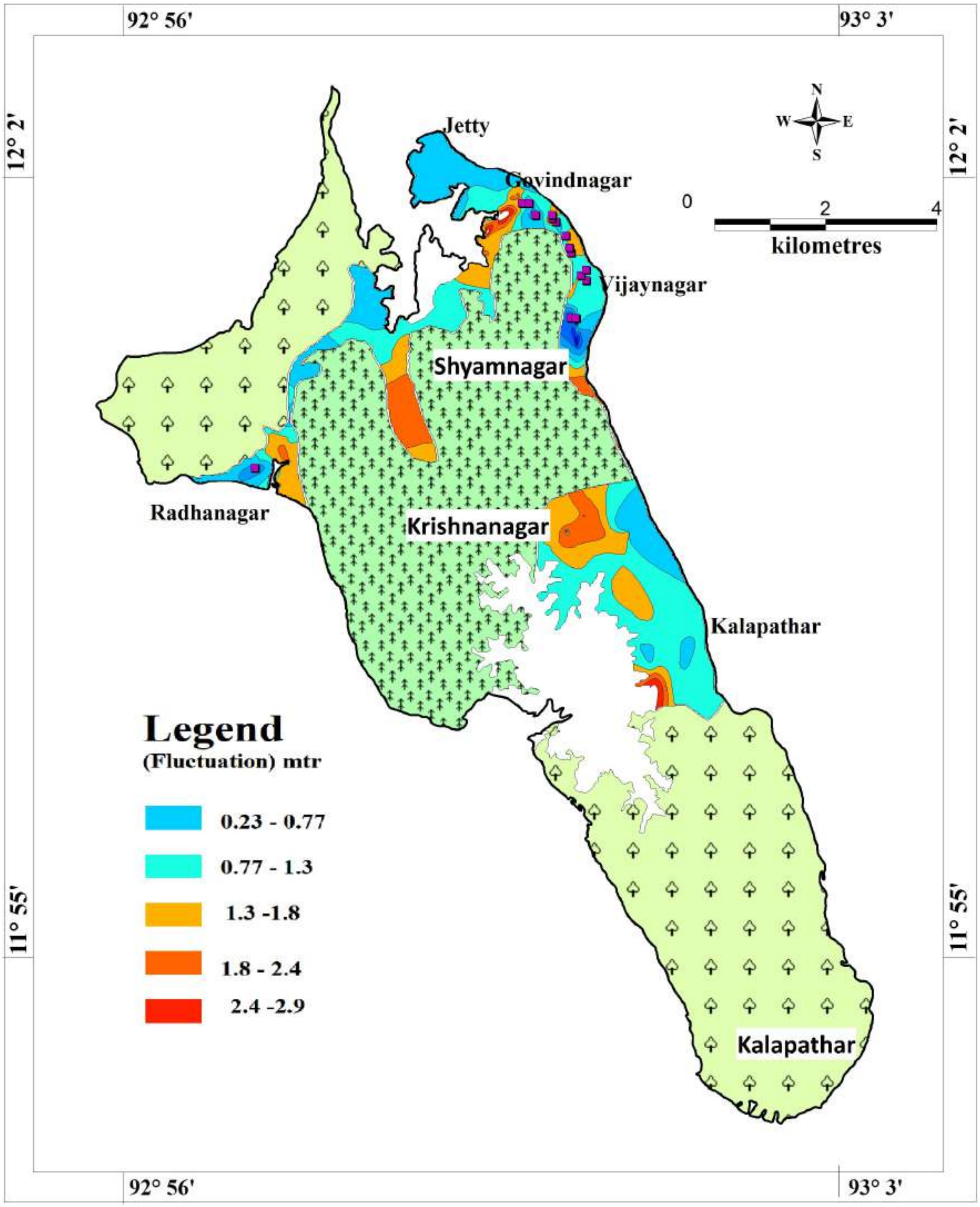


Figure-6.2.2.5 water level Fluctuation Map in Havelock Island (2017)

Maximum water level fluctuation ranges between 1.3 - 2.9 m in parts of Radhanagar, Vijaynagar, Shyamnagar and Krishnanagar villages The minimum fluctuation range between 0.23 - 1.3 m is in the area of Havelock Jetty, Kalapather village, Govindnagar village and remaining part of the island.

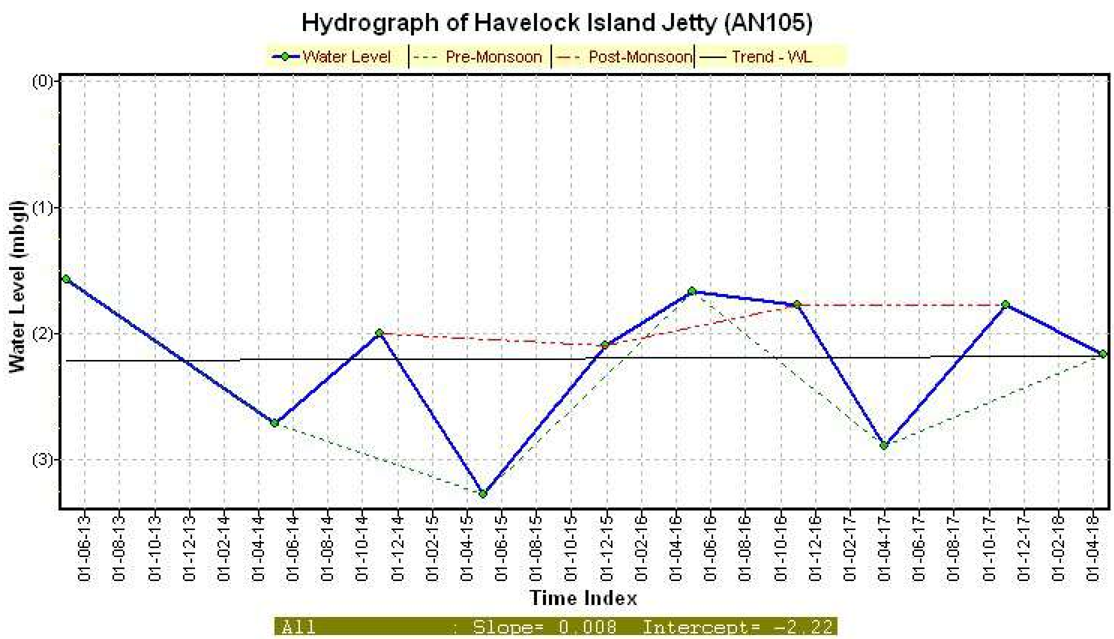


Figure-6.2.2.6 Hydrographs of Havelock Island Jetty

Table- 6.2.2.1 Trend ground water Level District South Andaman, Havelock Island (2009-2018)

Tahsil/Taluk/ Island	**Location**	**Well No**	**Pre- Monsoon**		**Post- Monsoon**	
			Rise (meter/y)	**Fall** (meter/yr)	**Rise** (meter/yr)	**Fall** (meter/yr)
Havelock Island	6½ No. Forest Camp	AN108	-	0.012	0.427	-
Havelock Island	Dolphin Yatri Nivas	AN055	0.037	-	0.052	-
Havelock Island	Govindanagar Vill No -	AN053	0.116	-	0.119	-
Havelock Island	Govindanagar Vill No -	AN054	-	0.057	0.089	-
Havelock Island	Havelock Island Jetty	AN105	-	0.054	0.098	-
Havelock Island	Radhanagar	AN056	0.014	-	0.200	-
Havelock Island	Vijaynagar	AN106	-	0.001	0.631	-

The long term trend analysis reveals that there is a falling trend at four Locations during Pre-monsoon. The Pre-monsoon trend varies from 0.012 m/year (at 6½ No Forest Camp) to 0.01 m/year (at Vijaynagar). The Post-monsoon trend shows rising trend in all the monitoring stations, and there is no falling trend reported in any of the stations. Details of pre-monsoon and post-monsoon water level trend (from 2009 to 2018) in cm/year for individual Village is given in **Table- 6.2.2.1.**

6.2.3: Little Andaman Island

The Little Andaman Island, lying between South Andaman and Car Nicobar, is the southernmost island of the Andaman Group. The geographical position of Little Andaman is between 10300 N – 10540 N, and 9220 E – 92370 E, which is separated from the South Andaman and Car Nicobar by the Duncan Passage and the Ten-Degree Channel, respectively In terms of area, Little Andaman is nearly 43 km long and 24 km wide. This is situated about 96 km south of Port Blair. The geological map of Little Andaman Island is shown in **Figure-6.2.3.1**. The pre monsoon water level map, post monsoon water level map and water level fluctuation for the year 2017 in Little Andaman Island are shown in **Figure-6.2.3.2**, **Figure-6.2.3.3** and **Figure-6.2.3.4** respectively.

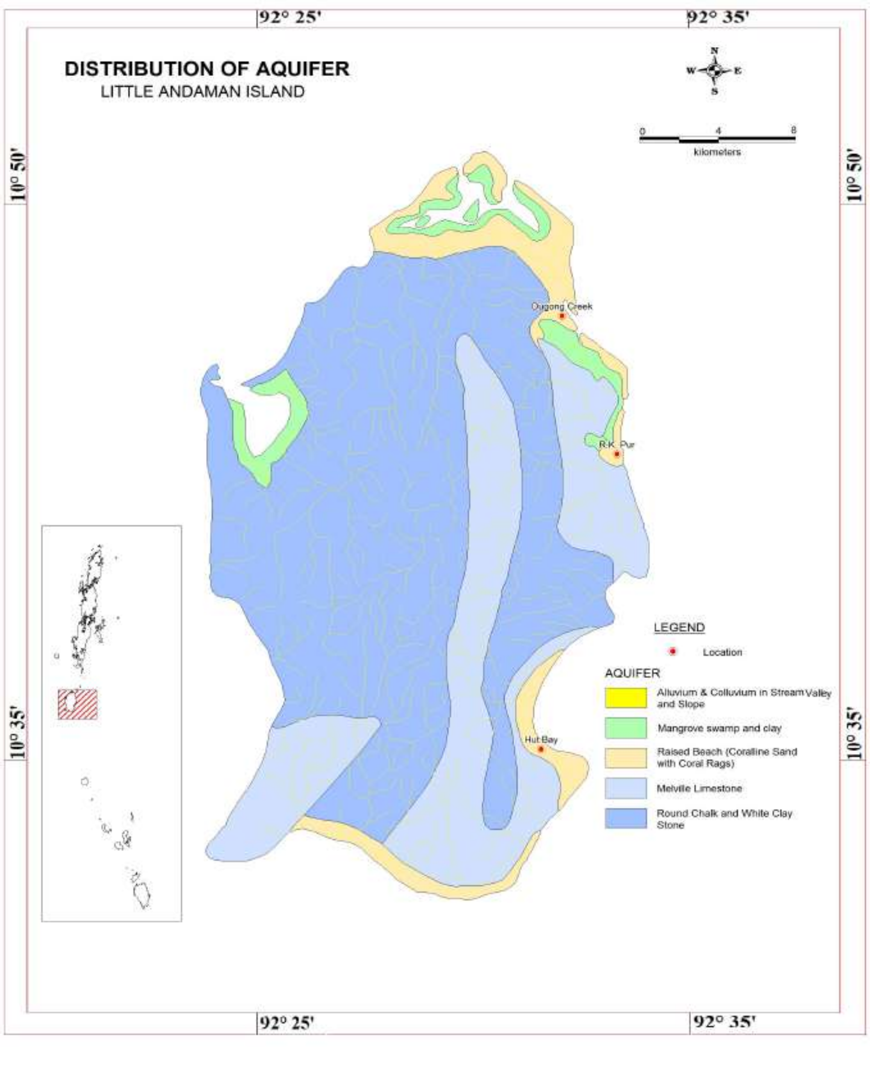


Figure-6.2.3.1: Geological map of Little Andaman Island

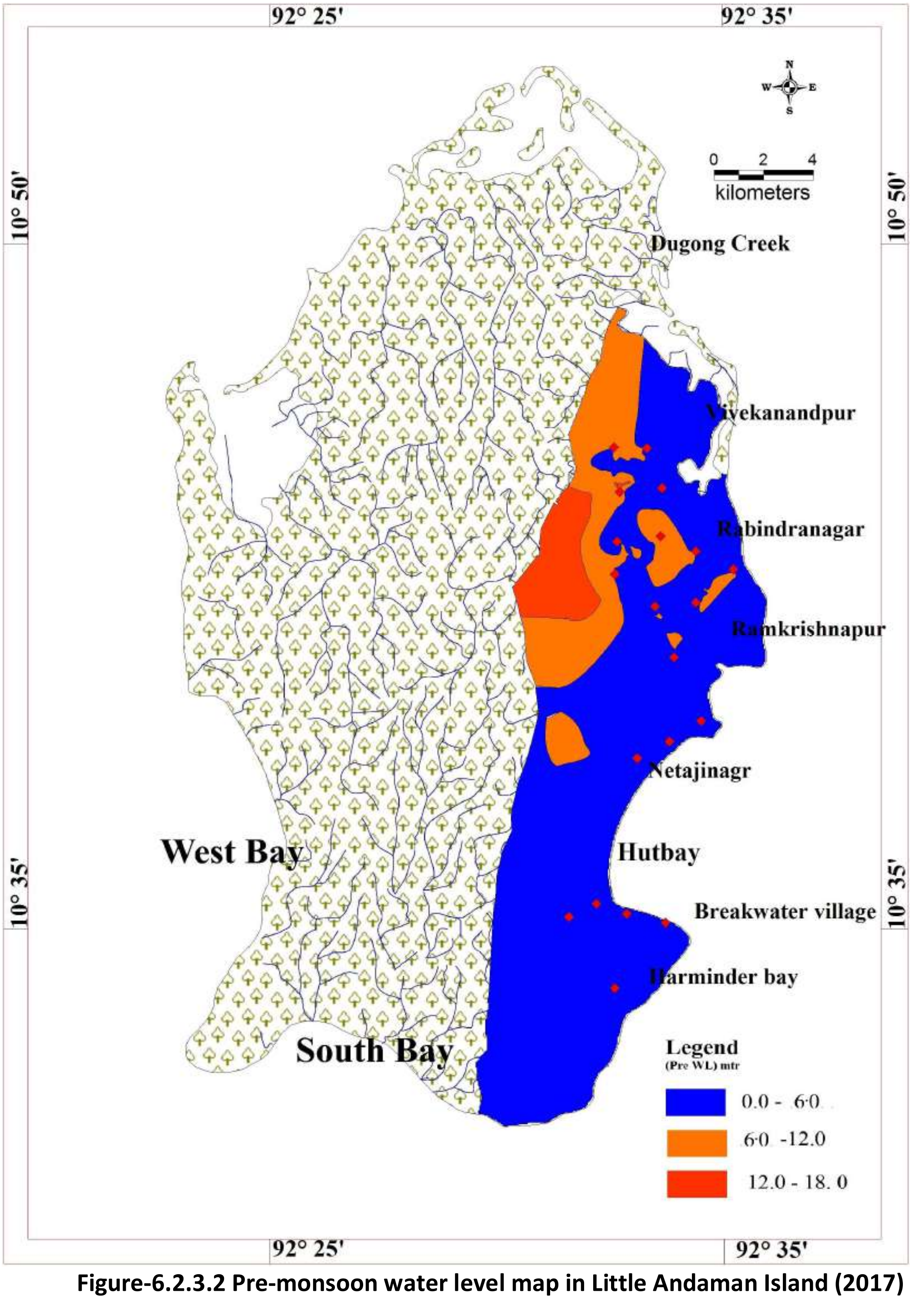


Figure-6.2.3.2 Pre-monsoon water level map in Little Andaman Island (2017)

In pre-monsoon the depth to water level 0 - 6 m is near Harminderbay, Breakwater Village, Netajinagar to Vevekanandpur, all along the costal area in Little Andaman Island and Western part of the Ramkrishnapur and Ravindranagar area showing the water level 6 - 12 m. Western part of Ravindranagar village area showing the maximum water level 12 - 18 m. The pre-monsoon water level ranges 0.0 to 6 mbgl and has been noticed predominantly spread over the entire island.

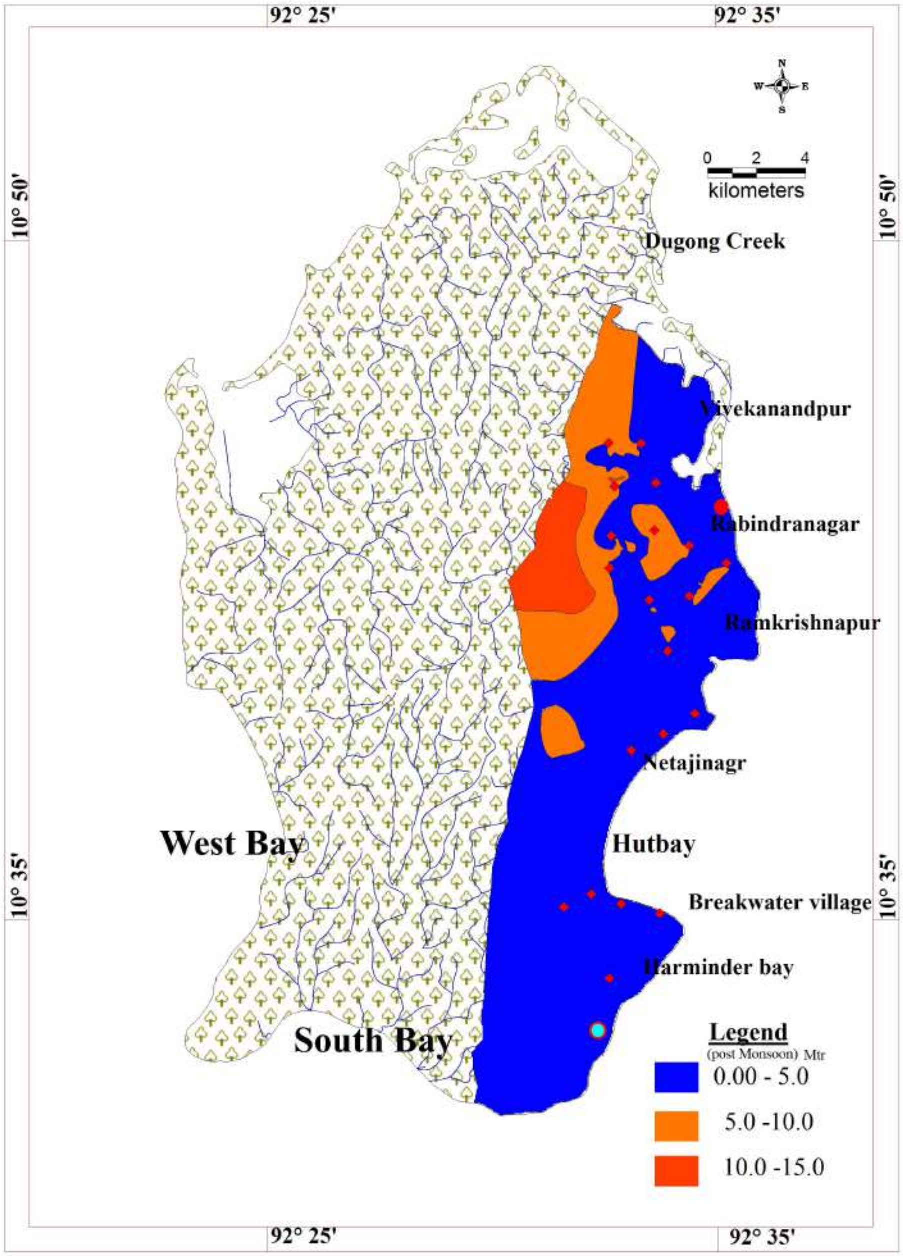


Figure-6.2.3.3 Post-monsoon water level map in Little Andaman Island (2017)

In post-monsoon the water level 0 - 5 m spread over the entire area of Little Andaman Island. Near Netaji nagar village, Ramkrisnapur village, Rabindranagar village showing water level in range of 5 - 10 m. Away from the costline near the forest area of Rabindranagar showing the maximum water level range 10 - 15 m.

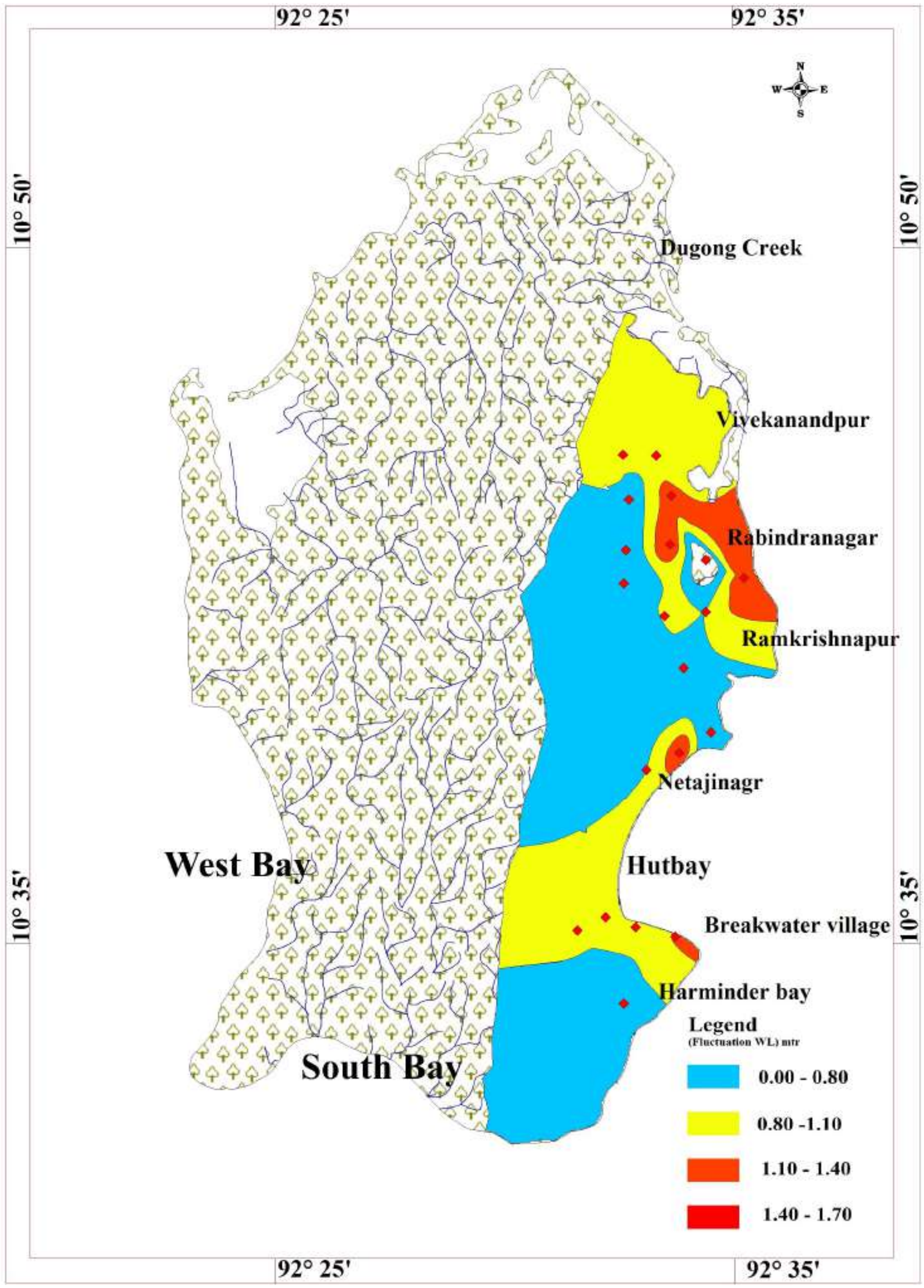


Figure-6.2.3.4 water level Fluctuation Map in Little Andaman Island (2017)

Water level fluctuation range between 0.0 – 0.8 m is near Hutbay, Harmindar Bay , Netajinagar and Break water village area of Little Andaman Island and southern parts of Ramkrishnapur village. The water level fluctuation 0.8 to 1.1 m showing near Hutbay Jetty, Ramkrishnapur village and Vivekanadpur village. Rabindranagar, and some northern part of Netajinagar village area showing the water level fluctuation range 1.1 to 1.40 m and the costline area of Breakwater village and western part of Rabindranagar area showing the maximum water level fluctuation range 1.40 to 1.70 m.

Annexure-6.2.3.1: Depth to water Level Data during the Ground Water Year 2017 of GWMW in Little Andaman Island, South Andaman District.

SL. No.	GP	Village	Island	Well Type	MP	Depth	actual depth of DW	DIA	Pre DTW	Latitude	Longitude	Post Water Level	fluctuation
1	Harminder bay	Harminder bay	Little Andaman	DW	1.18	12	10.82	2.8	2.35	10.5616667	92.54361111	1.65	0.7
2	Hutbay	Break water	Little Andaman	DW	1	8	7	1.5	2.54	10.5855556	92.5625	1.43	1.11
3	Hutbay	Anna Nagar	Little Andaman	DW	1.08	4.3	3.22	1.78	2.08	10.5888889	92.54805556	1.2	0.88
4	Hutbay	Netaji Nagar	Little Andaman	DW	0.75	6.8	6.05	2	1.5	10.6588889	92.57555556	1	0.5
5	Hutbay	Netaji Nagar	Little Andaman	DW	0.6	4.8	4.2	1.5	2.2	10.6513889	92.56388889	0.9	1.3
6	Hutbay	Netaji Nagar	Little Andaman	DW	1	10	9	2.5	1.8	10.6452778	92.55194444	1	0.8
7	Hutbay	Farm Tickery	Little Andaman	DW	0.9	6	5.1	2.8	2.62	10.5877778	92.52666667	1.8	0.82
8	Hutbay	Hutbay	Little Andaman	DW	0.45	8	7.55	3.5	2.05	10.5925	92.53694444	1	1.05
9	Ramkrishna Pur	RKP/w/13	Little Andaman	DW	0.55	16	15.45	2	5.22	10.7205556	92.57361111	5	0.22
10	Ramkrishna Pur	RKP/W/12	Little Andaman	DW	0	12	12	2.8	2.8	10.7141667	92.5875	1.6	1.2
11	Ramkrishna Pur	RKP/w/10	Little Andaman	DW	0	10	10	3	2.5	10.7019444	92.57361111	1.7	0.8
12	Ramkrishna Pur	RKP/w/04	Little Andaman	DW	0.5	20	19.5	3	6.5	10.7005556	92.55861111	5.6	0.9
13	Ramkrishna Pur	RKP/w/01	Little Andaman	DW	0.6	12	11.4	1.2	1.6	10.6819444	92.56555556	1	0.6
14	Vivekanand Pur	VKP/w/06	Little Andaman	DW	0.75	9	8.25	2.6	4.3	10.7580556	92.55555556	3.4	0.9
15	Vivekanand Pur	VKP/w/06	Little Andaman	DW	0.85	15	14.15	2.6	10.1	10.7583333	92.54333333	9.2	0.9
16	Vivekanand Pur	VKP/w/07	Little Andaman	DW	0.65	10	9.35	1.5	6.5	10.7422222	92.54555556	5.85	0.65
17	Ravindra Nagar	RN/w/06	Little Andaman	DW	1.2	15	13.8	4	6.2	10.7130556	92.54388889	8.16	-1.96
18	Ravindra Nagar	RN/w/06	Little Andaman	DW	1.1	12	10.9	4	5.8	10.7122222	92.54361111	6	-0.2
19	Ravindra Nagar	RN/w/04	Little Andaman	DW	1	8	7	3.5	4.3	10.7241667	92.54444444	3.8	0.5
20	Ravindra Nagar	RN/w/05/1	Little Andaman	DW	1.1	10	8.9	4	6.2	10.7261111	92.56055556	5	1.2

6.2.4: South Andaman Island

The Study area of South Andaman is hydrogeologically the Quaternary formations represented by Beach sand, Corals rages and thin alluvium cover and restricted in distribution as narrow linear tract along the coast and intermontane valleys constitute the unconsolidated group. The marine sedimentary rocks comprising the Andaman flaysh and the Mithakhari sandstone characterised by hard and compact nature, warrant grouping under semi- consolidated sedimentary formations and the volcanic suits of rocks characterised by fracture porosity, fall under the group of fissured formation. Ophiolite suite marine sedimentary rocks of Palaeocene to Oligocene age and recent to sub recent beach sand, Mangroves clay, alluvium and coral rags are exposed in the South Andaman island. The marine sedimentary rocks occupy more than 80% of the area. The geological map of South Andaman Island is shown in **Figure-6.2.4.1.**

The pre monsoon water level map, post monsoon water level map and water level fluctuation for the year 2017 in South Andaman Island are shown in **Figure-6.2.4.2**, **Figure-6.2.4.3** and **Figure-6.2.4.4** respectively. Further, a hydrograph near Shoalbay-12 in South Andaman Island is shown in **Figure-6.2.4.5.** Trend of ground water level (2009-2018) in South Andaman Island is given in **Table- 6.2.4.1.**

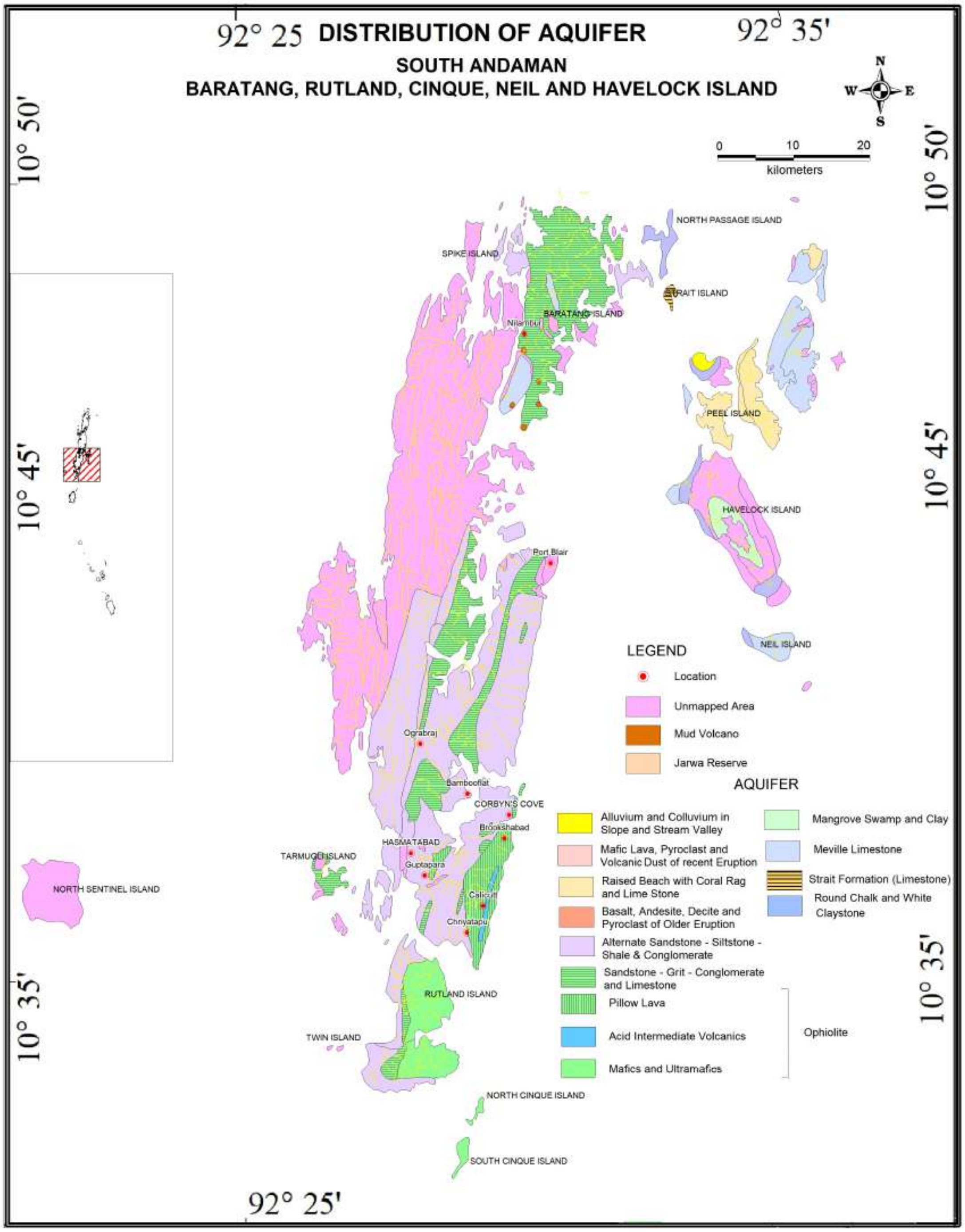


Figure-6.2.4.1: Geological map of South Andaman Islands

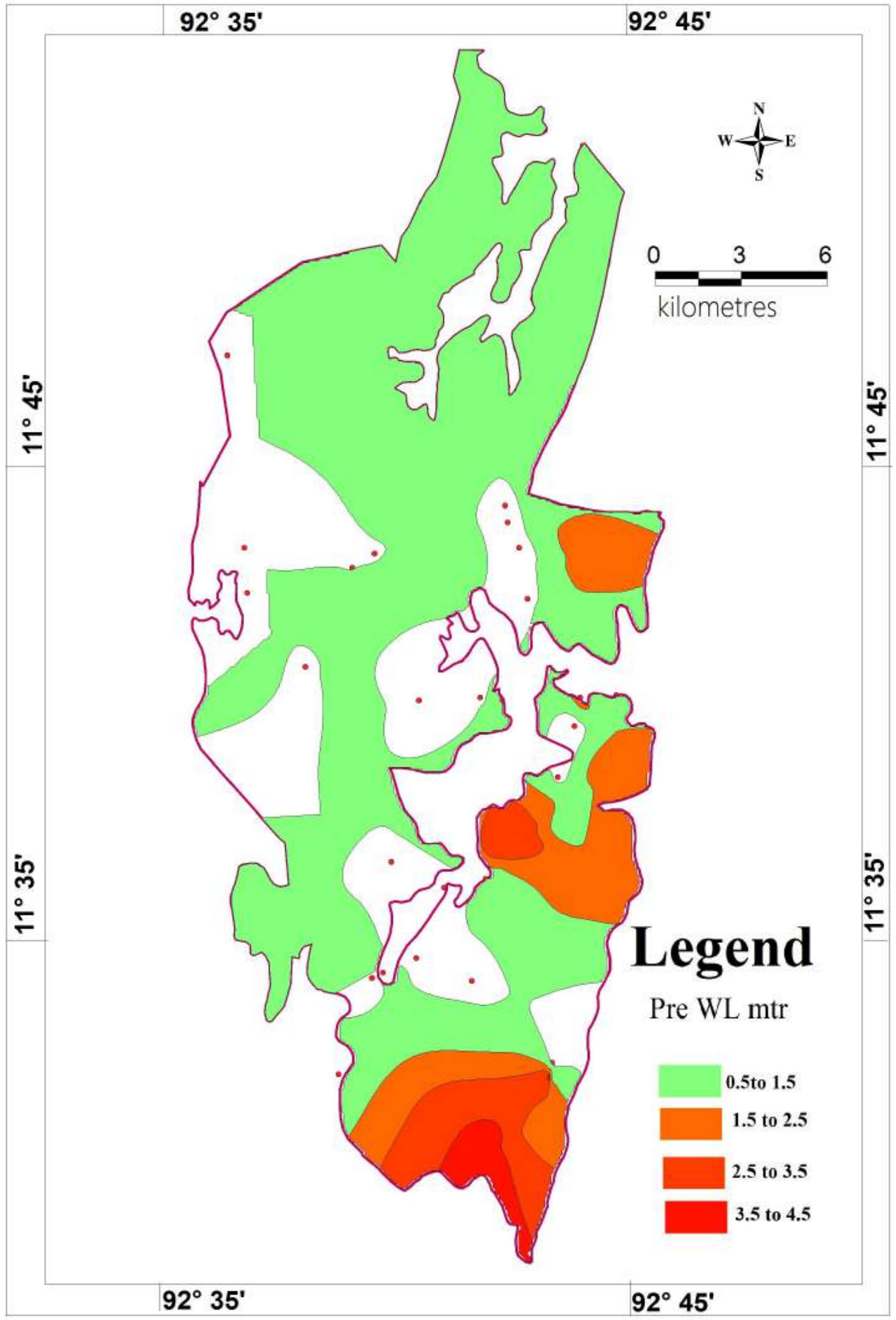


Figure-6.2.4.2 Pre-monsoon water level map in South Andaman Islands (2017)

Pre-monsoon water level range 0 - 2.5 m is observed throughout the South Andaman Island except southern (Chidiyatapu, Rangachang, Bednabad, Calicut area and eastern part

(Junglighat, Garacharma, Prothrapur area) where the pre monsoon water level is within the range of 2.5 - 4.5 m.

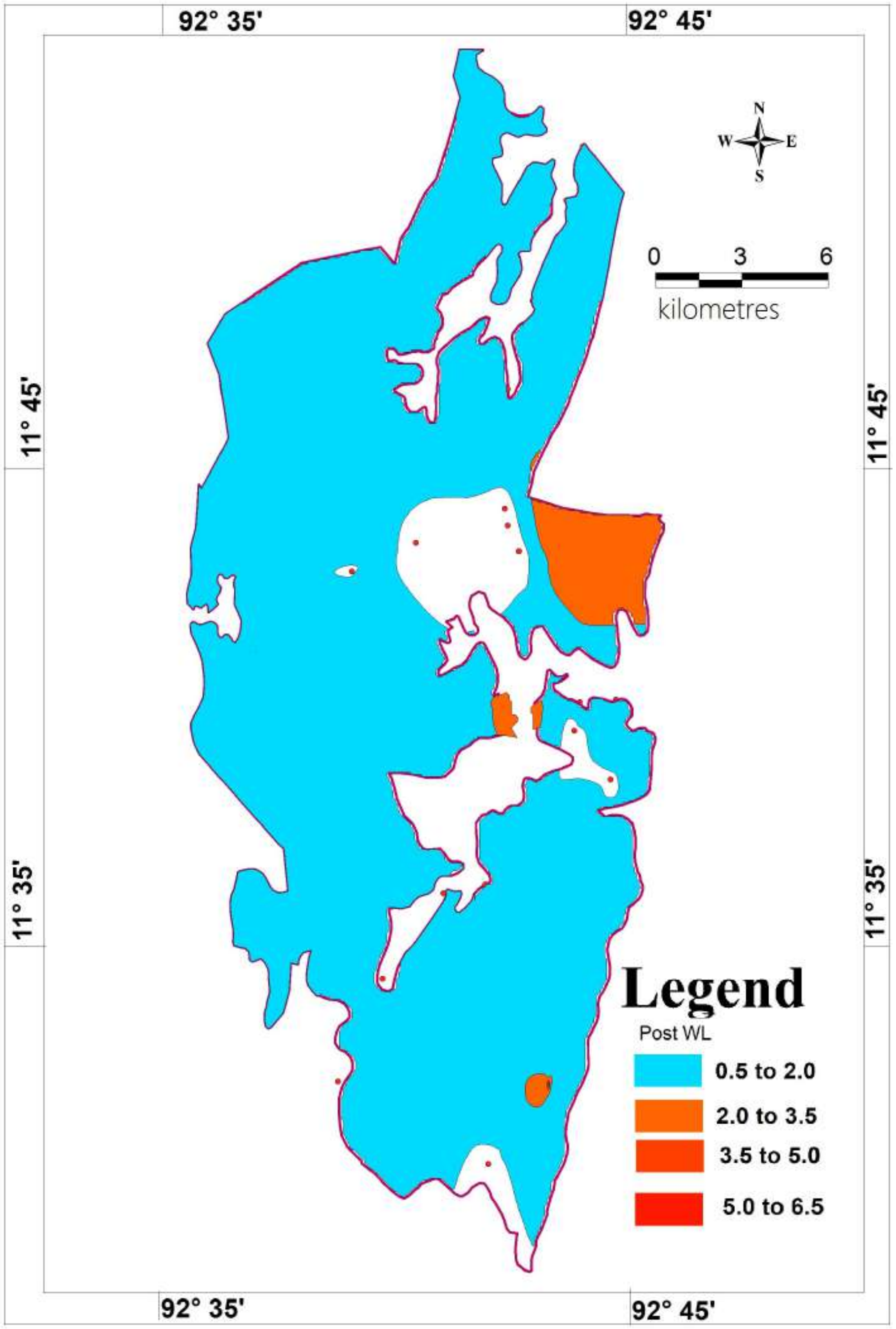


Figure-6.2.4.3 Post-monsoon water level map in South Andaman Islands (2017)

During post - monsoon depth to water level range 0.5 - 2.0 m is observed through out the South Andaman Island except in a very small area (Aberdeen in Jangali Ghat, Brookshabad and Brichganj area) where the post monsoon water level is within the range of 2.0 - 3.5 m.

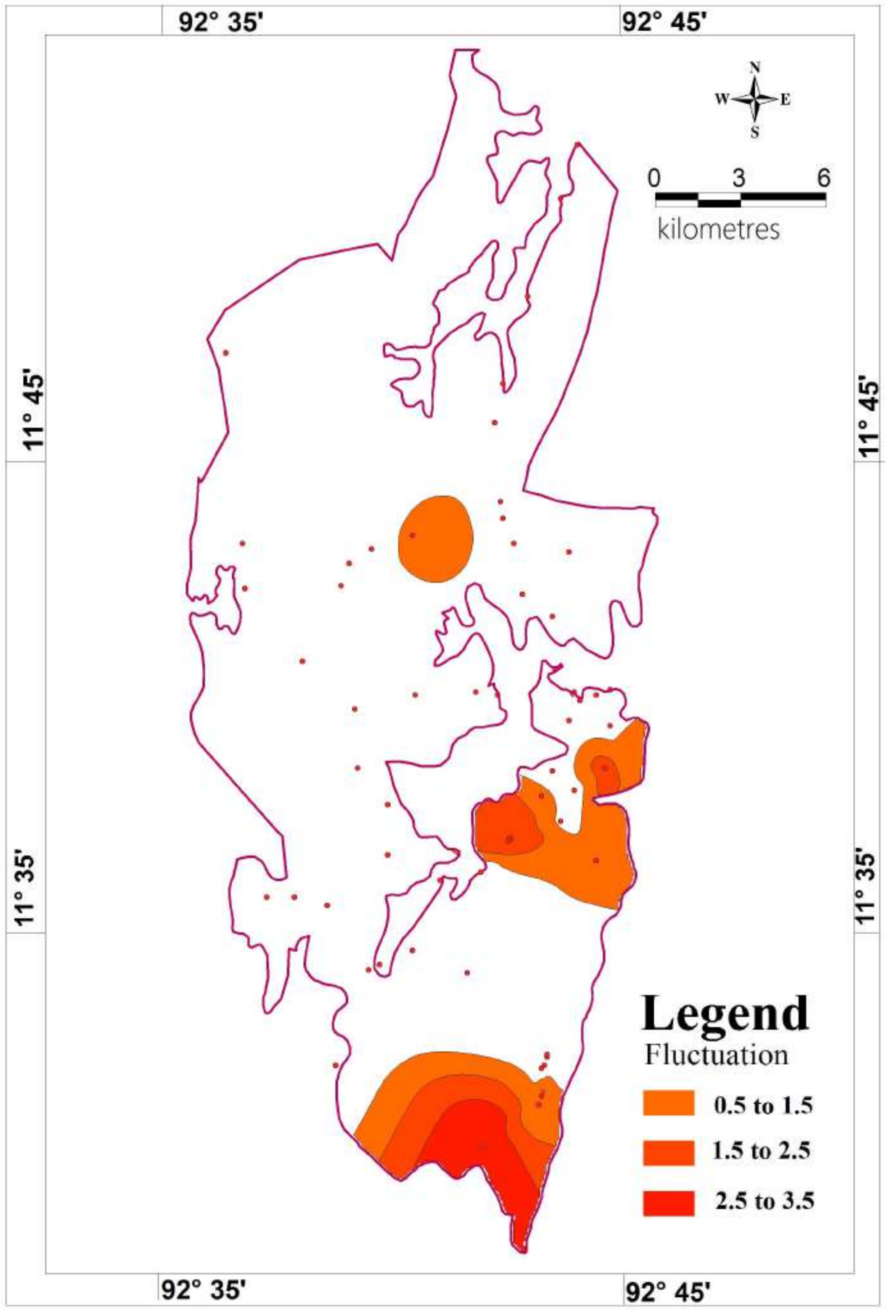


Figure-6.2.4.4 water level Fluctuation Map in South Andaman Islands (2017)

Water level fluctuation range between 0.5 – 2.5 m is observed near Bambooflat, Jangali Ghat, Nayagaon area, whereas it is observed in the range of 2.5 - 3.5 m near Chidiatapu and Porthrapur area. Remaining part of the South Andaman Island is showing no fluctuation.

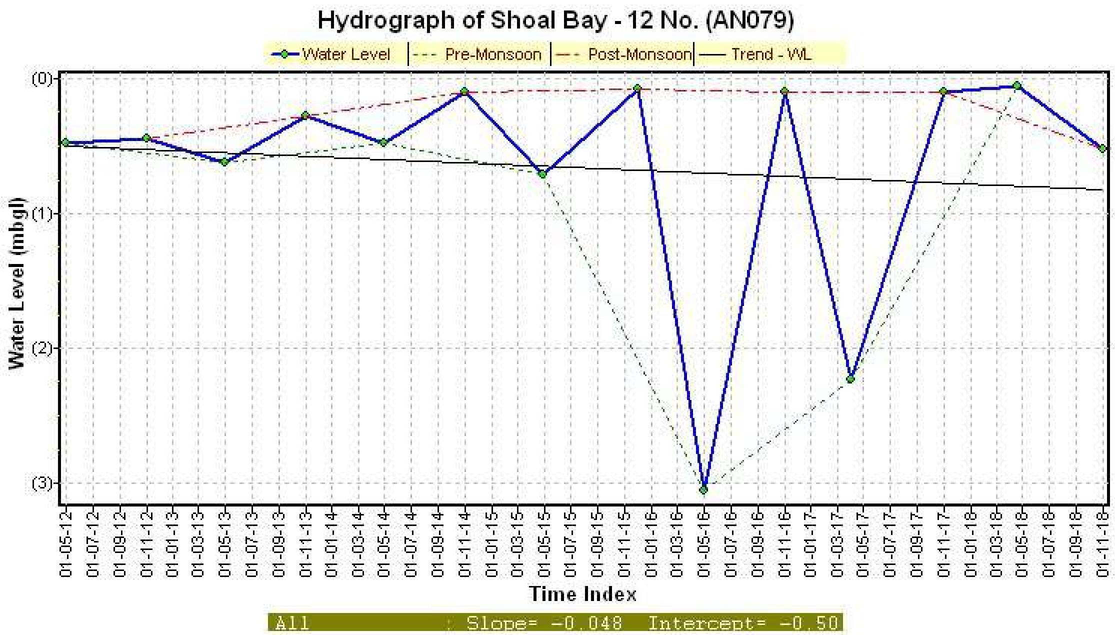


Figure-6.2.4.5: Hydrographs of Shoalbay-12 in South Andaman Island

Table- 6.2.4.1 Trend ground water Level District South Andaman (2009-2018)

Tehsil/Taluk/ Island	**Location**	**Well No**	**Pre- Monsoon**		**Post- Monsoon**	
			Rise (meter/yr)	**Fall** (meter/yr)	**Rise** (meter/yr)	**Fall** (meter/yr)
South Andaman	Austinabad (Port Blair)	AN005	0.159	-	0.052	-
South Andaman	Bambooflat	AN016	0.035	-	-	0.017
South Andaman	Calicut	AN017	0.144	-	-	0.052
South Andaman	Beadnabad Tubewell	AN047	-	0.367	0.134	-
South	Namunagar	AN049	0.073	-	-	0.047

Andaman						
South Andaman	Chouldari	AN069	0.051	-	0.021	-
South Andaman	Shoal Bay - 12 No.	AN079	-	0.163	0.004	-

The long term trend analysis reveals that there is a falling trend at two Locations during Pre-monsoon and at three locations during Post-monsoon periods. The Pre-monsoon trend varies from 0.367 m/year (in Bednabad) to 0.163 m/year (in Soal Bay-12). The Post-monsoon trend varies from 0.017 m/year (in Bambooflat) to 0.004m/year (in Soal Bay-12). Details of pre-monsoon and post-monsoon water level trend (from 2009 to 2018) in cm/year for individual village is given in **Annexure -6.2.4.1**

Annexure-6.2.4.1: Depth to water Level Data during the Year 2017 of Ground Water Monitoring Wells (GWMW) in South Andaman Island

Well No	District/Island	Locality	Well Type	M.P.	Depth	Well Dia	Water Level (in mbgl)	
							Apr-17	Nov-17
AN001	South Andaman	Port Blair	DW	0.67	10.56	3.17	0.33	0.04
AN002	South Andaman	South Point (Port Blair)	DW	0.49	5.85	1.03	0.87	0.85
AN003	South Andaman	Corbyn's Cove(Port Blair)	DW	0.68	4.4	2.46	3.61	0.43
AN004A	South Andaman	Kodiaghat	DW	1	4.37	1.92	1.65	2.18
AN005	South Andaman	Austinabad (Port Blair)	DW	0.67	5.5	2.03	1.28	0.91
AN006	South Andaman	Sippighat	DW	0.85	3.84	2.9	1.16	1.67
AN007	South Andaman	Brichganj	DW	0.55	-	-	1.11	0.28
AN008	South Andaman	Shadipur (Port Blair)	DW	0.6	7.57	1.85	1.30	1.07
AN009	South Andaman	Wimberleyganj	DW	0.8	-	-	0.12	0.21
AN010	South Andaman	Ograbraj	DW	1.04	5.5	1.95	4.35	0.10
AN011	South Andaman	Garacharma	DW	0.92	-	-	1.89	0.81
AN012	South Andaman	Burmanala	DW	0.4	5.64	1.31	2.24	1.92
AN013	South Andaman	Brookshabad (Port Blair)	DW	0.4	2.6	2.7	3.04	1.34
AN014	South Andaman	Hasmatabad	DW	1.22	4.8	2.01	2.42	1.50
AN015	South	Chidiyatapu	DW	0.45	5.55	1.45	1.90	0.11

	Andaman							
AN016	South Andaman	Bambooflat	DW	0.65	-	-	0.71	0.21
AN017	South Andaman	Calicut	DW	0.58	3.2	2.46	1.49	1.23
AN018	South Andaman	Saitankhari	DW	0.6	5.15	1.54	1.60	0.89
AN019	South Andaman	Dandas Point	DW	0.85	9.63	1.85	6.17	1.45
AN020	South Andaman	Junglighat (VIP Road)	DW	0.88	4.5	1.5	1.20	3.25
AN028	South Andaman	Gupta Para	DW	0.92	6.54	4.96	2.21	3.72
AN045	South Andaman	Marina Park	DW	0.56	3.3	1.06	1.39	0.63
AN046	South Andaman	Calicut Bore well	Bore Well	0.36	-	-	7.90	0.71
AN047	South Andaman	BeadnabadTubewell	TW	0.64	-	-	13.22	2.86
AN048	South Andaman	Annikat	DW	0.57	3.59	2.34	1.86	4.54
AN049	South Andaman	Namunagar	DW	0.24	6	1.54	0.72	0.19
AN057	South Andaman	Port Blair (Dobhi Well)	DW	0.61	3.85	2.34	2.19	0.05
AN059	South Andaman	Light House	DW	0.25	4.74	3.17	1.51	0.03
AN065	South Andaman	Rangachang	DW	0.92	5.33	2.35	2.80	1.13
AN066	South Andaman	Teylarabad	DW	0.81	4.81	2.53	1.74	2.15
AN067	South Andaman	New Bimliton	DW	0.8	3.98	2	3.55	1.38
AN068	South Andaman	Dhannikhari	DW	0.76	3.41	1.46	0.29	1.09
AN069	South Andaman	Chouldari	DW	0.87	3.39	2.49	2.31	0.31
AN070	South Andaman	Port Mout	DW	0.98	4.9	2	1.95	0.26
AN071	South Andaman	Tushnabad	DW	0.75	5.28	2.51	1.05	0.48
AN072	South Andaman	Herbertabad	DW	0.82	5.66	2.55	2.75	0.44
AN073	South Andaman	Tirur	DW	0.91	2.57	1.98	1.45	0.63
AN074	South Andaman	Ferrarganj	DW	0.66	5.16	2.58	1.31	0.47
AN075	South Andaman	Bindraban	DW	0.84	4.98	1.91	1.76	0.43
AN076	South Andaman	Mannarghat	DW	0.84	5.02	2.03	2.09	0.15
AN077	South Andaman	Wrightmyo	DW	0.91	4.8	2	1.17	0.93
AN078	South Andaman	Shoal Bay - 8 No.	DW	0.83	3.52	2.51	0.35	0.27
AN079	South	Shoal Bay - 12 No.	DW	0.97	4.35	2.31	2.23	0.78

	Andaman							
AN080	South Andaman	Shoal Bay - 15 No.	DW	0.75	3.35	1.5	0.28	0.09
AN081	South Andaman	Knoppuram	DW	0.98	5.11	1.94	0.95	0.21
AN082	South Andaman	Steuwartganj	DW	0.75	3.83	1.86	3.05	0.23
AN083	South Andaman	Mile Tilak	DW	0.7	-	-	1.58	0.46
AN084	South Andaman	Hope Town (Marmon Temple)	DW	0.91	4.31	1.96	2.40	0.65
AN085	South Andaman	Mithakhari	DW	0.84	3.29	2.35	2.12	0.61
AN086	South Andaman	Nayasahar	DW	0.91	5.44	2	1.59	0.73
AN087	South Andaman	Manglutan	DW	0.86	4.7	1.48	2.07	0.82
AN088	South Andaman	Manjeri	DW	0.95	5.31	2.51	2.86	1.23
AN089	South Andaman	Mamyo	DW	0.71	4.27	2.03	2.83	3.72
AN090	South Andaman	Wandur	DW	0.65	3.91	2	1.95	4.05
AN091	South Andaman	Dollyganj Chawk	DW	0.52	4.83	2.52	2.08	4.22
AN092	South Andaman	Lamba Line	DW	0.74	4.47	1.3	0.59	3.08
AN093	South Andaman	Haddo	DW	0.78	3.71	1.23	1.46	1.18
AN094	South Andaman	Mount Harriyat	DW	0.4	-	-	7.51	1.14

6.2.5 Rutland Island

Geology and Hydrogeology

Late Cretaceous igneous rocks i.e. the Ophiolite Suite, marine sedimentary rocks of Paleocene to Oligocene age, Recent to Sub-Recent Beach sand, Mangrove clay, alluvium, colluvium and Coral reefs around the periphery, are the major geological formations in the Island. The Ophiolite and marine sedimentaries have undergone different phases of deformation. Extensive fracturing is characteristics of Ophiolites, forms good conduits for recharge of rainwater which ultimately emanates as springs at various levels within the discharge zone. Springs are also found in Sedimentaries. CGWB study (Kar, 2002, 2005, 2018) revealed that perennial springs are generated mostly in Ophiolites and few of them are also traversing through the sedimentary formations in the west. Exploratory drilling and construction of wells in contiguous areas reveal that Ophiolites yield potentially from deeper depths. Hence, the formation can be used for construction of dugwells, borewells and dug-cum-bore wells. Sedimentary formations do not yield potentially both in shallow and deeper horizons. However, the stream valleys where appreciable porous materials are available, subsurface dam along with collector well and check dams can be constructed to tap significant quantity of base flow and intermittent recharge. Hence, apart from spring flow, good amount of groundwater is also flowing as subterranean flow to the sea through the alluvial and colluvial formations. During the estimation of potential of the springs, the base flow was also considered.

Springs, Its Origin and Role in Rural and Urban Water Supply in Rutland Island:

The characteristic geological and geomorphological conditions of the A&N Islands have facilitated the origin of numerous springs in all the three major geological formations (i.e. Marine sedimentary group of rocks, Ophiolite (an assemblage of igneous rocks) and coralline limestone). The rural drinking water supply in the entire A & N Islands except Neil and Car Nicobar Islands (Water supply is done in these Islands only from the wells) is maintained either directly from the springs or spring fed perennial streams. In the following paragraphs causes of generation of various kinds of springs and their occurrences in A&N Islands are described. It is also worth mentioning that in A&N Islands, the most potential springs are formed in Ophiolites i.e. the igneous rocks comprising the fractured mafic, ultramafic igneous rock, Pillow lava and other Acid and Intermediate volcanic rocks.

Topographic or Valley Springs: These types of springs are formed due to the abrupt change in slope where the water table truncates the ground surface. Such types of springs are mostly prevalent in the Marine sedimentary rocks and occur all over the archipelago.

Stratigraphic or Contact Springs: These are formed where porous rock overlies impervious material; the water that accumulates in the porous rock is forced to the surface at the contact. Occasionally such type of springs are seen in sedimentary formations in A&N Islands

Fault Spring: Such type of springs can form along faults when permeable rock has been moved against less permeable rock. Arrows show relative motion along fault. Occasionally such types of springs are seen in sedimentary formations in A&N Islands

Tubular Spring: Such type of springs is common in the limestone terrains in A&N Islands and seen in Havelock, Little Andaman, North Andaman near Betapur, Car Nicobar, Teressa Islands etc. Water enters in the caves along joints in limestone and exits as springs at the mouth of caves.

Fracture Spring: Water moves along fractures in crystalline rock and forms springs where the fractures intersect the land surface. These springs are abundant in Ophiolites in A&N Islands. In Sedimentary formations also fractures springs could be seen but the fracture space are often clogged in sedimentaries with clay, which easily formed through denudation.

Auto Flowing Spring: Generally springs show free flow under gravity. But in cases where pressure is developed in an aquifer due to overlying confining layer like clay or groundwater in fractures in hard rock shows high pressure. If these confined aquifers get some natural openings or are punctured by tube wells or bore wells, then the water automatically comes to the surface against gravity. These types of springs are called auto flowing springs or Auto flow. Such auto-flows are abundant in Ophiolite in South Andaman. However, the auto flowing condition at many places either ceased or the water level has gone too deep after the massive earthquake of 26.12.04. The earlier hydrogeological condition has been affected.

Management of Urban Water Supply to Port Blair City from springs in Rutland Island: In this connection a case study was carried out by CGWB (Kar, 2002) on the development of potential springs and interisland transfer of spring water from Rutland Island to Port Blair town would be worthwhile. The Water supply in the town is mainly catered from the Dhanikhari Dam, which is located nearly 20 Km west of Port Blair. The dam is constructed on the catchment of Dhanikhari at a relatively higher topography so that the water can come to Port Blair under gravity. Generally, the A&N Islands receive monsoon rainfall even in November - December every year. Consequently, the dams and reservoirs are filled up. In few years if this rainfall reduces, and the monsoon which starts in April is delayed, the water level in the reservoir at Dhanikhari will reduce if withdrawal is not regulated. With the recession of monsoon, often in the recent past the reservoir gets dried up. During those years the APWD, A&N Administration face tremendous problem of water supply in Port Blair town. To manage this, the water supply in the town is regulated in each lean period. Generally, thrice in a week water is supplied by the Port Blair Municipal Council during such stressed period. In extreme situation with further recession of monsoon, the water supply in Port Blair town is curtailed to even twice or once in a week. In such a severe water scarce situation in 2002, the water supply situation in Port Blair town was almost shattered. In the previous year i.e. 2001, the rainfall was close to normal, and as per the demand water supply was not controlled. The months of November - December experienced no rainfall, consequently the Dam dried up in December itself.

There were even proposals to carry water from water abundant islands like Car Nicobar, Little Andaman through ships and barges. There are many springs in Rutland Island (Kala Pahar), which could be the feasible water source for transportation to Port Blair. CGWB was entrusted to carry out a reconnaitory survey in the contiguous Rutland Island to recommend the feasibility of water supply source. Rutland Island is located in the South of South Andaman Island where Port Blair is situated (Fig- 1). The Islands are separated by a narrow strait i.e Macpherson Strait, which is narrow in the west and widens in the eastern side. The study was carried out in February 2002 and the survey report revealed that a major part of the island is underlain by fractured ultramafics. Several high discharging springs occur in the low lying areas in the hills, which are not too far from the coast. The good quality water free from colliform bacteria is draining into the sea. A sum total of 16 springs were studied (Table-1). Based the studies and recommendation, and in view of extreme scarcity of drinking water, supply of spring water for Port Blair city and for supply to the ships for Port Management Board, the water supply from Chain Nala was started through barges on 28.4.2002. The supply from Chain Nala continued till 2011 as the jetty was damaged. Since then, water supply is continuing from Rifle Man point jetty in the west. The recharge in the hills was so good that a submarine auto flowing condition was developed in the offshore area of Rutland Island in the North Eastern Side. The auto flow located nearly 150m off coast, is generated on tip of a mound of small coral reef, which accrued on a basement of fractured ultramafic rock having hydraulic connection with the recharge area in Rutland hill. The yield of auto flow was 0.8 lps and the head was 15 cm. The spot Electrical conductance was recorded as 395 Micro-Siemens per Cm.

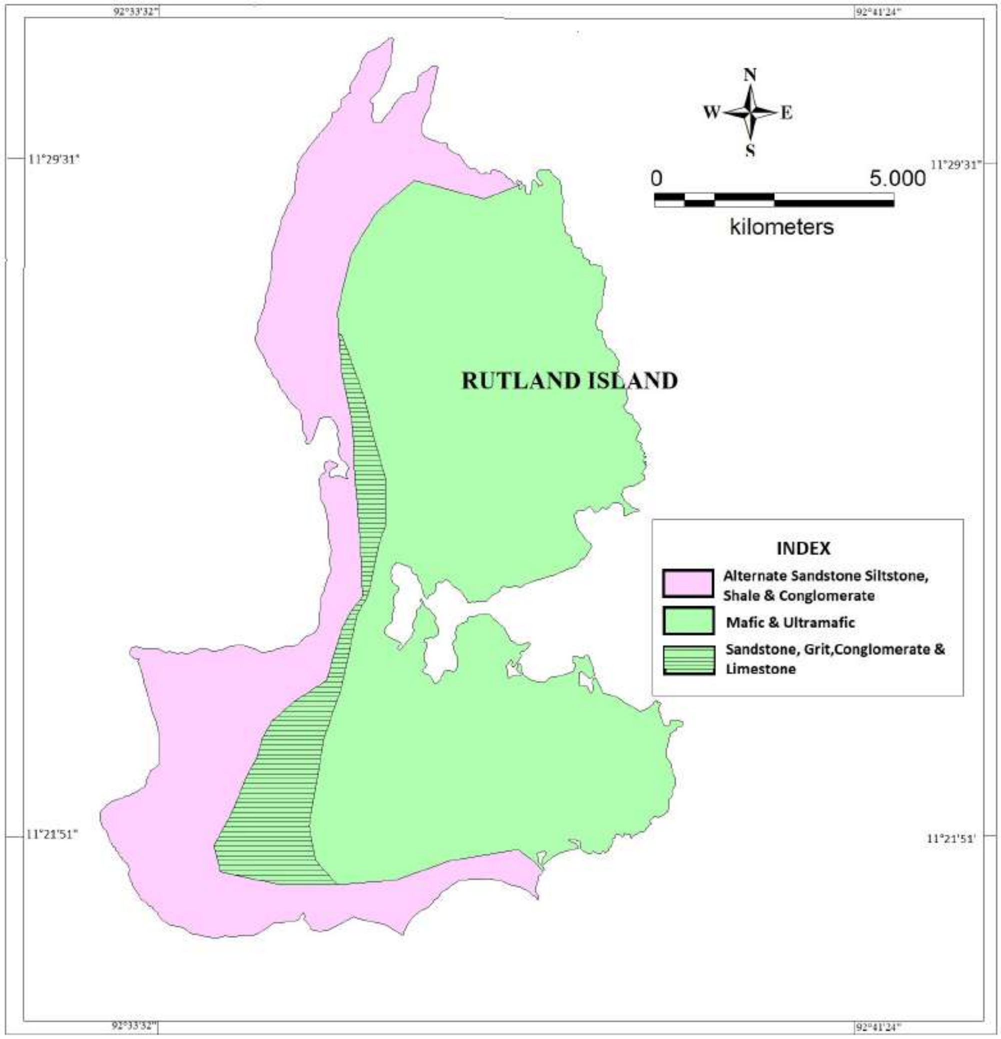


Figure-6.2.5.1: Geological map of South Andaman Islands

6.3 Ground Water Flow through the deeper 2nd Aquifer:

Ground water in Marine sedimentary formation occurs under unconfined condition in weathered residuum. Preponderance of clayey mineral renders groundwater development possibility very low. Yield of dug well (5 - 6m dia, 6 m depth) in Marine sedimentary group varies from 4000-5000 liters/day. Ground water in Ophiolites occurs under unconfined to semi-confined condition in weathered residuum while in fractured hard rock in deeper horizon in confined condition. Yield of dug well (5 - 6m dia, 6m depth) in Marine sedimentary group varies from 40,000-50000 liters/day. In case of bore well (6$^{//}$dia, 80m deep) yield varies from 80,000-1, 00,000 liters per day. In Coralline limestone in archipelago group yield of dug well (5 - 6m dia, 4 - 5 m depth) varies from 80,000-1,00,000 liters/day. Springs are profuse in all the geological formations. However, springs are sustainable in Ophiolites and archipelago group.

Valley fills near Bednabad proved to be a potential aquifer capable of sustaining supply for more than 8h/day at the rate of 45,000 lph. The fractured volcanic and plutonic rocks in the southern part of South Andaman Island (Port Blair area) have developed secondary porosity and permeability at place due to penetrative open fractures, joints and faults. Their permeability is however, widely varying. As revealed from exploratory drilling, yield of water in such zones varied from 0.52 m^3/ hr to 45 m^3/ hr. The bore well in Calicut is restricted to 40000 lph; it can be pumped for 8 - 10 hrs a day even in lean season without causing uneconomic drawdown.

Eighteen Exploratory boreholes, 13 in sedimentaries and 5 in volcanics were drilled in parts of South Andaman Islands. Depth range of exploratory wells in the sedimentaries and the Volcanics varies from 30.30 - 121.60 mbgl and from 80.40 – 128.60 mbgl respectively. Lithological log and hydrogeological details of wells tested are appended separately **Table-6.3.1.** Beside sub surface Lithological Correlation has been depicted **Figure 6.3.1.**

Table 6.3.1- Salient features of Exploratory drilling in South Andaman Island (based on old data)

Sl no	Location	Type of well	Coordinates		Depth drilled (in mtr)	Geology	Productive fracture zones(in mbgl)
			Latitude	Longitude			
1	Brindaban-1	EW	11°43’N	92°40’E	30.30	Sedimentary and Pyroclasic rocks	Abandoned due to air leakage
2	Tushnabad	EW	11°41’N	92°38’E	90.60	Mithakhari formation coarse grain sandstone grits conglomerates	Abandoned
3	Calicut-1	EW	11°36’N	92°43’30E	80.40	Volcanics & Ultramafics(Ophiolites Suits)	14-20, 45-52.5
4	Calicut-2	OW	11°36’N	92°43’30E	80.20	Volcanics & Ultramafics(Ophiolites Suits)	14-20
5	Calicut-3	OW	11°36’N	92°43’30E	60.20	Volcanics & Ultramafics(Ophiolites Suits)	14-20,45-52.5
6	Prothrapur-1	EW	11°38’’30N	92°43’30”E	56.60	Andaman Flysh, Very fins sandstone, Shale	--
7	Prothrapur-1A	EW	11°38’’30N	92°43’30”E	37.0	Andaman Flysh	--
8	Prothrapur-1B	EW	11°38’’30N	92°43’30”E	60.60	Andaman Flysh	25-27: 30-32: 59-60
9	Brichganj	EW	11°36’35N	92°44’10”E	128.60	Volcanics & ultramafics	Upto 30.0
10	Beadnabad	EW	11°35’N	92°44’E	105	Assorted pebbles of volcanics, ultramafics, cherts etc(colluviums)	0-16.60
11	Beadnabad-1	OW	11°35’N	92°44’E	16.60	Assorted pebbles of volcanics	--
12	Beadnabad-2	OW	11°35’N	92°44’E	15.50	Assorted pebbles of volcanics	--
13	Rangachang	EW	11°34’N	92°44’E	101.2	Diorites (Ophiolite suite)	Within 30 mtr
14	Dilthaman Tank	EW	11°39’N	92°44’E	121.0	Mithakhari formation Black shale and compact, fine grey sandstone	Within 30 mtr
15	Bimliton	EW	11°35’25N	92°401’50”E	90.6	Mithakhari formation	Within 30 mtr
16	Manglutan	EW	11°35’25”N	92°30’10”E	90.6	Mithakhari formation	30
17	Homfryganj	EW	11°35’30”N	92°439’50”E	90.6	Volcanic and Volcanogenic sediment	Below4.50 and up to 45.0m
18	Bamboo flat	EW	11°42’30”N	92°43’10”E	83.0	Mithakhari formation,(Black Shale)	Below4.50 and up to 45.0m
19	Steuwartganj	EW	11°43’20”N	92°42’40”E	90.6	Mithakhari formation	Nil
20	Mannarghat	EW	11°44’45”N	92°42’20”E	90.6	Mithakhari formation	Nil
21	Project Yatrik office	EW	11°38’N	92°44’E	103.6	Black Shale	Within 30 mtrs

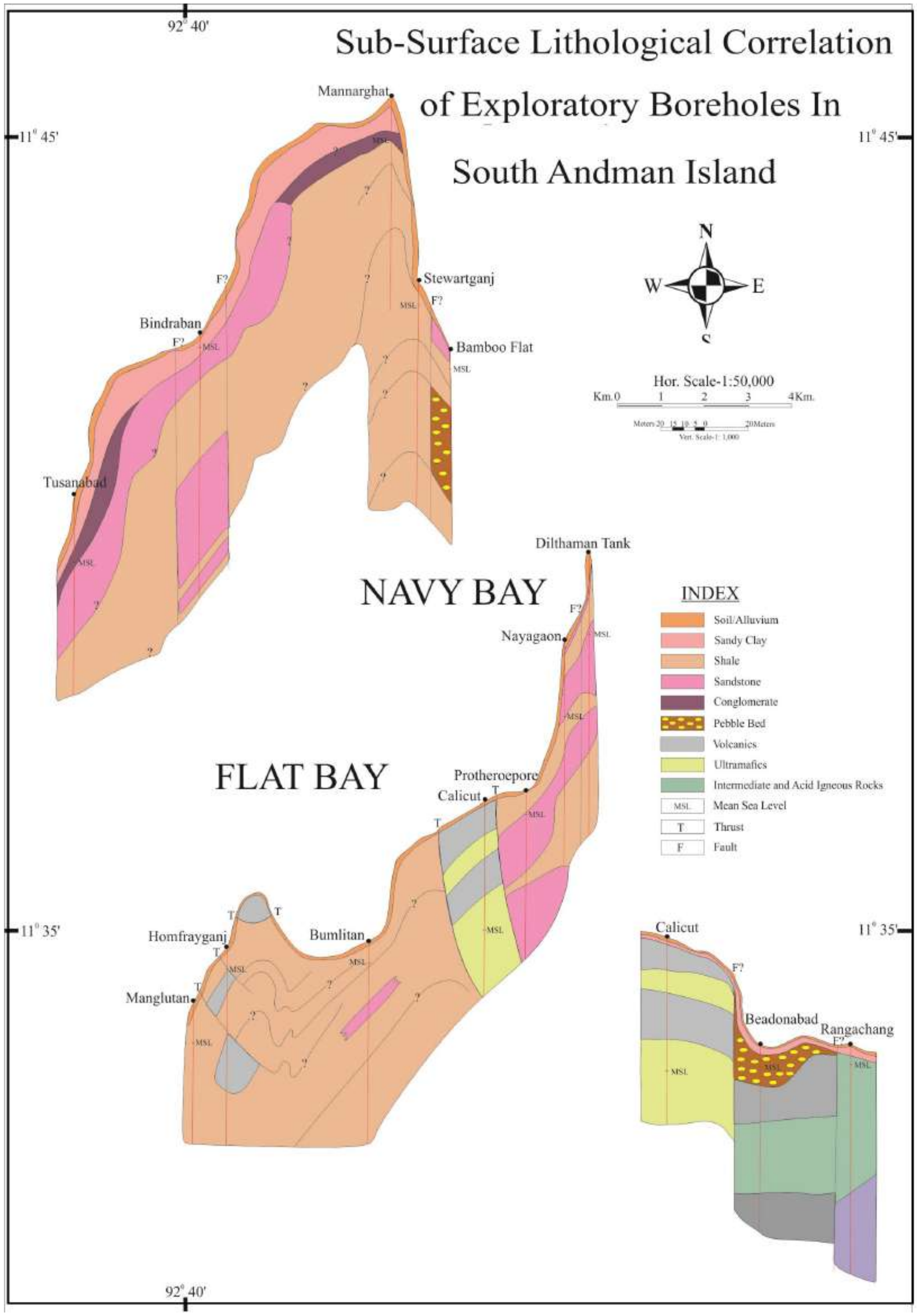


Figure 6.3.1 Sub surface Lithological Correlation of Exploratory Boreholes in South Andaman Islands

Chapter 7

GROUND WATER RESOURCE OF SOUTH ANDAMAN DISTRICT

Scientific utilization of groundwater in this Island territory needs assessment of ground water resources from time to time keeping in view of its changes with increase in population, irrigated agriculture and emerging tourism. This also warrants an evaluation of the availability, demand and projected demand scenarios of ground water in the islands. However, ground water being at the state of constant flow, assessment procedure becomes highly complicated involving several variables, which are not possible to measure directly. Nevertheless, the effort towards estimation of ground water resources is to cast at a glance over the existing status of ground water scenario of the Andaman & Nicobar Islands is pivotal for formulation of developmental strategies and proper planning.

Since, water level data of all the Islands are not available; the rainfall infiltration method is adopted for computation of annual replenishable ground water resource. As Andaman & Nicobar Islands show high slopy areas, therefore, natural ground water discharge of 10% of annual Replenishable Ground Water Resources has been considered. As there is wide variation in lithology, rainfall infiltration also varies; so, the range of rainfall infiltration factor as utilized during the resources calculation varies from 0.04 to 0.22.

During calculation, the inter-montane valley and relatively flat topographical areas are considered as recharge areas. The hilly areas having slope more than 20% are deducted from the geographical area available in the inhabited islands. In present area, all the ponds constructed by irrigation department are of similar size of 30m x 22m x 3m; also, in these islands rainfall takes place for about 8 months i.e. 240 days and the rest i.e. 125 days are non-rainfall days as suggested by APWD. For recharge by ponds, 1.44mm recharge by one hectare in one day has been considered.

In South Andaman, water for domestic need is made available by APWD from the storage of Dhanikhari Dam; accordingly, calculation for ground water draft for domestic purpose is considered as ‘0’ (for Port Blair city).

As regards the static ground water resources, since detailed drilling data is not available to ascertain the average depth of saprolite (weathered mantle) and fractured horizon, it could not be attempted.

Dynamic Ground Water Resources for the inhabited Islands of Union Territory Andaman & Nicobar Islands have been calculated on the basis of GEC (2015) methodology by CGWB and Andaman Public Works Department (APWD) for the year 2017. The computed data of dynamic ground water resources for the year 2017 in parts of South Andaman district is shown in **Table-7.1**.

Table-7.1: Ground water resource estimation in parts of South Andaman Islands (2017)

S.N0.	Name of Island	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category
1.	Neil	1.4763	0.0903	6.11	Safe
2.	Havelock	4.5496	0.1875	4.12	Safe
3.	Little Andaman	31.2579	0.5610	1.79	Safe
4.	South Andaman	15.7473	4.0025	25.41	Safe
5.	Rutland	21.3765	0.0075	0.035	Safe

Chapter 8

HYDROCHEMISTRY

8.1: Neil Island

The statistical chemical result of the Neil Island is shown in the **Table 8.1.1**. The pH ranges from 7.34 to 9.15. The maximum pH of 9.15 was detected at Laxmanpur-3, which is above the BIS (2012) drinking water standard. The electrical conductivity of the island varies from a minimum of 416 to a maximum of 4941 µS/cm at 25°C. The maximum electrical conductivity was detected at Laxmanpur-1. Electrical conductivity above 2000 µS/cm was detected in three locations namely Laxmanpur-3, Laxmanpur-2 and RamNagar-1. The abnormally high electrical conductivity in the study area may be attributed to sea water intrusion and evaporation process, which is the dominant force responsible for the hydrochemistry in the groundwater of the area, as suggested by the Gibbs Plot (**Figure 8.1.3).** The spatial distribution of electrical conductivity is shown in **Figure 8.1.1**.

Table 8.1.1: Statistical summary of the chemical result

		Min	Max	Mean	SD
pH	(µS/cm at 25°C)	7.34	9.15	7.87	0.28
EC	(mg/L)	416.30	4941.00	982.51	951.72
Ca	(mg/L)	14.00	70.00	28.50	13.33
Mg	(mg/L)	2.43	115.29	40.69	29.79
Total Hardness as $CaCO_3$	(mg/L)	120.00	580.00	238.91	131.31
Na	(mg/L)	25.80	956.00	128.15	186.15
K	(mg/L)	0.62	21.10	5.96	5.02
CO_3	(mg/L)	0.00	0.00	0.00	0.00
HCO_3	(mg/L)	91.50	402.60	147.16	54.05
Total Alkalinity as $CaCO_3$	(mg/L)	75.00	330.00	122.19	44.25
Cl	(mg/L)	92.17	92.17	92.17	0.00
SO_4	(mg/L)	2.46	35.00	21.79	7.87
NO_3	(mg/L)	1	44.64	9.20	13.53
F	(mg/L)	0.03	0.66	0.15	0.17
SiO_2	(mg/L)	0.11	392.00	126.87	114.72
TDS	(mg/L)	312.23	3705.75	736.88	713.79
PO_4	(mg/L)	0.01	1.50	0.09	0.26

The Chadha plot (**Figure 8.1.2**) shows the pervasiveness of Ca-Mg-Cl type and Na-Cl type of water in the study area. It is apparent from the plot that Ca, Mg and Na ion are the dominant cation and Cl ion, the dominant anion. The TDS vs. TH plot (**Figure 8.1.5**) reveals that the collected samples were from fresh source of water except for four sample location namely Laxmanpur-1, Laxmanpur-3, Laxmanpur-2 and RamNagar-1, the source of which are classified as brackish indicating sea water intrusion. The hardness varies from slightly hard to very hard. In terms of irrigation, the Wilcox diagram (**Figure 8.1.5**) classifies most of the water samples as suitable for irrigation. The water samples from the above mentioned locations, falls in the doubtful to unsuitable category in the Wilcox plot, emphasising treatment of the water before going for irrigation.

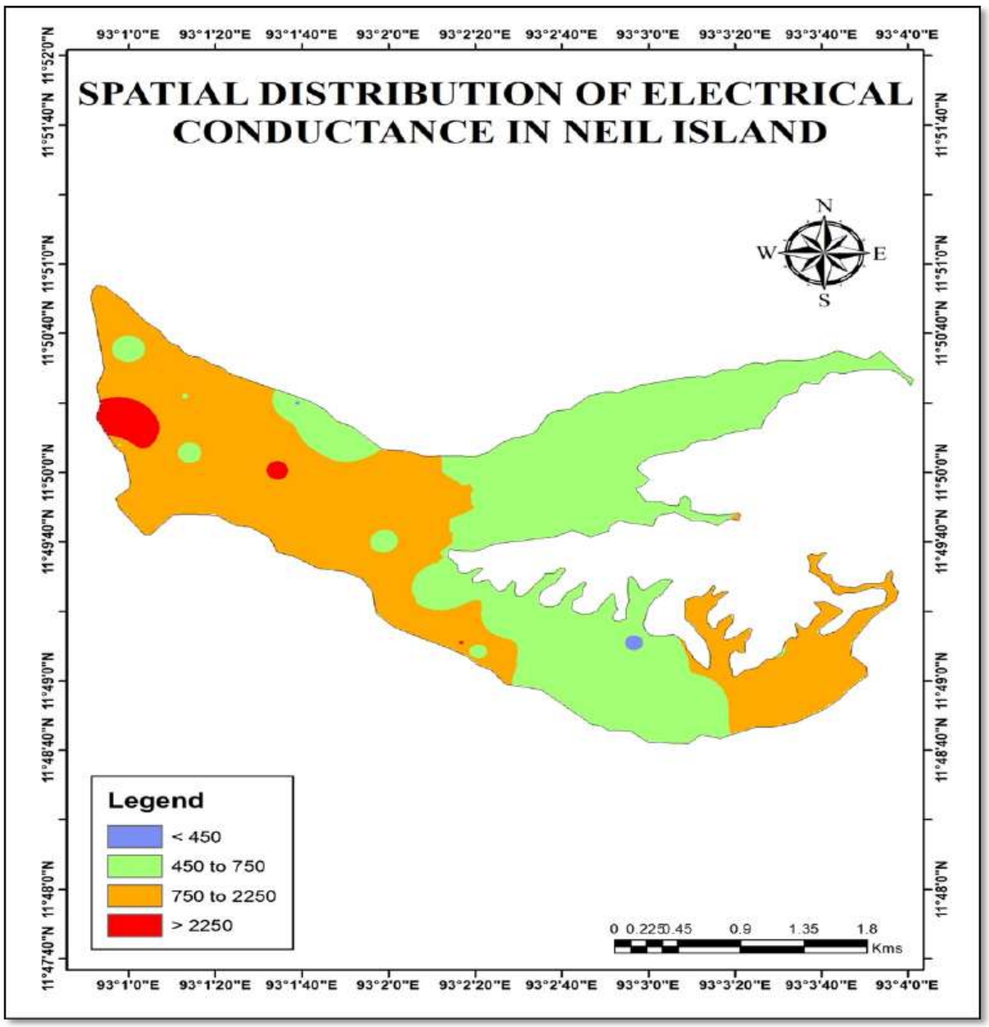


Figure 8.1.1: spatial distribution of Electrical Conductivity in Neil Island

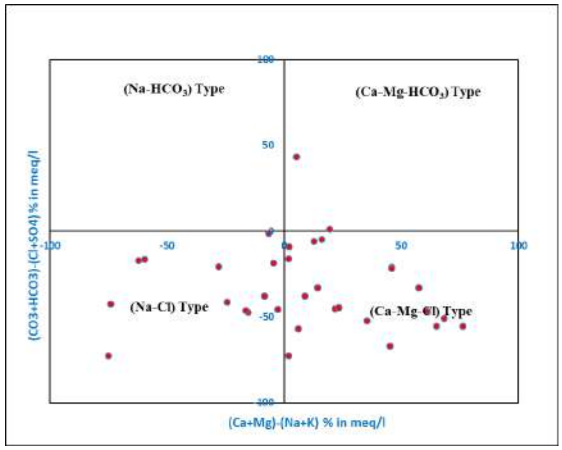


Figure 8.1.2: Chadha plot for Neil Island

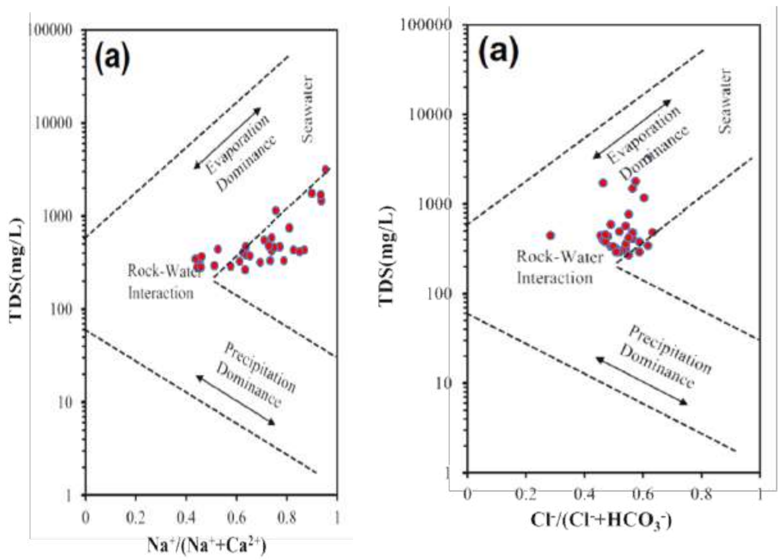


Figure 8.1.3: **Gibbs plot for Neil Island**

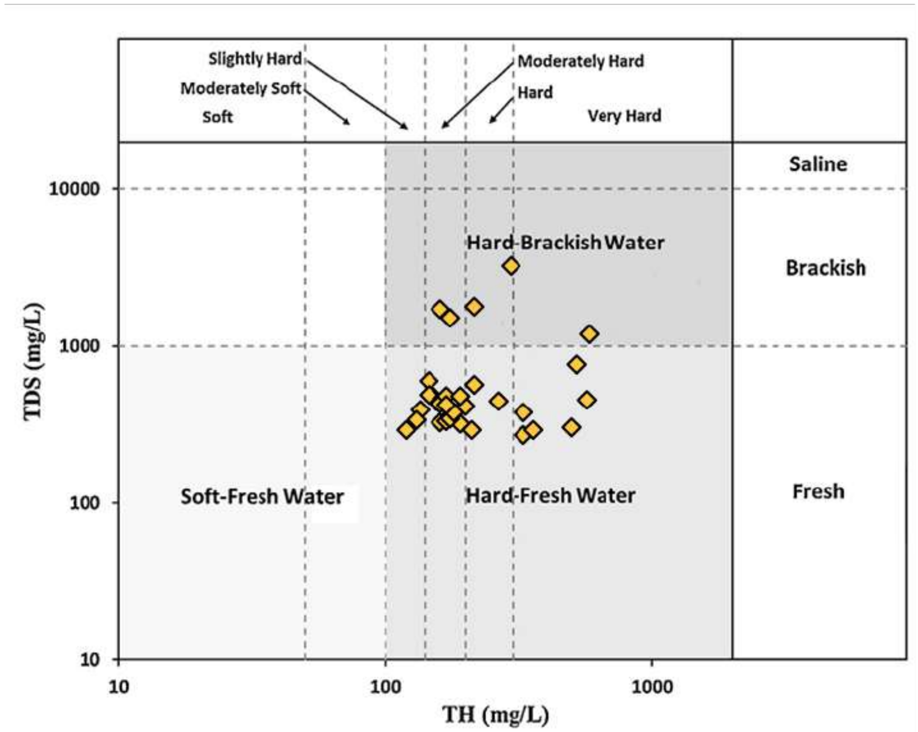


Figure 8.1.4: Plot of TDS vs. TH for characterisation of the groundwater for Neil Island

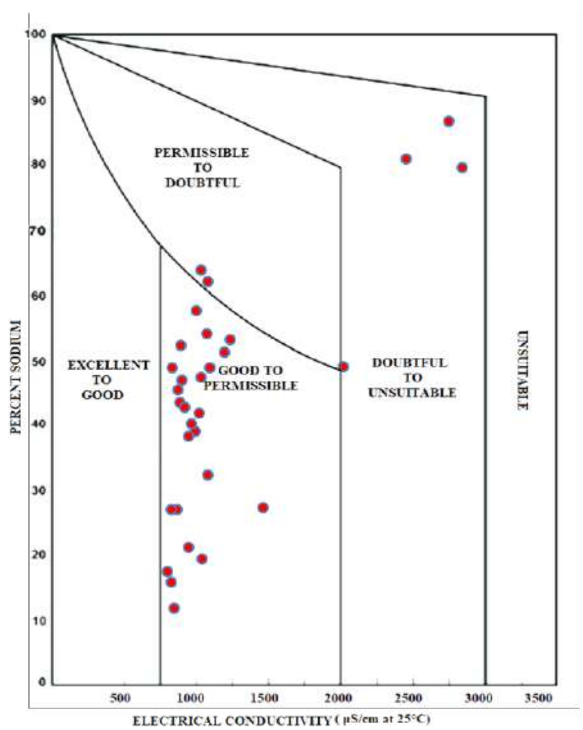


Figure 8.1.5: Wilcox diagram for Neil Island

Annexure- 8.1.1 Chemical Analysis of Ground water sampling of the study area in Neil Island, South

District	Block	Village	pH	EC (µs/cm) 25C	CO3	HCO3	TA as CaCO3	Cl	SO4	NO3	F	Ca	Mg	TH as CaCO3	Na	K	PO4	SiO4	TDS
South Andaman	Neil Island	Sitapur	7.34	735.4	0	122	100	92.17	106	23.67	0.5	26	20.63106796	150	100.8	21.1	0.07	8.78	478.01
South Andaman	Neil Island	Sitapur	7.48	868.1	0	134.2	110	92.17	159	4.05	0	36	30.33980583	215	101.6	4.61	0.08	15	564.265
South Andaman	Neil Island	Sitapur	7.72	679.3	0	189.1	155	92.17	102	40	0.06	22	24.27184466	155	119.3	12	0.06	20	441.545
South Andaman	Neil Island	Sitapur	7.64	1808	0	103.7	85	92.17	392	44	0.16	70	98.30097087	580	250.9	10.5	1.5	18.84	1175.2
South Andaman	Neil Island	Sitapur	7.89	635.4	0	122	100	92.17	129	0	0	28	31.55339806	200	54	8.4	0.06	35	413.01
South Andaman	Neil Island	Sitapur	7.9	498.2	0	134.2	110	92.17	109	0	0	22	25.48543689	160	57.5	7	0.01	33.91	323.83
South Andaman	Neil Island	Ram Nagar	7.95	416.3	0	128.1	105	92.17	226	1.1	0	16	70.38834951	330	31.9	0.62	0.01	21.64	270.595
South Andaman	Neil Island	Ram Nagar	7.94	512.8	0	164.7	135	92.17	20.57	13.32	0.14	30	23.05825243	170	54.8	9.8	0.03	16.92	333.32
South Andaman	Neil Island	Ram Nagar	7.96	487.2	0	152.5	125	92.17	59	9.16	0	32	26.69902913	190	30.7	2.8	0.08	25.91	316.68
South Andaman	Neil Island	Ram Nagar	7.91	663.7	0	170.8	140	92.17	23.6	1.37	0.19	16	29.12621359	160	52.4	1.5	0.1	19.17	431.405
South Andaman	Neil Island	RamNagar-3	7.93	604.5	0	183	150	92.17	15.97	3.37	0	20	20.63106796	135	40.7	2	0.02	26.47	392.925
South Andaman	Neil Island	RamNagar-1	7.94	549.6	0	134.2	110	92.17	85	0.43	0.03	66	2.427184466	175	59.07	2	0	25.56	357.24
South Andaman	Neil Island	RamNagar-1	7.93	466.2	0	140.3	115	92.17	259	22	0	22	108.0097087	500	26.8	7	0.02	28.78	303.03
South Andaman	Neil Island	RamNagar-1	7.65	2304	0	122	100	92.17	11.09	0.49	0	20	30.33980583	175	340.8	10	0.07	16.16	1497.6
South Andaman	Neil Island	RamNagar-1	7.93	527.8	0	97.6	80	92.17	155	1.5	0.07	16	32.76699029	175	68.9	4	0.05	33.75	343.07
South Andaman	Neil Island	Neil Kendra-3	7.83	685.7	0	402.6	330	92.17	0.11	2.5	0.25	14	55.82524272	265	106.3	6	0.05	28.6	445.705
South Andaman	Neil Island	Neil Kendra-3	7.81	914.3	0	164.7	135	92.17	8.2	0	0.11	22	21.84466019	145	72.06	7	0.1	26.01	594.295
South Andaman	Neil Island	Bharatpur-1	7.83	584.5	0	109.8	90	92.17	101	2.31	0	22	30.33980583	180	48	6	0.01	20.8	379.925
South Andaman	Neil Island	Bharatpur-1	7.84	729.7	0	122	100	92.17	88	2.83	0	26	25.48543689	170	90.17	4	0.08	26.45	474.305
South Andaman	Neil Island	Bharatpur-2	7.97	647.3	0	128.1	105	92.17	158	44.64	0.66	16	31.55339806	170	103.1	5.8	0.02	2.46	420.745
South Andaman	Neil Island	Neil Kendra-2	7.78	751	0	146.4	120	92.17	34.04	29.11	0.46	20	23.05825243	145	61.7	4	0.06	27.62	488.15
South Andaman	Neil Island	Neil Kendra-4	7.88	520	0	158.6	130	92.17	57	1.14	0.18	20	19.41747573	130	63.2	4	0.04	13.32	338
South Andaman	Neil Island	Neil Kendra-1	7.93	449.5	0	146.4	120	92.17	13.09	11.15	0.42	32	9.708737864	120	50.46	4	0.01	7.96	292.175
South Andaman	Neil Island	Neil Kendra-1	7.93	444.8	0	152.5	125	92.17	243	2.08	0	28	70.38834951	360	25.8	9	0.02	23.64	289.12
South Andaman	Neil Island	Neil Kendra-1	7.7	734.5	0	91.5	75	92.17	106	2.75	0	20	33.98058252	190	40.6	2	0.04	22.05	477.425
South Andaman	Neil Island	Laxmanpur-1	7.88	579.6	0	176.9	145	92.17	152	10	0.22	40	55.82524272	330	39.82	2	0.02	17.78	376.74

Annexure- 8.1.1 Chemical Analysis of Ground water sampling of the study area in Neil Island, South Andaman District

South Andaman	Neil Island	Laxmanpur-1	7.87	446.8	0	109.8	90	92.17	10	0.04	0.18	36	29.12621359	210	35.25	1	0.06	28	290.42
South Andaman	Neil Island	Laxmanpur-1	7.65	1175	0	128.1	105	92.17	388	0	0.17	18	115.2912621	520	88.53	2.7	0.05	14.43	763.75
South Andaman	Neil Island	Laxmanpur-1	7.89	691	0	176.9	145	92.17	258	0.48	0.21	46	110.4368932	570	58.95	7.3	0.01	34.82	449.15
South Andaman	Neil Island	Laxmanpur-1	7.9	4941	0	97.6	80	92.17	358	0.31	0.24	42	46.11650485	295	956	1.2	0.01	19.64	3211.65
South Andaman	Neil Island	Laxmanpur-2	7.82	2641	0	183	150	92.17	231	0.32	0.38	30	20.63106796	160	480.02	20.7	0.09	19.22	1716.65
South Andaman	Neil Island	Laxmanpur-3	9.15	2748		115.9	145	92.17	2.13	20.22	0.11	38	29.12621359	215	390.8	0.78	0.01	18.49	1786.2

8.2 Havelock Island

The summarised statistical data of the Havelock is shown in the **Table 8.2.1**. The pH of the island varies from a minimum of 7.79 to 8.28, which is within the drinking water standard set by the BIS (2012). The observed Electrical conductivity of the island is 372.8 to 3082µS/cm at 25°C. The spatial distribution of electrical conductivity in the study area of the island is shown in the **Figure 8.2.1**. The incursion of the sea water has not been observed in the island which is also supported by the Gibbs Plot **Figure 8.2.2,** indicating dominance of rock-water interaction in the ground water hydrochemistry of the study area along with evaporation in few locations. All the analysed physico-chemical parameters of the island is within the BIS (2012) permissible limit.

Table 8.2.1 Statistical summary of the chemical result in Havelock Island

	Min	Max	Mean	SD
pH	7.79	8.28	8.04	0.12
EC	372.80	3082.00	988.38	674.93
Ca	8.00	42.00	29.09	9.81
Mg	1.94	61.89	26.29	15.64
Total Hardness as $CaCO_3$	110.00	330.00	181.05	62.20
Na	20.50	490.30	165.22	144.97
K	0.88	24.00	11.42	6.09
CO_3	0.00	0.00	0.00	0.00
HCO_3	103.70	402.60	177.24	72.61
Total Alk as $CaCO_3$	85.00	330.00	149.21	60.92
Cl	92.17	92.17	92.17	0.00
SO_4	5.00	302.00	89.50	91.31
NO_3	0.04	15.67	4.67	4.91
F	0.04	0.87	0.21	0.28
SiO_2	4.22	37.77	19.41	8.89
TDS	242.32	2003.30	642.45	438.70
PO_4	0.01	0.10	0.05	0.03

The study area is dominated by the Na-Cl type and Ca-Mg-Cl type of water (**Figure 8.2.3**) with Na, Ca and Mg as the dominating anion and Cl as the dominating anion. The plot of TDS vs. TH (**Figure 8.2.4)** shows that the most of the collected water were from fresh source and hardness varies from slightly hard to very hard. Some of the collected water samples indicates brackish source. The Wilcox diagram (**Figure 8.2.5)** reveals that the utilisation of the groundwater from the study area for irrigation is not ideal and majority of the samples falls in the good to permissible zone, one sample in the unsuitable and two samples in the doubtful to unsuitable

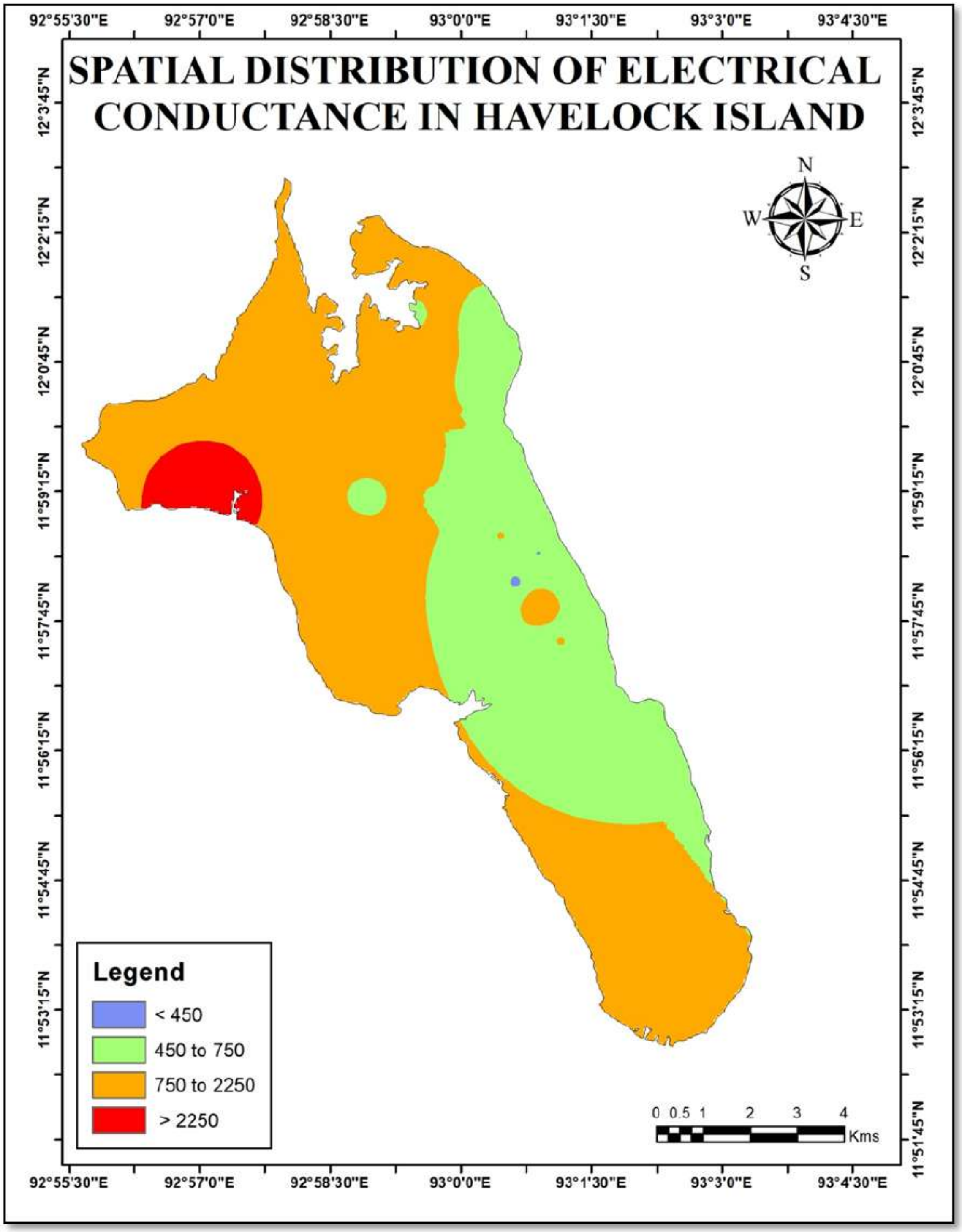


Figure 8.2.1: Spatial distribution of Electrical Conductivity in the Havelock Island

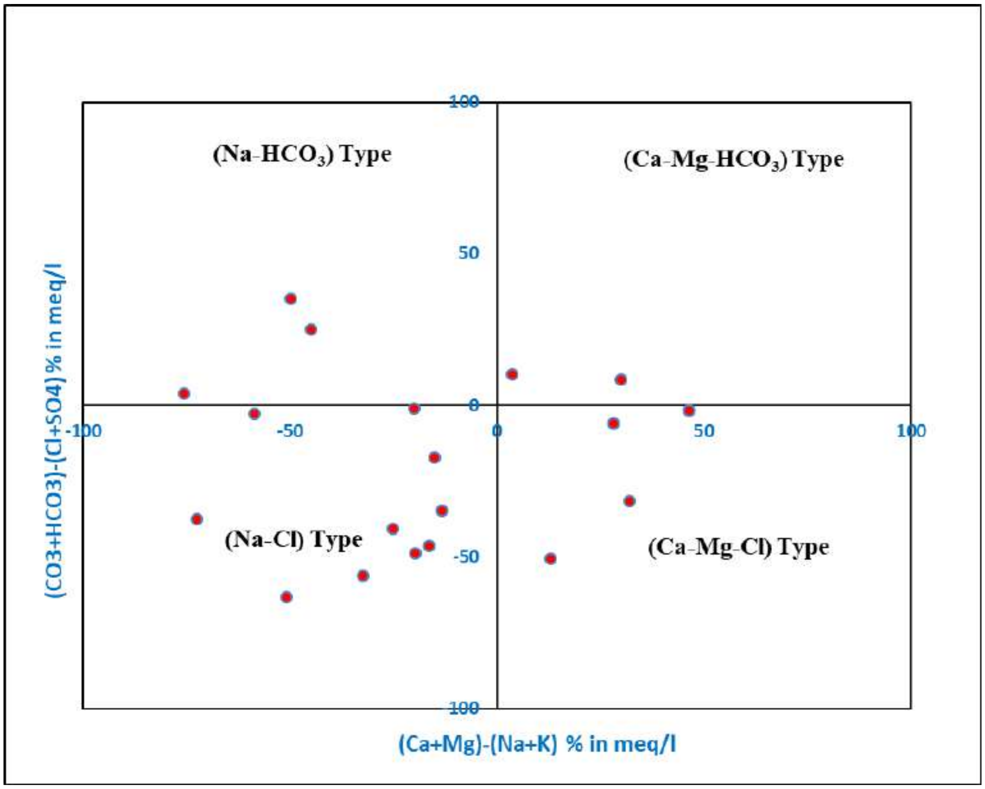


Figure 8.2.2: Chadha plot for Havelock Island

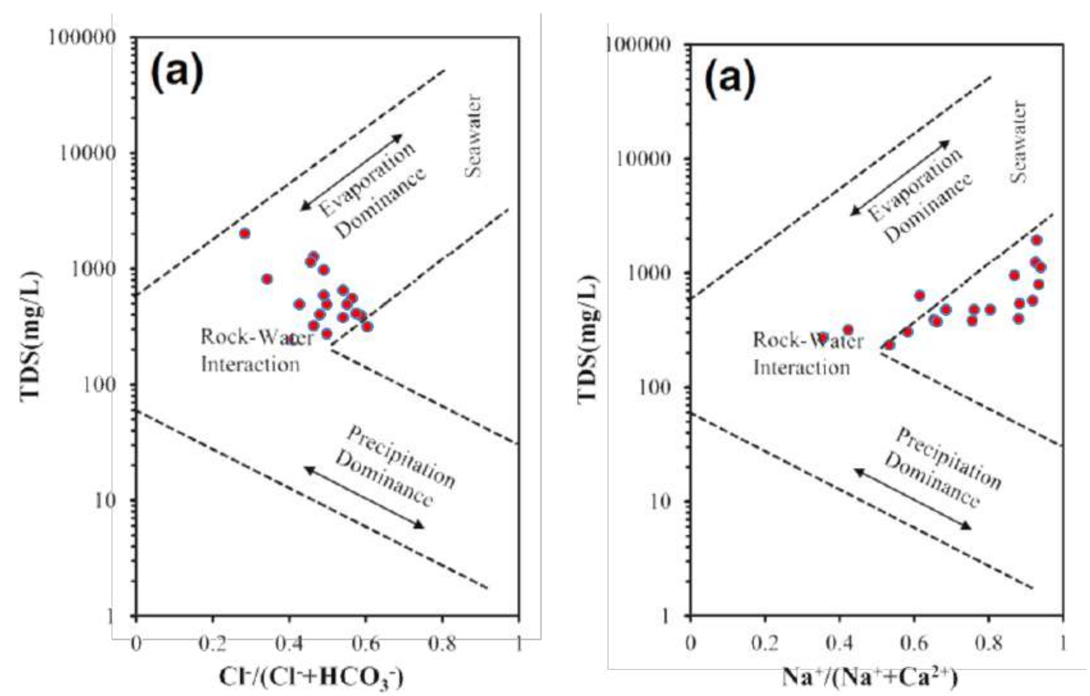


Figure 8.2.3: Gibbs plot for Havelock Island

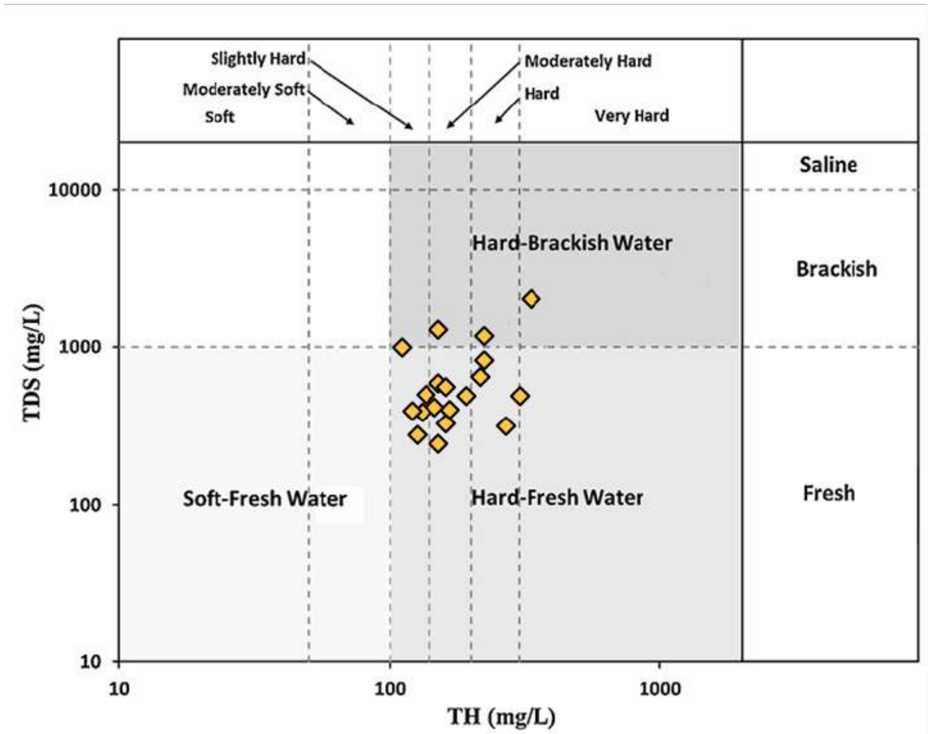


Figure 8.2.4: Plot of TDS vs. TH for characterisation of the groundwater for Havelock Island

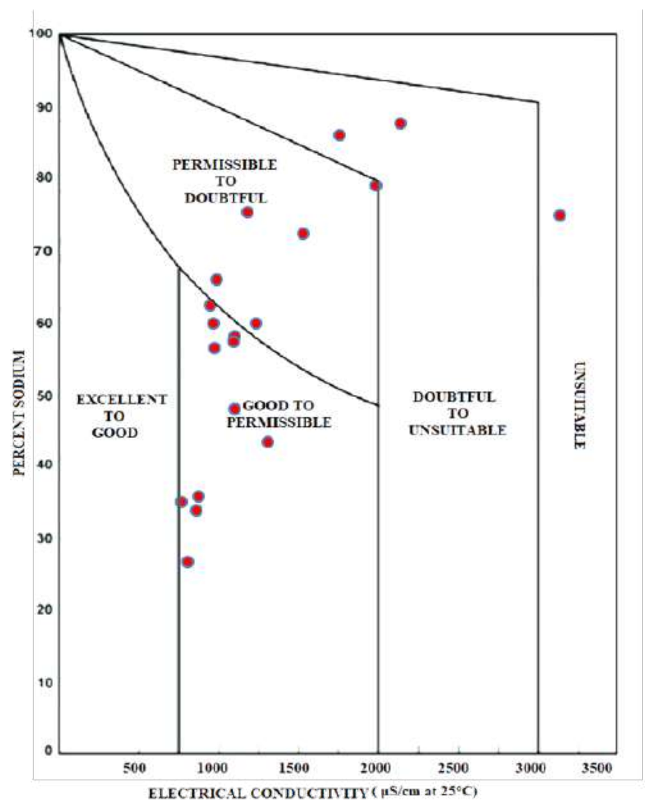


Figure 8.2.5: Wilcox diagram for Havelock Island

Anexure.8.2.1 Chemical Analysis of Ground water sampling of the study area in Havelock Island, South Andaman District

District	Block	Village	pH	EC (µs/cm) 25C	CO_3	HCO_3	TA as $CaCO_3$	Cl	SO_4	NO_3	F	Ca	Mg	TH as $CaCO_3$	Na	K	PO_4	SiO_4	TDS
South Andaman	Havelock Island	Kalapathar	8.28	755.30	0.00	158.60	130.00	92.17	216.00	5.80	0.27	30.00	27.91	190.00	110.70	19.00	0.03	12.47	490.95
South Andaman	Havelock Island	Nayebasti	8.14	757.90	0.00	213.50	175.00	92.17	12.00	9.63	0.00	22.00	19.42	135.00	55.50	3.40	0.03	15.37	492.64
South Andaman	Havelock Island	Nayebasti	8.17	909.40	0.00	164.70	135.00	92.17	7.73	1.79	0.57	8.00	31.55	150.00	101.40	3.80	0.08	16.96	591.11
South Andaman	Havelock Island	Vijaynagar	8.10	615.50	0.00	170.80	140.00	92.17	152.00	2.35	0.04	42.00	14.56	165.00	90.70	13.90	0.06	23.69	400.08
South Andaman	Havelock Island	Vijaynagar	8.02	499.30	0.00	183.00	150.00	92.17	36.72	14.41	0.35	38.00	15.78	160.00	32.30	15.00	0.04	23.47	324.55
South Andaman	Havelock Island	Govind Nagar	8.08	848.30	0.00	122.00	100.00	92.17	302.00	1.48	0.07	26.00	23.06	160.00	220.90	10.00	0.06	29.94	551.40
South Andaman	Havelock Island	Govind Nagar	7.95	993.40	0.00	134.20	110.00	92.17	195.00	1.11	0.00	38.00	29.13	215.00	70.20	10.00	0.05	25.62	645.71
South Andaman	Havelock Island	Sitanagar	7.98	585.00	0.00	134.20	110.00	92.17	125.00	12.45	0.34	40.00	7.28	130.00	90.30	16.00	0.01	30.00	380.25
South Andaman	Havelock Island	Krisnanagar	7.79	1507.00	0.00	164.70	135.00	92.17	160.00	1.88	0.00	40.80	1.94	110.00	310.80	10.00	0.08	10.00	979.55
South Andaman	Havelock Island	Krisnanagar	8.00	604.50	0.00	109.80	90.00	92.17	126.00	1.70	0.00	22.00	15.78	120.00	77.80	8.00	0.06	27.93	392.93
South Andaman	Havelock Island	Kalapathar(PB)	7.97	423.10	0.00	159.00	205.00	92.17	5.00	2.07	0.00	32.00	10.92	125.00	20.50	0.88	0.02	4.22	275.02
South Andaman	Havelock Island	Krishna Nagar	8.06	631.90	0.00	115.90	95.00	92.17	201.00	1.56	0.00	14.00	26.70	145.00	117.30	22.00	0.01	17.09	410.74
South Andaman	Havelock Island	Kalapathar	8.04	372.80	0.00	225.70	185.00	92.17	25.30	3.52	0.09	26.00	20.63	150.00	34.30	5.00	0.06	21.13	242.32
South Andaman	Havelock Island	Kalapathar	8.06	753.40	0.00	128.10	105.00	92.17	17.22	0.04	0.84	38.00	49.76	300.00	180.60	10.00	0.05	37.77	489.71
South Andaman	Havelock Island	Vijaynagar	7.81	1944.00	0.00	183.00	150.00	92.17	8.41	1.90	0.00	34.00	15.78	150.00	490.30	10.00	0.07	24.82	1263.60
South Andaman	Havelock Island	Vijaynagar	8.07	481.50	0.00	103.70	85.00	92.17	31.87	8.24	0.42	34.00	43.69	265.00	55.01	13.00	0.00	18.31	312.98
South Andaman	Havelock Island	Govind Nagar	7.88	1768.00	0.00	189.10	155.00	92.17	32.33	15.67	0.87	22.00	40.05	220.00	380.00	11.00	0.03	11.74	1149.20
South Andaman	Havelock Island	Govind Nagar	8.20	1247.00	0.00	305.00	250.00	92.17	19.61	1.74	0.22	16.00	43.69	220.00	260.00	12.00	0.10	6.06	810.55
South Andaman	Havelock Island	Radhanagar	8.07	3082.00	0.00	402.60	330.00	92.17	27.34	1.34	0.00	30.00	61.89	330.00	440.60	24.00	0.05	12.22	2003.30

8.3 Little Andaman Island

The summarised statistical data of the Little Andaman Island is shown in the **Table 8.3.1**. The pH of the island varies from a minimum of 7.37 to 8.16, which is within the drinking water standard set by the BIS (2012). The observed Electrical conductivity of the island is 120 to 1617 µS /cm at 25° C. The spatial distribution of electrical conductivity in the study area of the island is shown in the **Figure 8.3.1**. The incursion of the sea water has not been not observed in the island which is also supported by the Gibbs Plot **Figure 8.3.3,** indicating dominance of rock-water interaction in the ground water hydrochemistry of the study area. All the analysed physico-chemical parameters of the island are within the BIS (2012) permissible limit.

Table 8.3.1: Statistical summary of Little Andaman chemical result

		Min	Max	Mean	SD
pH		7.37	8.16	7.80	0.25
EC	(µS/cm at 25°C)	120	1671	511.83	390.20
Ca	(mg/L)	12	120	41.67	27.01
Mg	(mg/L)	6.07	70.47	24.40	16.85
Total Hardness as $CaCO_3$	(mg/L)	55	590	204.58	133.13
Na	(mg/L)	3.16	144.20	26.06	39.73
K	(mg/L)	0.37	13.78	3.65	3.82
CO_3	(mg/L)	0	0	0	0
HCO_3	(mg/L)	48.80	494.10	197.23	106.30
Total Alkalinity as $CaCO_3$	(mg/L)	40	405.00	161.67	87.13
Cl	(mg/L)	14.18	269.42	49.93	70.24
SO4	(mg/L)	26	48.94	13.26	20.31
NO_3	(mg/L)	0.13	16.36	5	5.13
F	(mg/L)	0.04	0.45	0.04	0.13
SiO_2	(mg/L)	6.26	22.38	14.84	4.72
TDS	(mg/L)	72.69	973.40	299.16	225.46

Assessment of the groundwater samples from the Little Andaman reveals that the groundwater is mostly Ca-Mg-HCO_3 type (**Figure 8.3.2**) with Ca and Mg being the dominant cation and HCO_3, the dominant anion. Further, the plot of TDS vs. TH (**Figure 8.3.4**) indicates that, most of the sample water is fresh and hardness varies from soft-fresh water to hard-fresh water with the exception of one sample, which indicates slightly brackish water. The

Wilcox diagram (**Figure 8.3.5**) suggests that the groundwater is suitable for irrigation and all the samples except for one falls in the Excellent to Good category.

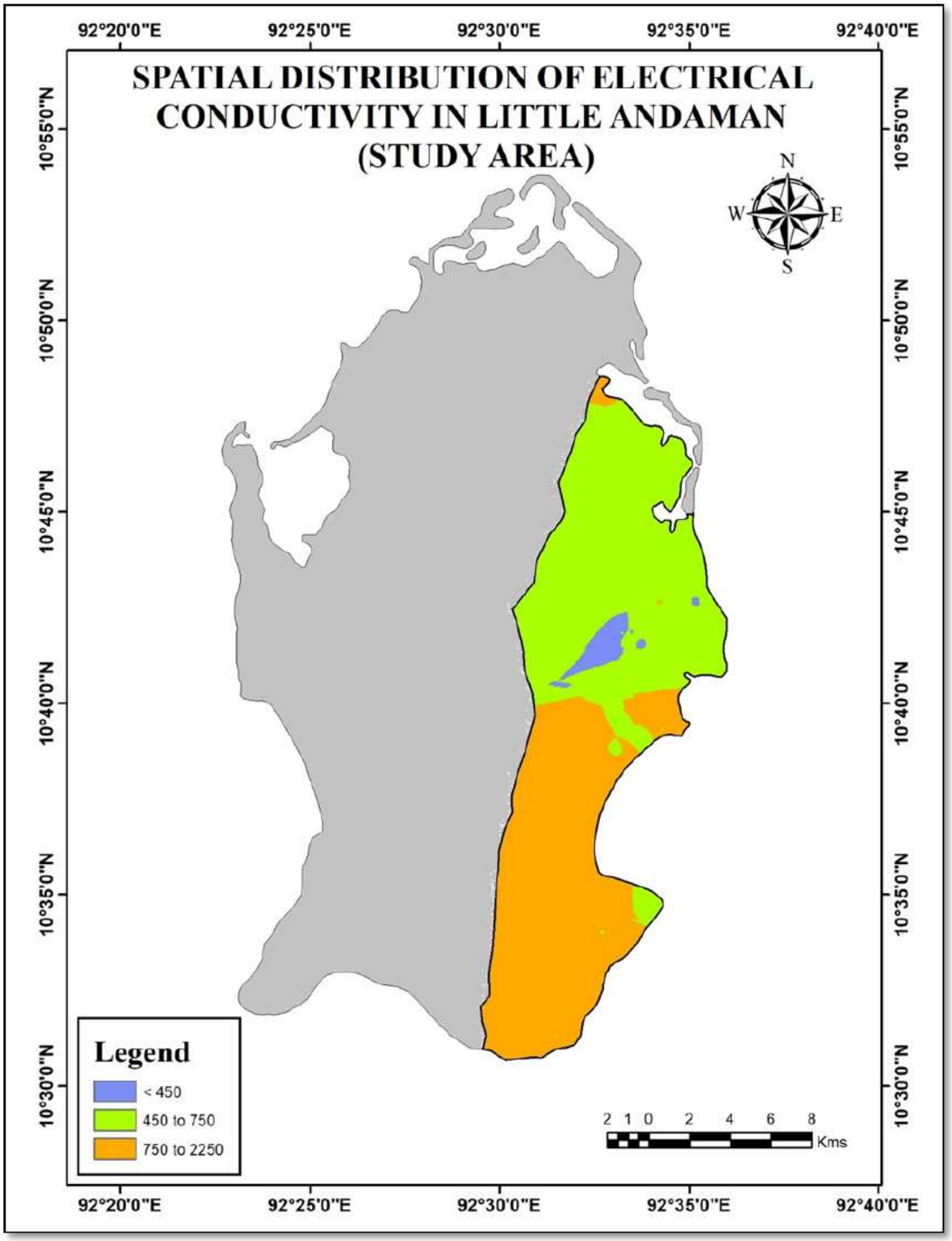


Figure 8.3.1 Spatial distribution of EC in Little Andaman

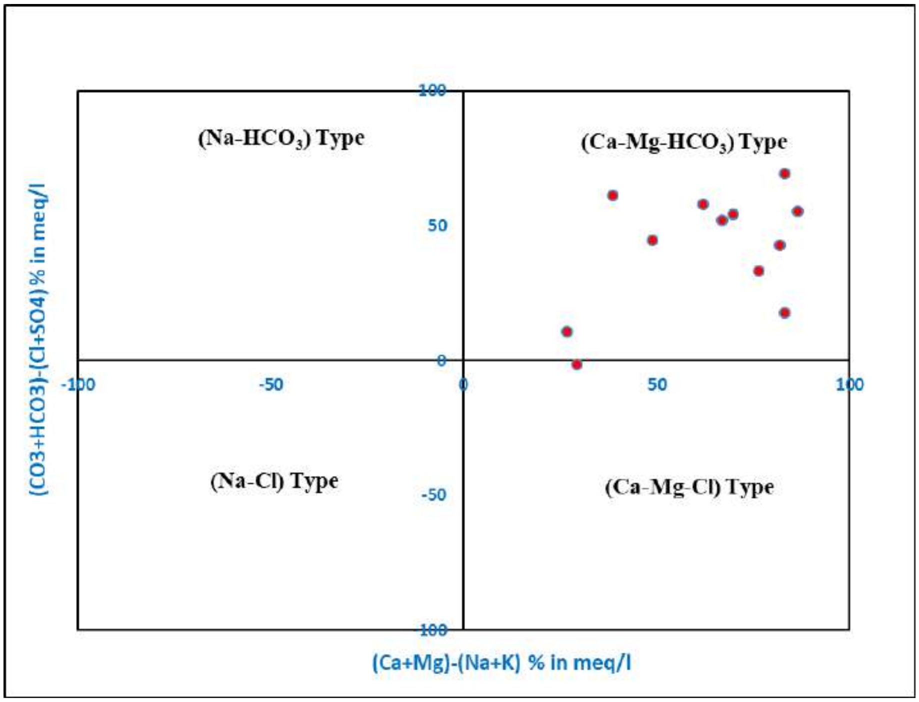


Figure 8.3.2 Chadha plot for Little Andaman

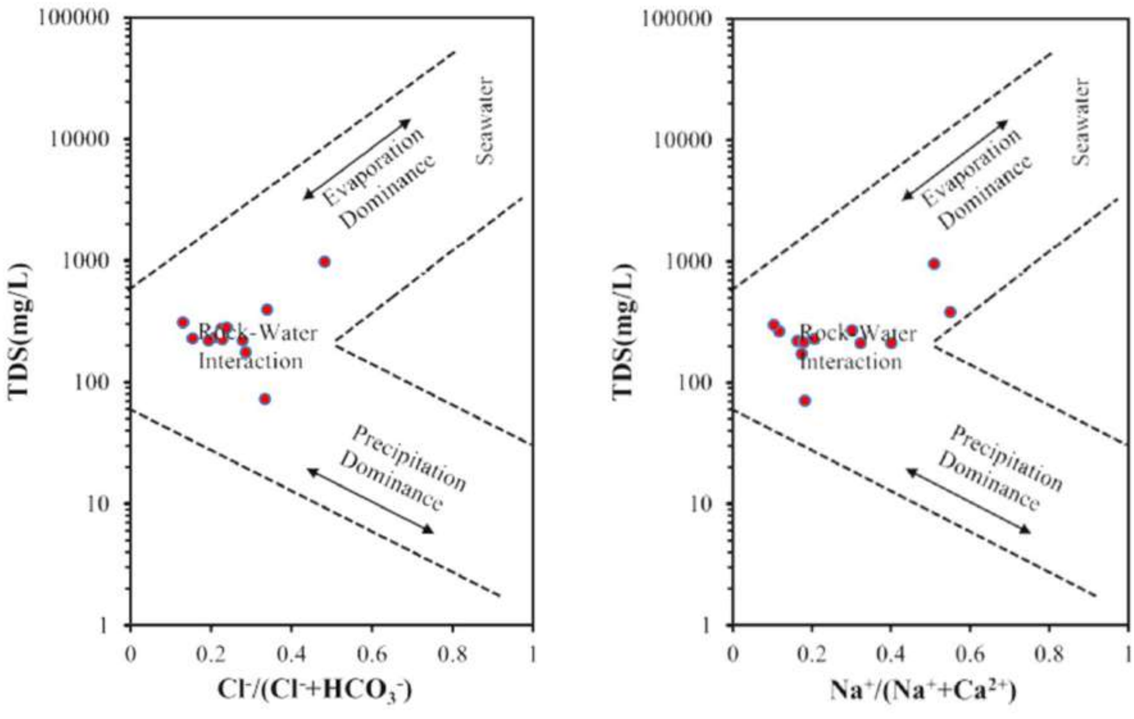


Figure 8.3.3 Gibbs plots for Little Andaman

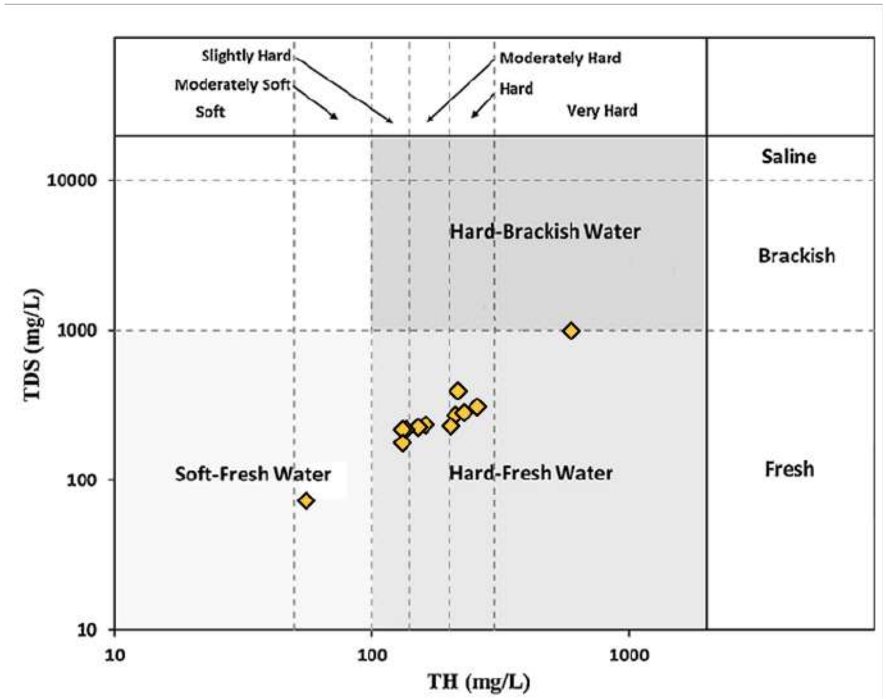


Figure 8.3.4 Classification of groundwater on the basis of TDS and TH for Little Andaman

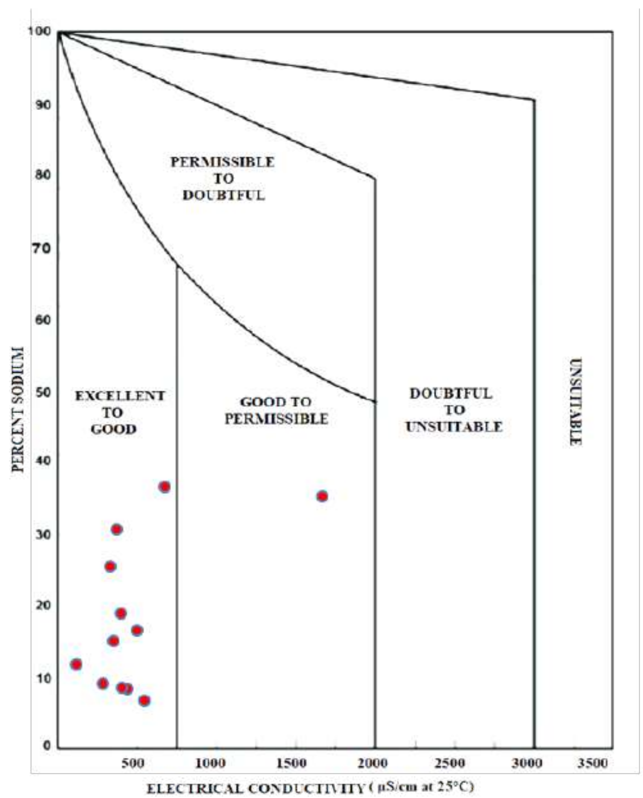


Figure 8.3.5 Wilcox diagram the assess the suitability of water for irrigation for Little Andaman

Annexure: 8.3.1 Chemical Analysis of Ground water sampling of the study area in Little Andaman District

District	Block	Village	pH	EC (µs/cm) 25C	Ca	Mg	TH as CaCO3	Na	K	CO3	HCO3	TA as CaCO3	Cl	SO4	NO3	F	SiO4	TDS
Little Andaman	Little Andaman	Harminder bay	7.98	441.00	52.00	19.44	210.00	8.30	0.91	0.00	146.40	120.00	24.82	46.86	11.53	0.04	17.66	270.86
Little Andaman	Little Andaman	KichadNala	7.50	680.00	38.00	29.16	215.00	53.95	5.59	0.00	213.50	175.00	63.81	48.94	2.47	0.00	19.25	391.41
Little Andaman	Little Andaman	Netaji Nagar	7.42	1671.00	120.00	70.47	590.00	144.20	6.90	0.00	494.10	405.00	269.42	36.87	1.31	0.45	22.38	973.40
Little Andaman	Little Andaman	Farm Trickery	7.80	504.00	38.00	31.59	225.00	19.15	2.42	0.00	213.50	175.00	39.00	0.00	1.74	0.01	16.13	278.27
Little Andaman	Little Andaman	Ramakrishnapur	7.83	549.00	50.00	31.59	255.00	6.94	2.61	0.00	244.00	200.00	21.27	26.42	4.56	0.00	13.94	306.17
Little Andaman	Little Andaman	Netaji Nagar(RO)	8.16	120.00	12.00	6.07	55.00	3.16	0.37	0.00	48.80	40.00	14.18	0.00	0.88	0.00	6.26	72.69
Little Andaman	Little Andaman	Ramakrishnapur	7.90	410.00	34.00	27.95	200.00	7.80	1.22	0.00	201.30	165.00	21.27	0.00	0.13	0.00	12.80	227.96
Little Andaman	Little Andaman	Vivekanandpur	7.77	402.00	30.00	20.65	160.00	9.14	13.78	0.00	183.00	150.00	28.36	0.00	9.60	0.00	11.20	234.37
Little Andaman	Little Andaman	Rabindranagr	7.90	358.00	36.00	14.58	150.00	9.24	5.16	0.00	164.70	135.00	28.36	0.00	16.36	0.00	13.01	223.18
Little Andaman	Little Andaman	Dugong creak	7.91	337.00	38.00	9.72	135.00	21.03	0.48	0.00	158.60	130.00	35.45	0.00	0.36	0.00	16.69	218.48
Little Andaman	Little Andaman	Dugong creak	7.37	378.00	32.00	12.15	130.00	24.84	2.68	0.00	176.90	145.00	24.82	0.00	4.21	0.00	8.91	217.51
Little Andaman	Little Andaman	Vivekanandpur& Rabindranagr Spring	8.04	292.00	20.00	19.44	130.00	4.98	1.69	0.00	122.00	100.00	28.36	0.00	6.85	0.00	19.88	175.62

8.4 South Andaman Island

The statistical summary of chemical result of the South Andaman is presented in **Table 8.4.1.** The pH of the study area varies from 7.18 to 9.58. Except for the groundwater sample from Haddo-2, the pH of the study area is within the permissible limit of 6.5-8.5 set by BIS (2012) for drinking water. The electrical conductivity varies from a minimum of 118 to a maximum of 6135 µS/cm at 25°C. Groundwater samples collected from the two locations namely Mithakhari and Junglighat (VIP Road) shows electrical conductivity of 6135µS/cm at 25°C and 5412 µS/cm at 25°C respectively. The high electrical conductivity in these two locations, suggests sea water intrusion. The intrusion of sea water in the groundwater of these two locations is also supported by the Gibbs plot (**Figure 8.4.3**) which prophesies the dominance of sea water interaction and Evaporation in the hydrochemistry of these two locations. The dominance of Evaporation in these two locations also resulted in high TDS. The hydrochemistry of rest of the locations is due to the dominance of the rock- water interaction.

Table 8.4.1: Statistical summary of the chemical result of South Andaman Island

		Min	**Max**	**Mean**	**SD**
pH		7.18	9.58	8	0.32
EC	(µS/cm at 25°C)	118	6135	661.24	938.57
Ca	(mg/L)	6	44	20.99	8.60
Mg	(mg/L)	1.22	170.10	33.35	29.22
Total Hardness as $CaCO_3$	(mg/L)	40	800.00	189.70	128.62
Na	(mg/L)	6.80	1118.80	64.13	174.64
K	(mg/L)	0.16	98.60	5.19	13.12
CO_3	(mg/L)	0	0	0	0
HCO_3	(mg/L)	24.40	1433.50	205.58	188.78
Total Alkalinity as $CaCO_3$	(mg/L)	20	1175.00	168.51	154.74
Cl	(mg/L)	10.64	1453.45	91.16	242.35
SO_4	(mg/L)	1	241.95	32.46	50.44
NO_3	(mg/L)	1	44.64	5.08	8.90
F	(mg/L)	0.02	1.01	0.17	0.25
SiO_2	(mg/L)	2.46	40.05	19.76	8.29
TDS	(mg/L)	79.40	3741.34	397.70	577.47
PO_4	(mg/L)	0.01	0.10	0.05	0.03

The categorisation of groundwater samples from the South Andaman Island by using Chadha plot (**Figure 8.4.2**) shows that almost 70% of the groundwater sample is Ca-Mg-HCO_3 type, 15% is Ca-Mg-

Cl type, 8% is Na-Cl type and 7% is Na-HCO_3. It clearly divulges that Ca and Mg is the dominant cation and HCO_3 is the dominant anion. The Gibbs plot for the island suggests, sea water intrusion in few samples with the governing dynamic, liable for the hydrochemistry being the rock-water interaction. The plot of TDS vs. TH (**Figure 8.4.4**) reveals that most of the groundwater samples were from the fresh source except for the two samples which falls in the brackish category. The type of water varies from soft-fresh water to hard-brackish water. The suitability of the groundwater for irrigation on the basis of Wilcox diagram (**Figure 8.4.5**), suggests that the quality of the water varies from excellent to doubtful category.

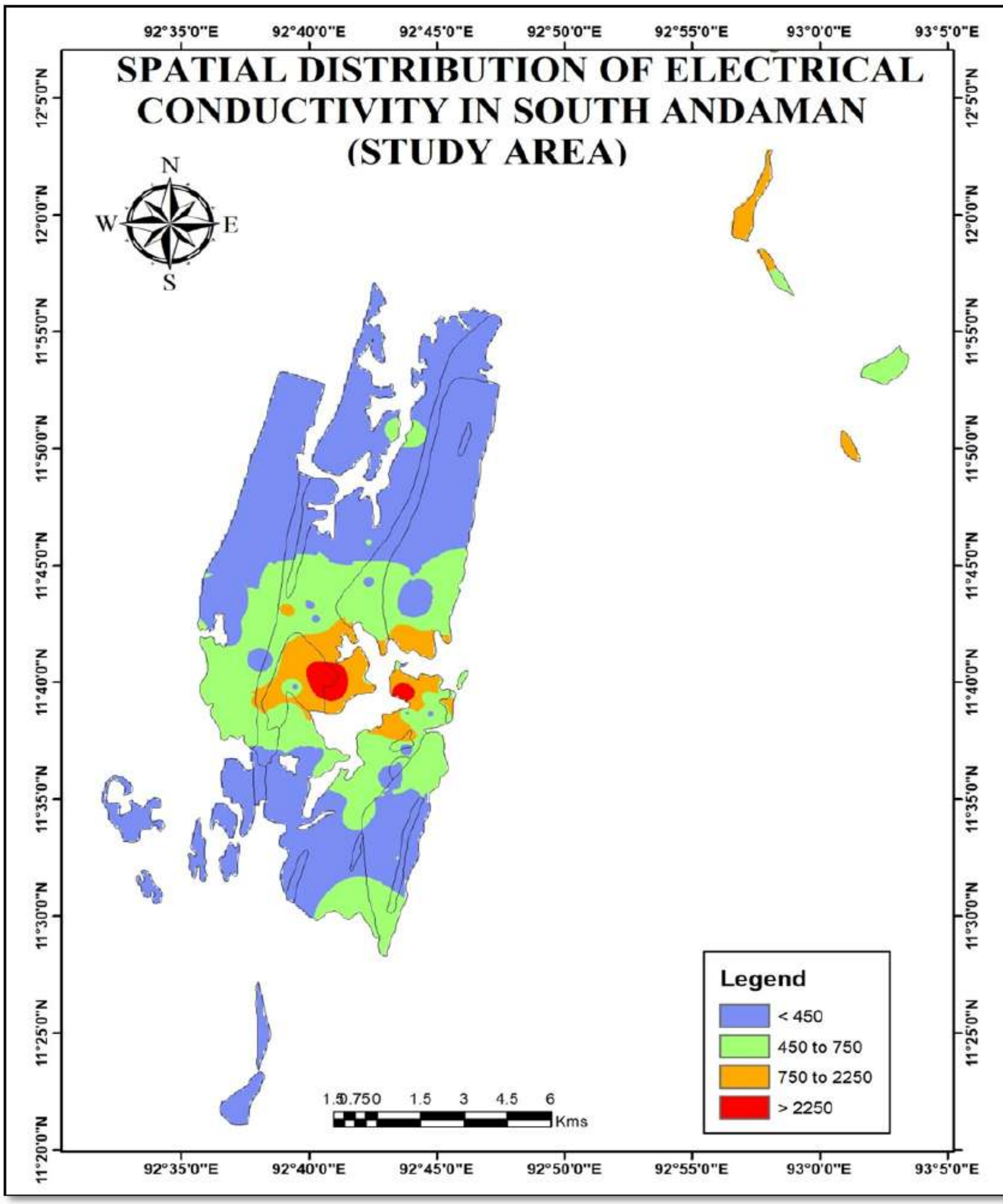


Figure 8.4.1: Spatial distribution of Electrical Conductivity in the South Andaman Island

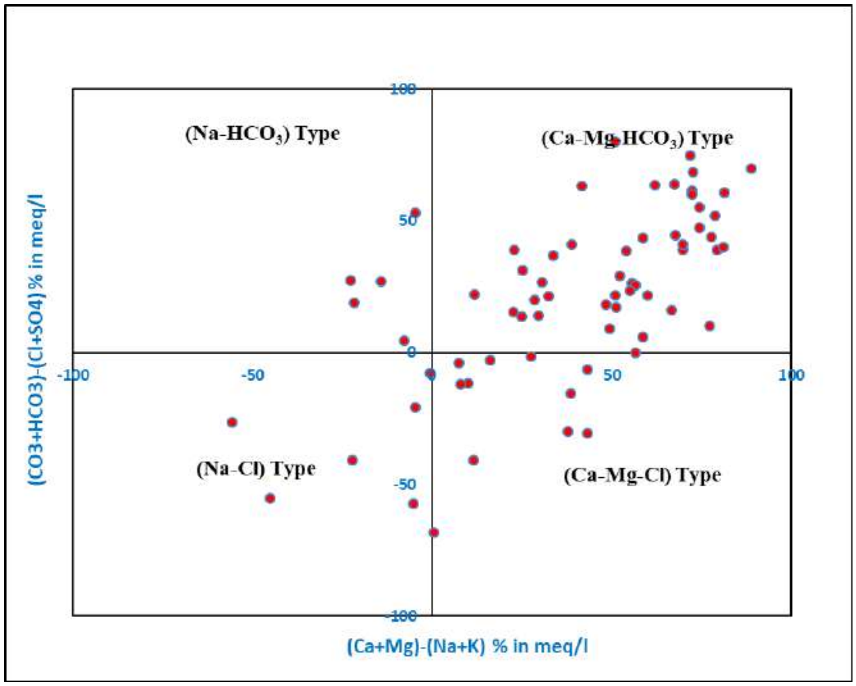


Figure 8.4.2 Chadha Plot for South Andaman Island

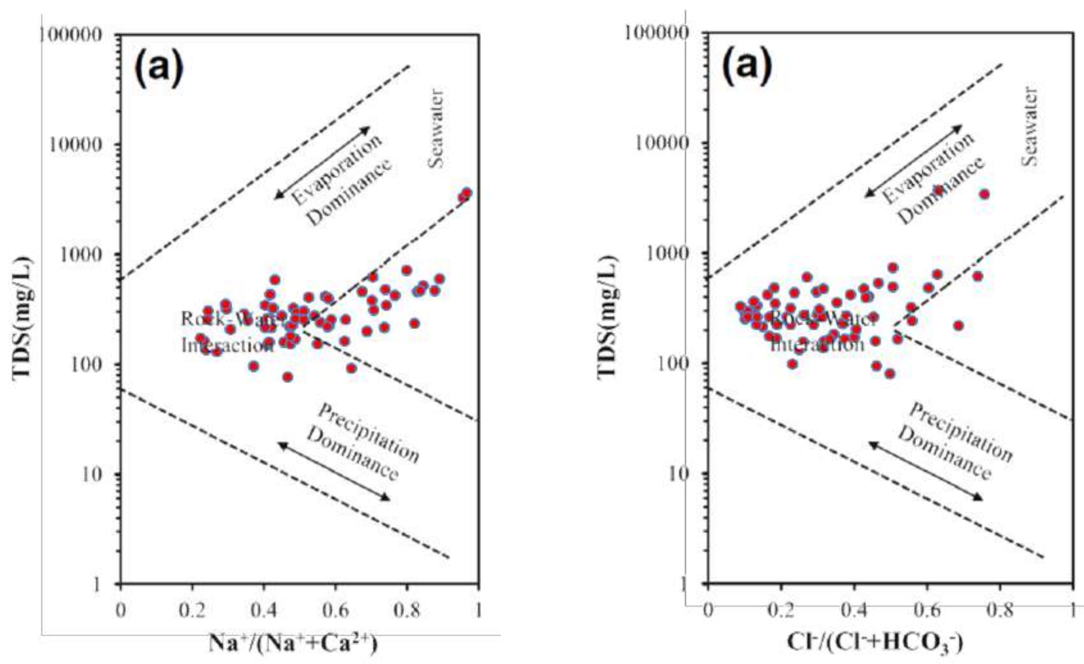


Figure 8.4.3 Gibbs Plot for South Andaman Island

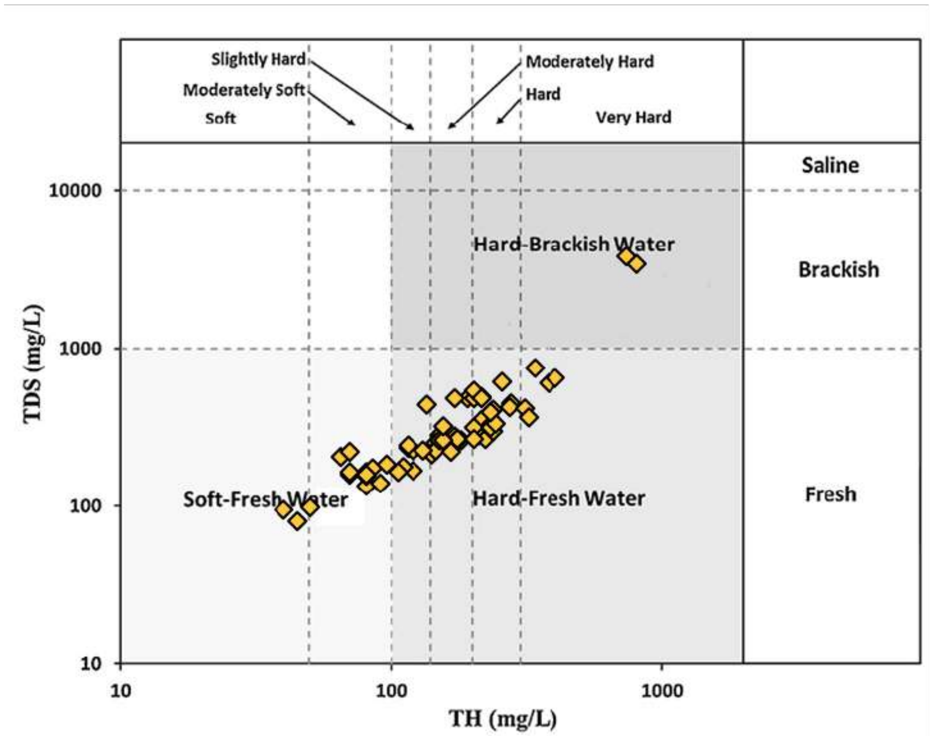


Figure 8.4.4 Plot of TDS vs. TH for characterisation of the groundwater for South Andaman Island

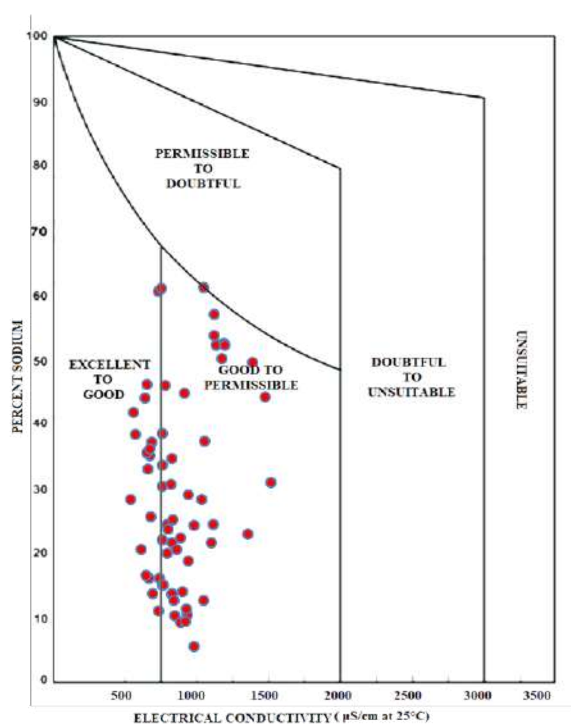


Figure 8.4.5 Wilcox diagram for the South Andaman Island for South Andaman Island

Annexure: 8.4.1 Chemical Analysis of Ground water sampling of the study area in South Andaman District

District	Block	Location	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	PO4	SiO2	TDS
A&N Islands	South Andaman	Port Blair	8.09	775	275	40	43	33	13	0	275	225	67	24	48	0.50	0.07	9	444
A&N Islands	South Andaman	South Point (Port Blair)	8.11	624	230	40	32	31	4	0	214	175	67	4	28	0.00	0.08	20	357
A&N Islands	South Andaman	Corbyn's Cove (Port Blair)	8.30	372	115	20	16	32	2	0	134	110	46	0	15	1.01	0.06	19	233
A&N Islands	South Andaman	Kodiaghat	8.29	293	120	24	15	9	1	0	134	110	18	0	1	0.16	0.00	19	168
A&N Islands	South Andaman	Austinabad (Port Blair)	8.18	1048	380	44	66	39	23	0	409	335	89	44	23	0.00	0.06	26	602
A&N Islands	South Andaman	Sippighat	8.22	756	270	22	52	34	1	0	220	180	82	0	62	0.00	0.01	34	421
A&N Islands	South Andaman	Brichganj	8.30	263	110	26	11	9	2	0	122	100	14	1	18	0.00	0.01	22	176
A&N Islands	South Andaman	Shadipur (Port Blair)	8.28	447	150	26	21	36	2	0	171	140	43	13	21	0.14	0.03	17	282
A&N Islands	South Andaman	Wimberleyganj	8.17	407	145	26	19	21	2	0	220	180	14	9	0	0.00	0.08	26	251
A&N Islands	South Andaman	Ograbraj	8.09	371	120	22	16	23	3	0	159	130	21	1	24	0.19	0.10	19	226
A&N Islands	South Andaman	Garacharma	8.03	577	230	22	43	24	2	0	281	230	25	3	16	0.00	0.02	26	332
A&N Islands	South Andaman	Burmanala	8.14	343	140	24	19	12	0	0	177	145	18	0	7	0.03	0.00	26	214
A&N Islands	South Andaman	Brookshabad (Port Blair)	7.91	526	210	14	43	16	0	0	281	230	18	0	8	0.00	0.02	29	299
A&N Islands	South Andaman	Hasmatabad	7.89	266	80	18	9	17	4	0	92	75	32	0	11	0.00	0.07	16	164
A&N Islands	South Andaman	Chidiyatapu	7.97	695	310	16	66	21	1	0	348	285	39	2	27	0.07	0.05	34	416
A&N Islands	South Andaman	Bambooflat	7.51	575	215	12	45	40	2	0	299	245	39	3	0	0.25	0.05	29	351
A&N Islands	South Andaman	Calicut	7.98	444	210	16	41	15	0	0	250	205	21	0	8	0.11	0.10	26	281
A&N Islands	South Andaman	Saitankhari	8.03	409	160	12	32	18	1	0	153	125	25	2	43	0.00	0.01	21	247
A&N Islands	South Andaman	Dandaspoint	8.04	372	145	16	26	17	3	0	146	120	50	3	0	0.00	0.08	26	230
A&N Islands	South Andaman	Junglighat (VIP Road)	7.65	5412	800	40	170	948	44	0	793	650	1453	45	203	0.66	0.02	2	3390
A&N Islands	South Andaman	Gupta Para	8.24	138	40	6	6	13	1	0	43	35	21	0	7	0.17	0.05	14	95
A&N Islands	South Andaman	Marina Park	8.01	844	215	30	34	98	3	0	226	185	135	4	25	0.09	0.06	21	488
A&N Islands	South Andaman	Calicut Bore well	8.16	369	145	14	27	12	0	0	146	120	25	0	17	0.84	0.05	38	223
A&N Islands	South Andaman	Beadnabad Tube well	8.12	444	180	34	23	13	1	0	214	175	25	2	8	0.00	0.07	25	261
A&N Islands	South Andaman	Annikat	8.15	447	170	34	21	21	1	0	171	140	35	8	32	0.42	0.00	18	275
A&N Islands	South Andaman	Namunagar	8.14	778	190	42	21	100	3	0	238	195	103	16	32	0.87	0.03	12	475

A&N Islands	South Andaman	Port Blair (Dobhi Well)	7.95	696	135	26	17	98	1	0	256	210	46	1	53	0.10	0.08	35	433
A&N Islands	South Andaman	Light House	8.23	796	200	12	41	99	4	0	390	320	50	2	27	0.38	0.00	9	482
A&N Islands	South Andaman	Rangachang	8.16	468	220	14	45	12	0	0	201	165	32	1	26	0.12	0.10	13	265
A&N Islands	South Andaman	Teylarabad	8.15	480	175	18	32	20	2	0	140	115	50	3	31	0.08	0.06	27	268
A&N Islands	South Andaman	New Bimliton	8.09	517	235	18	46	11	0	0	250	205	18	2	24	0.38	0.05	24	296
A&N Islands	South Andaman	Dhannikhari	8.19	339	165	12	33	9	0	0	159	130	14	0	30	0.00	0.09	27	222
A&N Islands	South Andaman	Chouldari 1	8.08	621	320	14	69	7	3	0	342	280	28	3	10	0.00	0.01	19	362
A&N Islands	South Andaman	Port Mout	8.03	554	230	28	39	11	1	0	232	190	39	1	25	0.13	0.04	31	316
A&N Islands	South Andaman	Tushnabad	7.88	231	70	24	2	25	1	0	92	75	25	3	12	0.00	0.08	10	158
A&N Islands	South Andaman	Herbertabad	7.74	368	130	18	21	28	4	0	134	110	32	3	25	0.49	0.07	12	226
A&N Islands	South Andaman	Tirur	8.07	198	80	20	7	9	2	0	92	75	18	2	4	0.15	0.06	16	133
A&N Islands	South Andaman	Ferrarganj	7.93	858	200	16	39	101	2	0	104	85	53	14	231	0.80	0.05	12	532
A&N Islands	South Andaman	Bindraban	8.06	418	155	18	27	22	1	0	159	130	14	15	50	0.30	0.06	18	261
A&N Islands	South Andaman	Mannarghat	7.99	458	200	14	40	11	4	0	201	165	14	3	37	0.16	0.04	18	264
A&N Islands	South Andaman	Wrightmyo	8.07	118	45	8	6	8	0	0	24	20	14	3	17	0.25	0.02	7	79
A&N Islands	South Andaman	Shoal Bay – 8 No.	7.97	252	80	22	6	18	1	0	104	85	21	3	9	0.00	0.07	12	155
A&N Islands	South Andaman	Shoal Bay– 12 No.	7.93	561	240	16	49	14	1	0	189	155	11	1	107	0.07	0.02	16	331
A&N Islands	South Andaman	Shoal Bay– 15 No.	8.09	236	90	20	10	7	1	0	79	65	21	1	16	0.00	0.05	12	138
A&N Islands	South Andaman	Kanyapuram	7.67	542	155	20	26	56	5	0	140	115	103	5	0	0.00	0.02	21	319
A&N Islands	South Andaman	Steuwartganj	7.61	703	230	22	43	60	6	0	232	190	103	3	0	0.00	0.10	16	393
A&N Islands	South Andaman	Mile Tilak	7.22	248	85	16	11	18	7	0	92	75	35	3	0	0.00	0.03	27	172
A&N Islands	South Andaman	Hope Town (Maremon Temple)	7.18	1229	400	28	80	77	10	0	238	195	234	15	31	0.00	0.04	20	640
A&N Islands	South Andaman	Mithakhari	7.49	6135	730	36	156	1119	99	0	1434	1175	1429	15	0	0.40	0.10	14	3741
A&N Islands	South Andaman	Nayasahar	8.15	281	95	24	9	25	1	0	116	95	35	2	0	0.00	0.09	17	184
A&N Islands	South Andaman	Manglutan	8.09	270	80	14	11	20	2	0	79	65	39	1	11	0.02	0.08	11	157
A&N Islands	South Andaman	Manjeri	8.00	337	65	18	5	46	1	0	116	95	46	2	0	0.07	0.08	14	203

A&N Islands	South Andaman	Mamyo	8.22	249	70	32	-2	26	2	0	73	60	46	1	0	0.00	0.09	14	164
A&N Islands	South Andaman	Wandur – 2	8.15	280	105	8	21	15	2	0	98	80	28	2	15	0.00	0.03	15	165
A&N Islands	South Andaman	Dollyganj Chowk	7.97	868	215	18	41	106	5	0	195	160	174	7	0	0.00	0.05	12	482
A&N Islands	South Andaman	Lamba Line	8.23	389	115	8	23	42	5	0	110	90	82	2	0	0.00	0.07	12	241
A&N Islands	South Andaman	Haddo – 2	9.58	361	70	14	9	45	10	0	61	50	78	2	8	0.00	0.06	18	221
A&N Islands	South Andaman	Mount Harriyat	7.25	153	50	18	1	12	3	0	61	50	11	3	7	0.00	0.01	5	98

Chapter 9

Aquifer Management Plans of islands in South Andaman District

9.1: Neil Island

Since, the island is small, ground water resources are limited, and in view of its growing demand for agriculture and tourism, a pragmatic management plan needs to be envisaged in this island. The R&D work by CGWB (Kar, 2000-2007, 2010-2013, Kar, A. Kumar and A. Sinha, 2016-2019) has enabled to adopt many new plans based upon ground water and rainwater harvesting to manage the ground water resources to a great extent. The following ground water management plans were envisaged to tackle the future crisis of water resources in the Island.

1. Adopt large scale rainwater harvesting.
2. Augmentation of artificial recharge in the Island.
3. Rejuvenation of natural lakes

9.2 Havelock Island

Since the island is having huge tourist potential as also in view of its high demand for agriculture a pragmatic management plan needs to be envisaged in this island. The following water resources management plans were envisaged to tackle the envisaged future crisis of water resources in the Island.

1. Adopt large scale rainwater harvesting.
2. Rejuvenation of springs.
3. Conservation of surface water through check dams.
4. Augmentation of artificial recharge in the Island.

9.3 Little Andaman Island

In view of adequacy of Surface water and groundwater resources in the island, recharge and conservation practices may be adopted in the island for better management. Actually this island is having abundant fresh water resources so its conservation and utilisation are the main objective for augmentation of irrigation potential. However, the following plans may be undertaken for better management of water resources (Ground and surface water) in the island.

- Site specific artificial recharge practices may be undertaken for sustainability of ground water.
- There should be adequate check dam to conserve the outflow of spring water and surface water to sea. The water can be utilised to augment the irrigation potential of the island.

9.4 South Andaman Islands

Since ground water resources are limited and the islands receive copious rainfall, the fresh water resources are managed through rainwater harvesting in reservoir and ponds. However, due to limitation of utilisable land resources due to the presence of dense forestry as also environmental regulations, water resources management has not been done full proof by the A&N Administration. Due to ongoing climatic change and population pressure the gap in demand and availability has been widened day by day. The following plans were envisaged to tackle the crisis of water resources in the Island.

- To augment water supply in the rural areas by adopting artificial recharge cum conservation of ground water.
- Inter island transfer of spring water from Rutland Island to Port Blair.
- Development of freshwater lake.
- Augmentation of freshwater supply through desiltation of existing reservoirs, ponds/lakes, wells in and around Port Blair and their protection.
- Construction of small and medium dams in rural areas.
- Construction of new ponds in rural areas and in the environs of Port Blair.
- Rejuvenation of springs
- Adopting artificial recharge practices in groundwater worthy areas for sustainable Management.

9.5 Rutland Island

Management of Urban Water Supply to Port Blair City from springs in Rutland Island:

The Water supply in the town is mainly catered from the Dhanikhari Dam Source, which is located nearly 20 Km west of Port Blair. The dam is constructed on the catchment of Dhanikhari at a relatively higher topography, so that the water can come to Port Blair under gravity. Generally, the A&N Islands receive monsoon rainfall even in November-December every year. Consequently the dams and reservoirs are filled up. If this rainfall is not adequate and the monsoon which starts in April is delayed, the water level in the reservoir at Dhanikhari will be at the lowest level if withdrawal is not regulated. With the recession of monsoon, often in the recent past the reservoir gets dried up. During those years the APWD, A&N Administration face tremendous problem of water supply in the Port Blair town to manage the water supply in the town during each lean period. Generally, thrice in a week water is supplied by the Port Blair Municipal Council during such stressed period. In extreme situation with the recession of monsoon further, the water supply in Port Blair town is curtailed to even twice or once in a week. In such a severe water scarce situation in 2002, the water supply situation in Port Blair town was severely affected. In the previous year i.e. 2001, the rainfall was close to normal rainfall, so as per the demand water supply was not controlled. Unfortunately, in November-December no rainfall occurred, consequently the Dam dried up in December itself.

The following plans were envisaged to tackle the crisis of water resources in the Island.

- Several highly discharging springs are developed in the low lying areas in the hills which are not too far from the coast. **Need for immediate transportation of water from Rutland through ship and barges** – To mitigate the severe scarcity of Port Blair. Formerly the water supply was being met from the Chain nala source which is occurring in the North-Eastern side of the Island. Spring sources in the West and North in Rutland Island are connected by the pipe lines, while the sources in the North-east and North like Meetha Nala, Chain Nala, Komio nala etc are yet to be tapped.

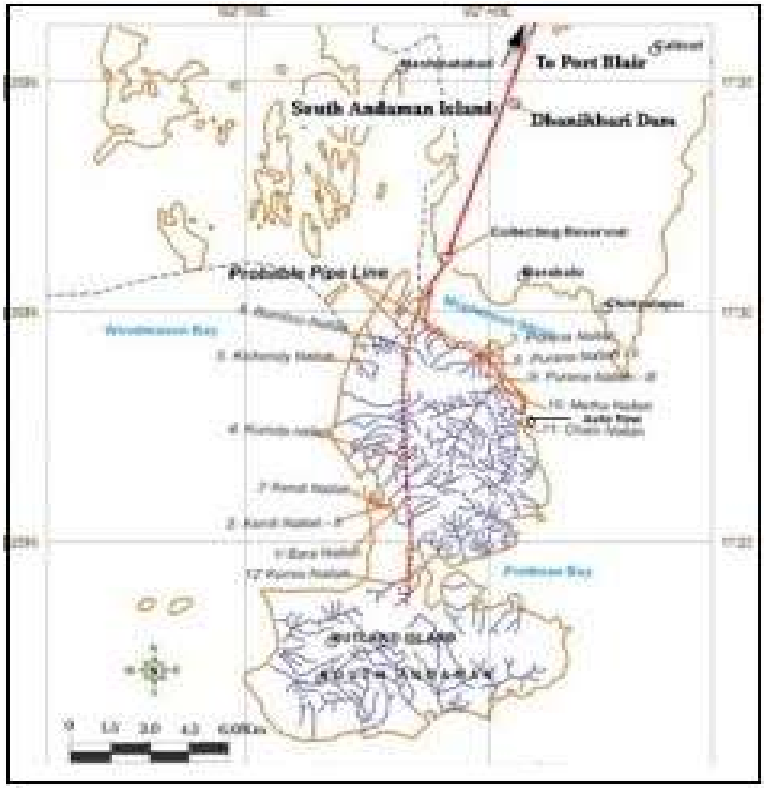


Figure-9.5.1 Plan of Interisland transfer of spring water from Rutland

Table-9.5.1 Details of Spring Discharge from Rutland Island

Sl. no	Date of inspection		Location of place of origin of the spring from sea coast (in KM)	Reading through 900 V-notch plate	Discharge(in Gallons per day)	Electrical conductivity (micro-Siemens/cm)
1	6.2.02	Bada Khadi Nala	2.5 K.M	20 c.m.	460320	270
			5 K.M	20 c.m.		270
2	9.2.02	Kendi Nala no-I	2.5 K.M	20 c.m.	460320	320
			3.5 K.M	21.5 c.m.	555200	310
3	9.2.02	Kendi Nala no-II	2.5 K.M	14 c.m.	189760	350
			3 K.M	14 c.m.		330
4	9.2.02	Kumda Nala	2.5 K.M	14 c.m.	189760	350
5	12.2.02	Beth Nala-I	2.5 K.M	Dry	Negligible	290
6	12.2.02	Beth Nala-II	2.5 K.M	Dry	Negligible	300
7	12.2.02	Grass Nala	2.5 K.M	Dry	Negligible	340
8	12.2.02	Nimboo Nala	2.5 K.M	Dry	Negligible	320
9	12.2.09	Kichedy Nala	2 K.M	8 c.m	45120	350
10	12.2.09	Bamboo Nala	3 K.M	13 c.m.	156800	340
11	11.2.02	Chain Nala	0.75 K.M	23 c.m.	657600	240
12	11.2.02	Meetha Nala	1 K.M	11 c.m.	104320	280
13	11.2.02	Purana Nala-I	0.5 K.M	3 c.m	4038	310
14	11.2.02	Purana Nala-II	0.75 K.M	12 c.m.	126400	330
15	11.2.02	Purana Nala-III	0.75 K.M	9 c.m	63630	320
16	11.2.02	Komio Nala	0.5 K.M	23 c.m.	657600	240
Cumulative discharge from all Springs in Rutland island					32,10,278 GPD	
Subsurface discharge as base flow along all spring locations					4,44,444 GPD	
Total Ground water availability for transfer to Port Blair					36,54,722 GPD	

9.6 Recommendations for South Andaman District

9.6.1 Selection criteria of various projects sites

Based upon long research and development studies carried out by CGWB, various ground water recharge and rain water harvesting structures are suggested in the Islands depending upon suitable hydro-geological situations, and keeping in view of geology, hydrogeology, climate conditions and the case studies.

In the major parts of South Andaman, traditional ordinary dug wells are the most suitable structures. The dug wells are to be constructed right in the foothill regions, keeping in view of the availability of the rock exposures. Since the geological formations are not favourable for high rate of infiltration of rainfall, such dug wells even won't yield high. Dug wells of 3 - 4 m diameter and 5 - 6m depth may yield to the tune of 4000 to 5000 liters per day. In such cases large diameter (5 - 6m diameter) dug wells with proper design with wire mesh cover would be highly beneficial and in favourable locations in Minnie bay and Haddo, such a dugwell may yield to the tune of 10,000 to 15,000Lpd. There may be adequate number of weep holes all around the well. Nearly 50-70 cm thickness of pea size gravel or stone chip (since gravels are not readily available in Andaman) are to be shrouded around the dug well so that the weep holes are not clogged by clay minerals and good filtration of ground water takes place during its entrance in to well.

9.6.1.1 Dug wells with artificial recharge technique: these are the important outcome of CGWB studies on recharge in the islands (Figure 9.6.1.1.1). While the uplands are forming low ground water potential zone as described above, in case of dug wells even in valleys or foothills, those may also yield to the tune of low to moderate as described above. However, the stream valleys are found highly potential as it possesses lot of porous sediments of varying thickness of 0.5 1 0 m. It has been observed that lot of ground water flows along the stream channels all around the year into the sea. This subsurface flow can be restricted by means of subsurface dykes. Considerable quantity of ground water can be tapped by intake wells (dug wells). These wells are to be constructed in the upstream side of the subsurface dams/ dykes (Figure 9.6.1.1.2). For accounting the artificial recharge process 2 to 5 numbers of check dam/ weirs with recharge shafts are to be constructed in the upstream side of the intake dugwells.

9.6.1.2: Dug well cum bore well: The basic design and mode of construction of this kind of well is same as mention above. Only bore wells are to be constructed additionally prior to digging of dug well. Since lot of water accumulates in the ditch during the construction of dugwell, which will disturb the drilling operation or huge pumping would be involved, it's wise to construct the borehole prior to construction of the dug well.

This plan envisages both development of ground water and integrated water shed development with rainwater harvesting through multiple check dams, subsurface dams, tidal bars etc. For this purpose, Hill to Sea Model was envisaged for optimum conservation of rainwater and ground water both for areas underlain by marine sedimentary rocks and Ophiolites **figure 9.6.1.2.1**

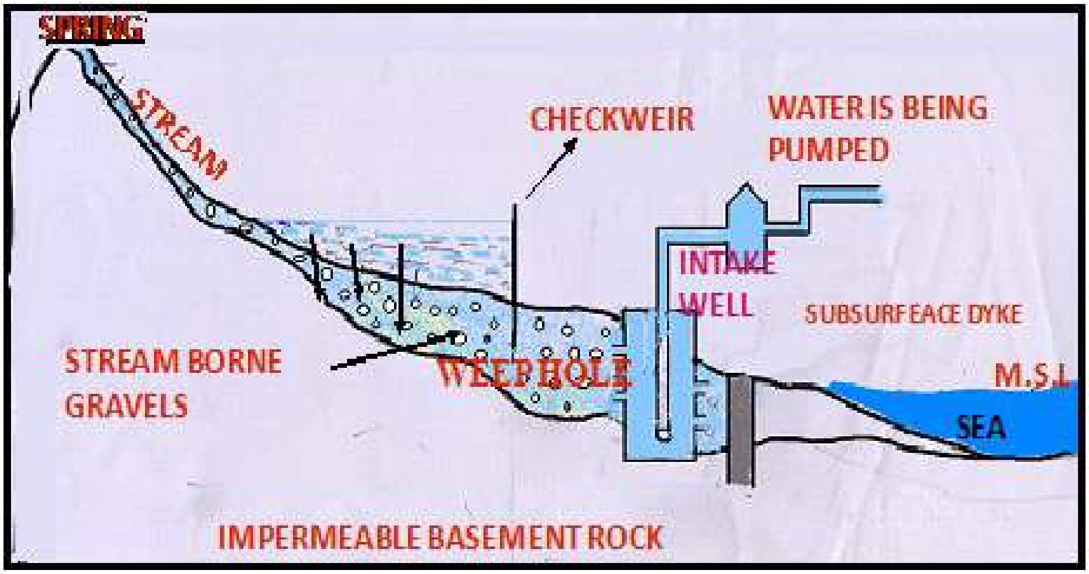


Figure 9.6.1.1.1: Model design of Artificial Recharge and conservation technique applicable in Andaman & Nicobar Islands

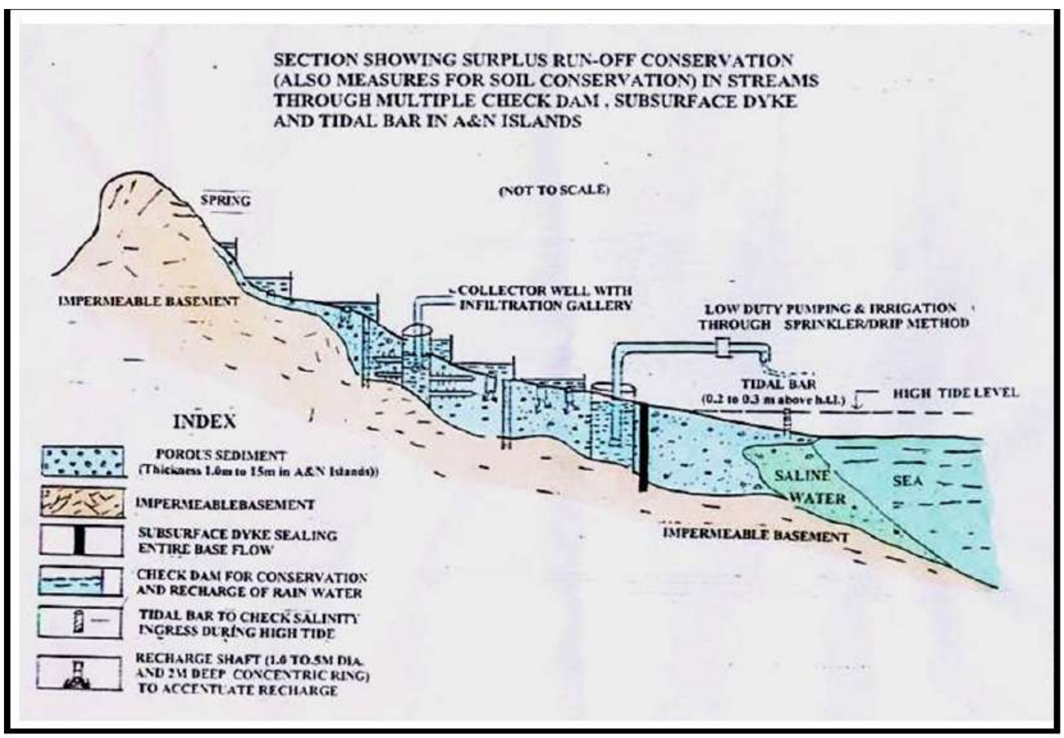


Figure 9.6.1.1.2: Model design of Runoff conservation in streams through multiple check dam, subsurface dyke and tidal bar in Andaman & Nicobar Islands

Figure 9.6.1.1.3: Model design of Dam/check wire

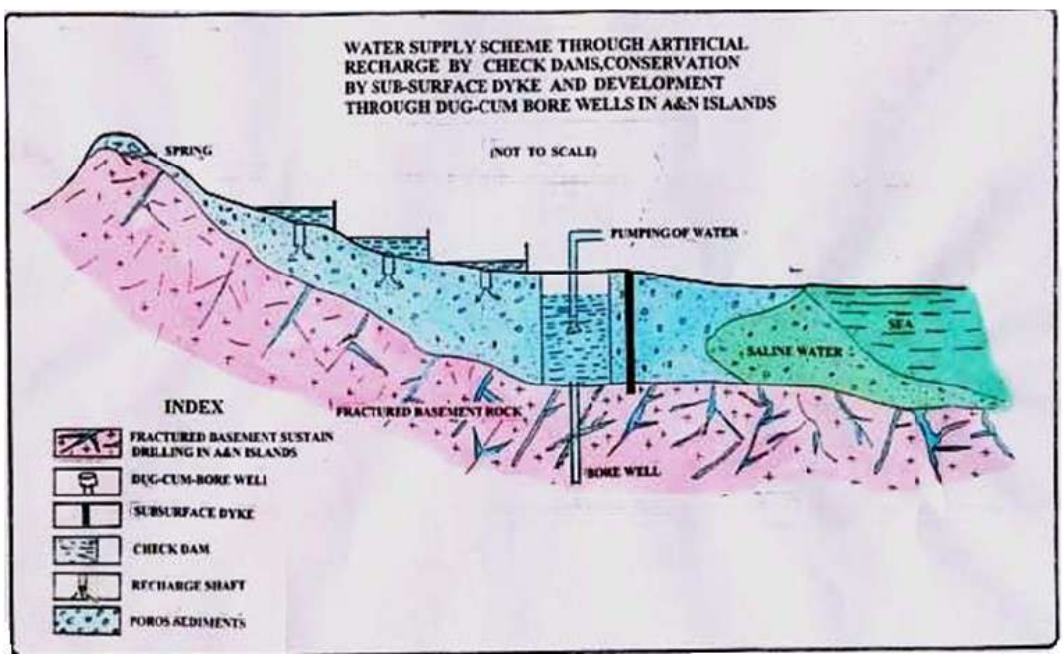


Figure 9.6.1.2.1: Model design of water supply scheme through artificial recharge by check dam, conservation by subsurface dyke and development through dug cum bore well in Andaman & Nicobar Islands

PART - II

10

DETAILED AQUIFER MANAGEMENT PLANS OF ISLANDS

OF SOUTH ANDAMAN DISTRICT,

UNION TERRITORY OF ANDAMAN & NICOBAR ISLANDS

10: Aquifer Information and Management System
Neil Island, South Andaman District, Andaman & Nicobar Islands
(18.9 Sq.km area covered under NAQUIM)

10.1: General Information

U.T. Name — Andaman & Nicobar Islands

District name — South Andaman district

Island Name — **Neil Island**

Location

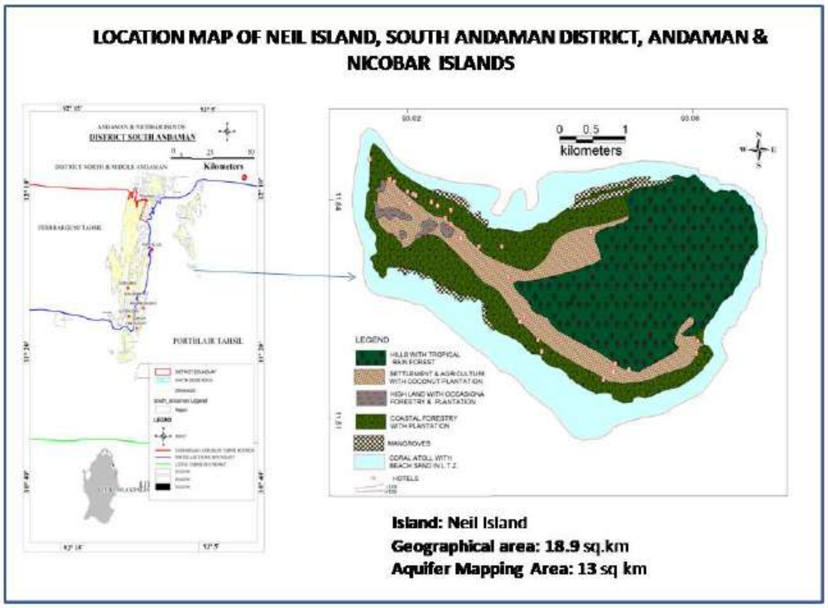


Figure 10.1.1: Location Map of Neil Island, South Andaman district, Andaman & Nicobar Islands

Geographical Area — 18.9sq. km.

Basin/Sub-basin — Andaman Fore Arc Sub basin

Principal Aquifer System — Mainly Two aquifer systems occur down to the depth of 60mbgl.

Major Aquifer System — **Shallow aquifer (A1):** Constituted of coralline limestone.
Deeper aquifer (A2): Constituted of Chalkstone & Claystone

Normal Annual Rainfall — 3295 mm

10.2: Aquifer Disposition

Aquifer Disposition — Two aquifer groups occur down to the depth of 60mbgl.

- **Shallow aquifer (A 1):** occurs up to depth of 30 mbgl; 3 Sub-Aquifers, Middle Aquifer is Fresh and sandwiched between top and bottom Saline Aquifers. Yield potential: 5-10 lps.
- **Deeper aquifer (A2):** occurs in the depth span of 30-60 mbgl; Yield potential: Negligible – 5 lps; Hardly explored

Status of GW Exploration: NIL

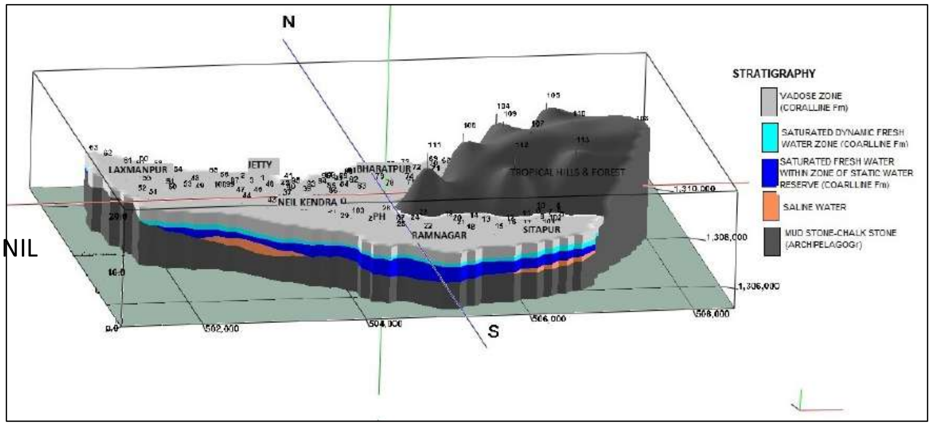


Figure 10.2.1: 3D Aquifer Deposition towards Southern Coast of Neil Island

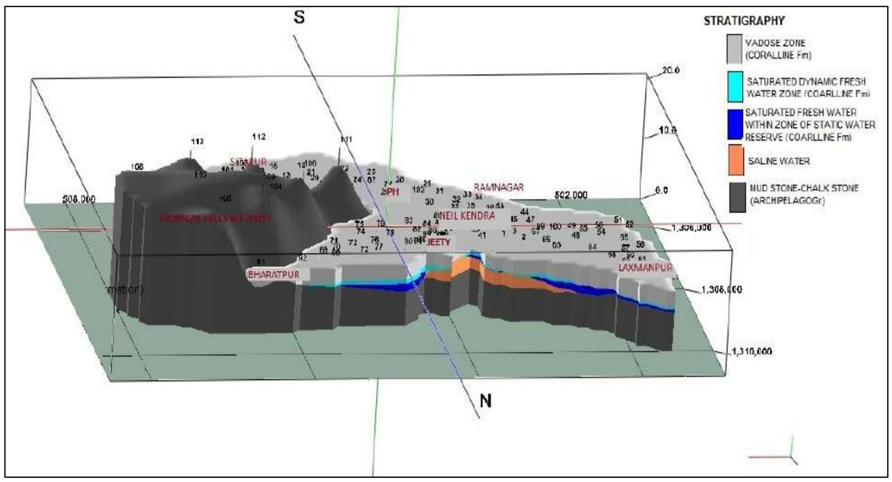


Figure 10.2.2: 3D Aquifer Deposition towards Northern Coast of Neil Island

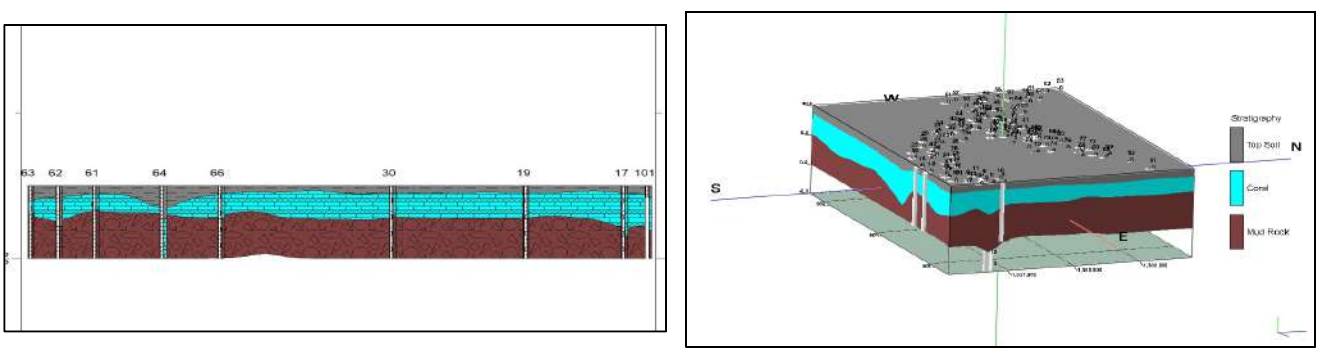


Figure 10.2.3: 2D cross-section & 3D disposition of aquifer system in Neil Island

10.3: VES investigations by CGWB: 103

Dug wells inventory: 195 wells across the Island was inventoried during field study

10.4: Aquifer Characteristics based on hydrogeological and geophysical investigation

- Mainly 2 Aquifer System exists in Neil Island.
- Aquifer – I : Depth up to 30 m; Occurs in coralline limestone; Yield potential: 5 – 10 lps
- Aquifer – II: Depth 30 – 60m; Occurs in Chalkstone & Claystone; Yield potential: Negligible to 5 lps.

Groundwater Monitoring Stations: 7 Dug Well.

10.5: Groundwater Quality: Aquifer – I – The sub middle aquifer is Potable and fit for domestic, drinking and irrigation purpose. The top & the bottom sub aquifer of Aquifer-I are saline.

Aquifer II- Not explored, hence quality not ascertained.

Aquifer Potential: Aquifer- I occurring in Coralline Limestone has higher yield potential and is mainly being developed through Public Water Supply wells.

10.6: Groundwater Resource:

- Net Ground Water Availability: 1.4763 MCM
- Gross Ground Water Draft: 0.0903 MCM
- Stage of Ground Water Development: 6.11 %

Existing and Future Water Demand:

- Present demand for All Usage: 0.0903 MCM
- Future Demand for Domestic and Industrial Use: 1.3729 MCM

10.7: Aquifer Management plan

Groundwater Management Issues

1. The island is mostly dependent on ground water resource, mainly harnessed from dug wells.
2. Topography is undulating, and catchment areas are small. Residence time of precipitation with ground is limited, which results into maximum run-off to the sea.
3. Island aquifers are of limited capacity.
4. Threat of disasters like earthquake & tsunami, poses damage to fresh water resource of the island and aggravation of salinity issues. This scenario was observed immediately after 2004 tsunami, which prolonged for subsequent years.
5. Vegetable cultivation and agriculture in the island is dependent on ground water irrigation.
6. Tourism in the island has increased over the years, resulting in increasing

demand for fresh water.

7. Low per capita fresh water availability.

10.8: Groundwater Management Plan

The island is small and ground water resources are limited in view of its growing demand for agriculture and tourism, a pragmatic management plan needs to be envisaged in this island. The R&D work by CGWB has enabled to adopt many new plans based upon ground water and rainwater harvesting to manage the ground water resources to a great extent. The following ground water management plans were envisaged to tackle future water resources crisis in the Island.

1. To adopt the practices of large scale rainwater harvesting.
2. Augmentation of artificial recharge in the Island through existing dug wells.
3. Rejuvenation of natural lakes

10.9:AR & Conservation Possibilities

- A major part of the north-eastern, eastern and south-eastern part of Niel Island comprises hills with tropical rainforest, and coastal forestry with plantations. This area has micro catchments.
- Apart from the hilly terrain, the remaining parts of the island are feasible for implementation of artificial recharge techniques/ structures.
- Ground water resource in and around Neil Island should be augmented through artificial recharge. Roof top harvesting structures should be made mandatory.
-

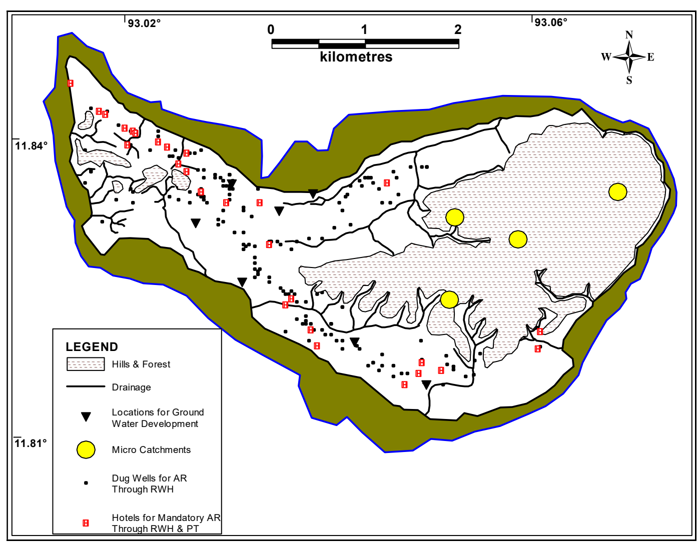


Figure 10.9.1: Map showing feasibility area for adopting Artificial Recharge through Rainwater harvesting.

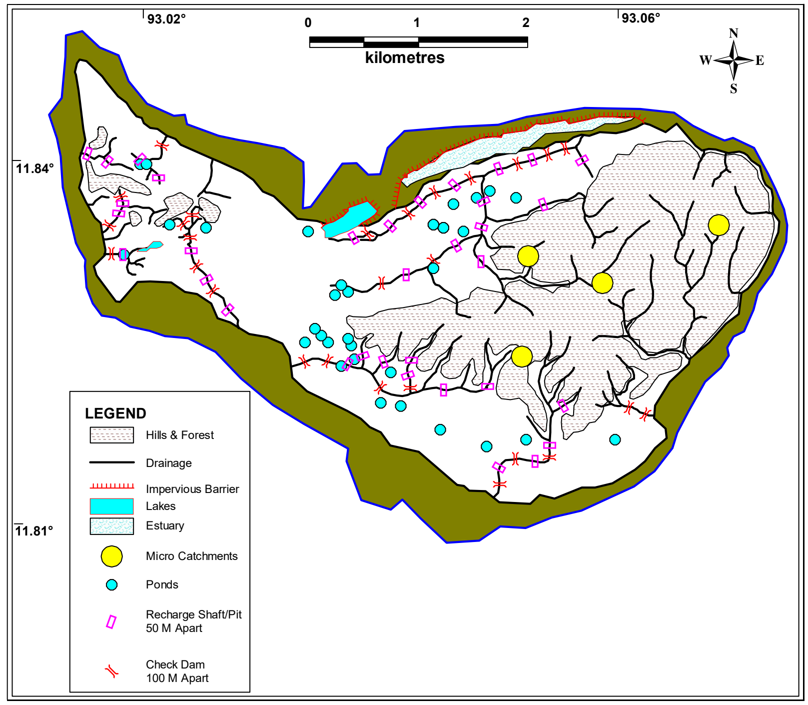


Figure 10.9.2: Map showing recommended locations of feasible artificial recharge structures

11 Aquifer Information and Management System

Havelock Island, South Andaman District, Andaman & Nicobar Islands

(40 Sq.km area covered under NAQUIM)

11.1: General Information

U. T. Name	Andaman & Nicobar Islands
District name	South Andaman district
Island Name	**Havelock Island**
Location	

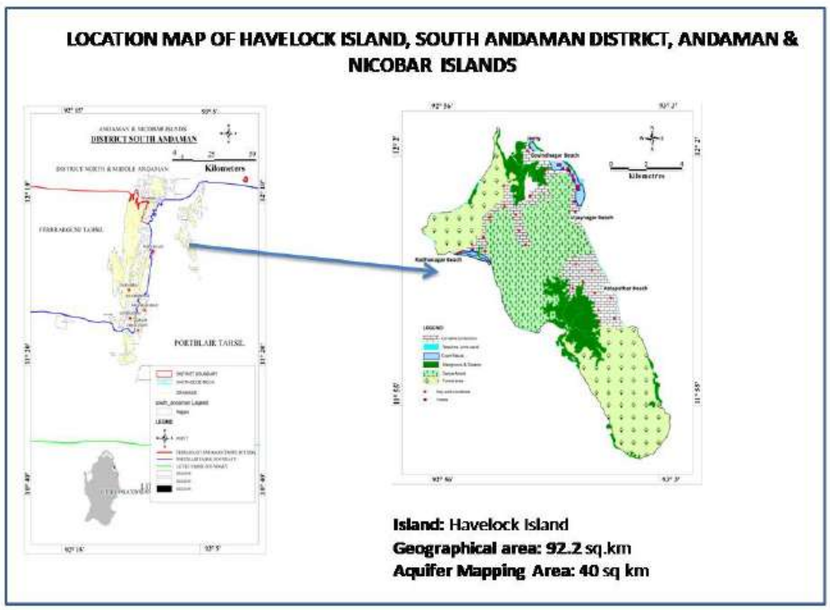


Figure 11.1.1: Location Map of Havelock Island, South Andaman district, Andaman & Nicobar Island

Geographical Area	92.2 sq. km.
Basin/Sub-basin	Andaman Fore Arc Sub Basin
Principal Aquifer System	Mainly Two aquifer systems occur down to the depth of 60mbgl.
Major Aquifer System	**Shallow aquifer (A1):** Constituted of coralline limestone. **Deeper aquifer (A2):** Constituted of Chalkstone & Claystone
Normal Annual Rainfall	3295 mm
11.2:Aquifer Disposition	**Shallow aquifer (A1):** Constituted of coralline limestone. Occurs up to depth of 30 mbgl; Yield potential: 5-25 lps. **Deeper aquifer (A2):** Constituted of Chalkstone & Claystone. Occurs in the depth span of 45-60 mbgl; Yield potential: Negligible – 12 lps

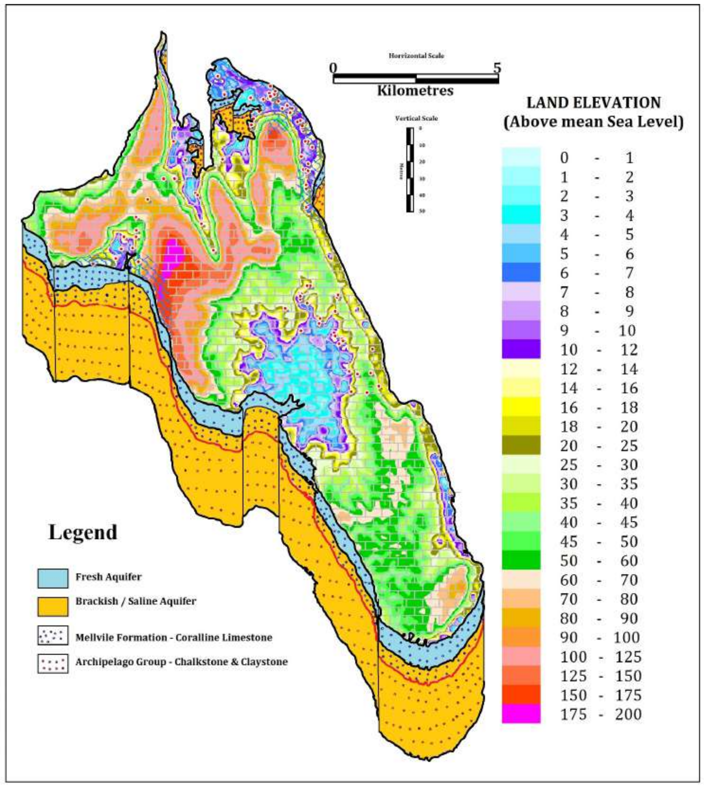


Figure11.2.1 Aquifer disposition of Havelock Island

Status of GW Exploration: Exploratory Wells : 0; Observation Wells : 0

11.3: VES investigations by CGWB: Nil

Dug wells inventoried: 87 wells across the Island was inventoried during field study

11.4: Aquifer Characteristics based on hydrogeological and geophysical investigation

- Mainly 2 Aquifer System exists in Havelock Island.
- Aquifer – I : Depth up to 30 m; Occurs in coralline limestone; Yield potential: 5 – 25 lps
- Aquifer – II: Depth 45 – 60m; Occurs in Chalkstone & Claystone; Yield potential: Negligible to 12 lps.

Groundwater Monitoring Status: 09 NHS Dug Wells.

11.5: Groundwater Quality

Aquifer – I - Potable and fit for domestic, drinking and irrigation purpose.

Aquifer II- Brackish/ saline aquifer.

Aquifer Potential

Aquifer I occurring in Coralline limestone have higher yield potential and is mainly being developed by Public Water Supply wells.

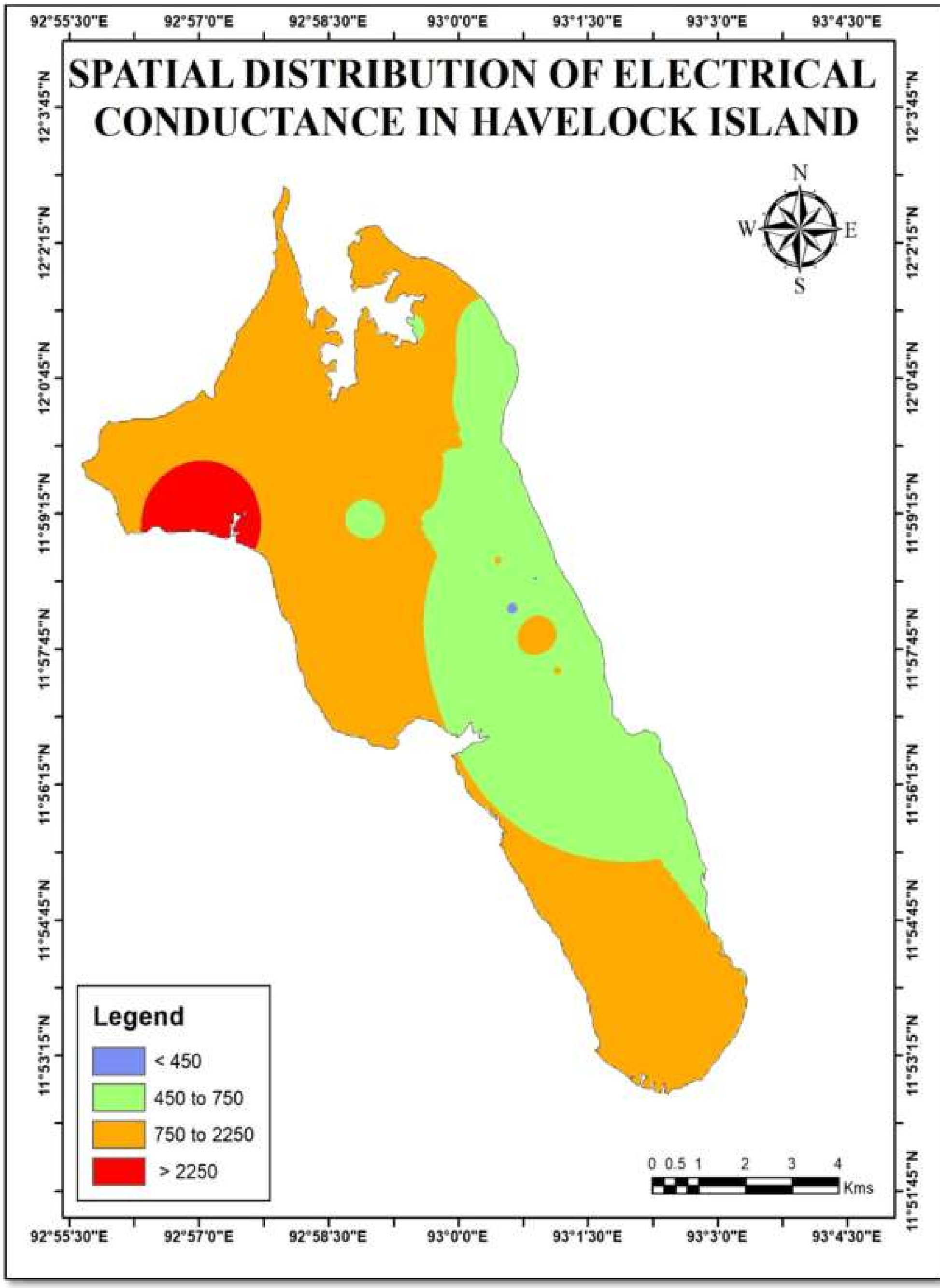


Figure 11.5.1: EC disposition in Havelock Island

11.6: Groundwater Resource

- Net Ground Water Availability: 4.5496 MCM
- Gross Ground Water Draft: 0.1875 MCM
- Stage of Ground Water Development: 4.12 %

Existing and Future Water Demand

- Present demand for All Usage: 4.334 MCM
- Future Demand for Domestic and Industrial Use: 0.1875 MCM

11.7: Aquifer Management plan

Groundwater Management Issues

8. The island is mostly dependent on ground water resource, mainly harnessed from dug wells and springs.
9. Topography is undulating, and catchment areas are small. Residence time of precipitation with ground is limited, which results into maximum run-off to the sea.
10. Island aquifers are of limited capacity.
11. Threat of disasters like earthquake & tsunami, poses damage to fresh water resource of the island and aggravation of salinity issues. This scenario was observed immediately after 2004 tsunami, which prolonged for subsequent years.
12. Vegetable cultivation and agriculture in the island is dependent on ground water irrigation.
13. Tourism in the island has increased over the years, resulting in increasing demand for fresh water.
14. Low per capita fresh water availability.

11.8: Groundwater Management Plan

Havelock island has huge tourist potential, and in view of high demand for agriculture, ground water recharge and rainwater harvesting is recommended to manage the ground water resources to a great extent.

Recommendations:

- Ground Water Availability in terms of Quality and Quantity is restricted, hence rain water harvesting for conservation and artificial recharge should be advocated.
- Rejuvenation of natural springs.
- Augmentation of artificial recharge in the Island through sub-surface dykes & check dams.
- Roof top rain water harvesting structure should be mandatory.
- Recycle & Reuse to be made mandatory to the extent feasible to reduce water requirement
- Installation of Low Cost and easily operational Desalination Plant – in emergency situations.
- Ground water abstraction should be regulated in terms of
- Spatial location of the structures
- Rotational Operational Hours
- Regulating rate of ground water abstraction by mandating low capacity of pump usage for ground water abstractions – to minimize

saline water upcoming

- Prioritizing usage of ground water abstraction in the order of Drinking and Domestic Purpose, followed by Irrigation and then to Industries (including hotels)

11.9: AR & Conservation Possibilities

- Ground water resources of Havelock Island should be augmented through rain water harvesting for conservation and artificial recharge.

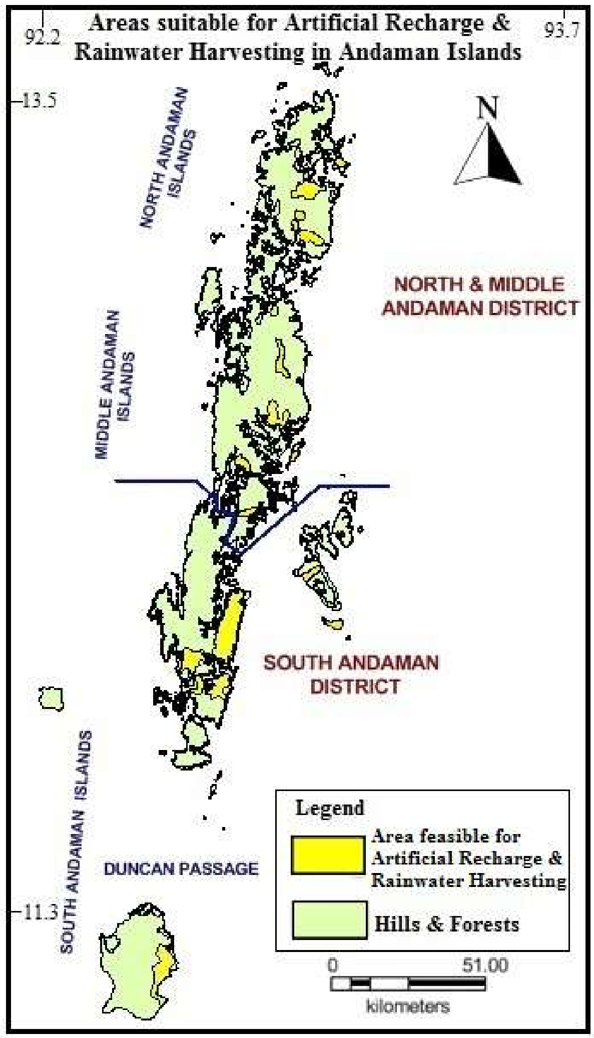


Figure 11.9.1: Feasible areas for Rain water harvesting for conservation and Artificial recharge in Havelock island.

- Havelock Island has few springs, hence intervention recommended for harnessing spring water, is through spring shed development and catchment area treatment.

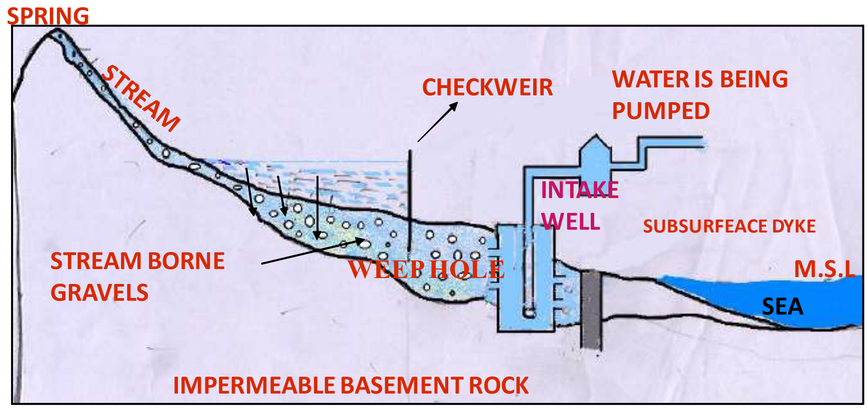


Figure 11.9.2: Aquifer Management Plan – for stream and spring based water supply

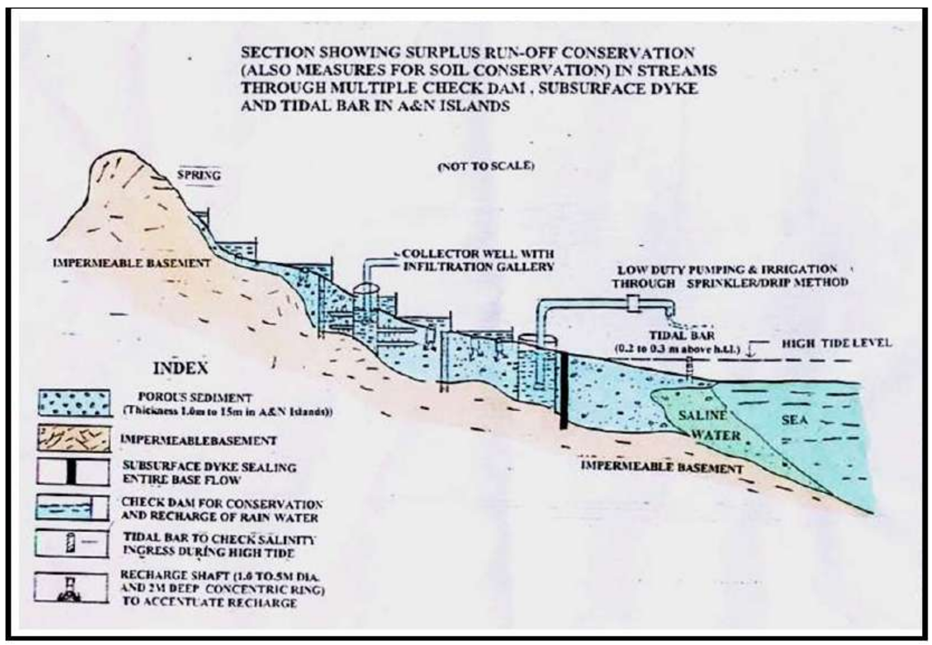


Figure11.9.3: Aquifer Management Plan – spring shed management

- Augmentation of artificial recharge in the Island through sub-surface dykes & check dams.

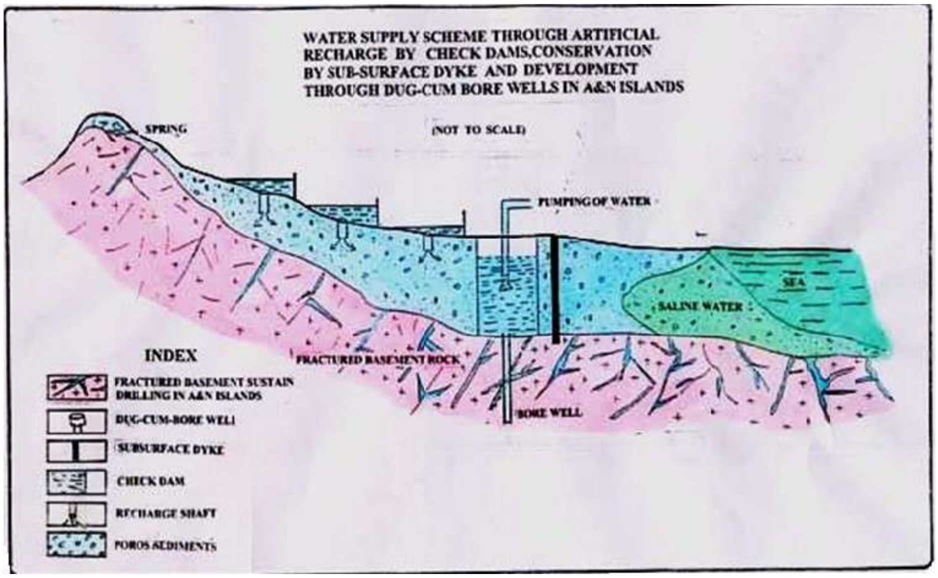


Figure11.9.4: Aquifer Management Plan – sub-surface dykes

12. Aquifer Information and Management System

Little Andaman Island, South Andaman District, Andaman & Nicobar Islands
(200 Sq.km. area covered under NAQUIM)

12.1: General Information

U.T. Name Andaman & Nicobar Islands
District name South Andaman district
Island Name **Little Andaman Island**
Location

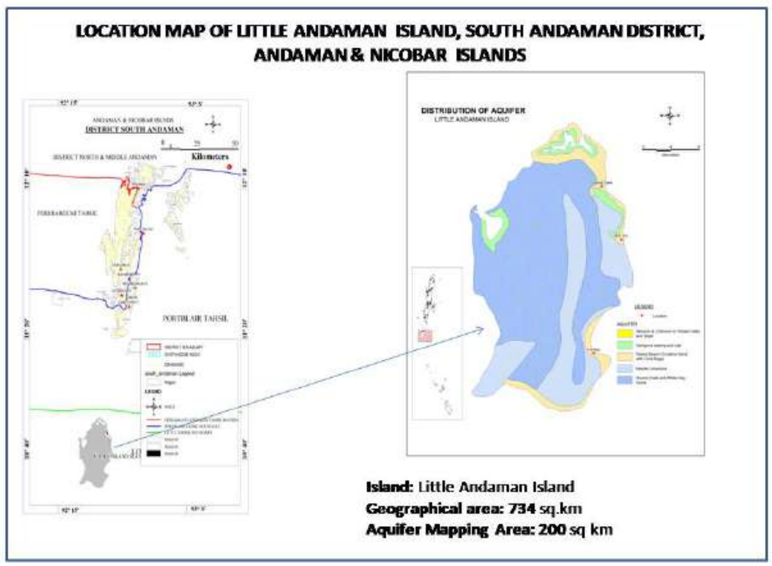


Figure 12.1.1: Location Map of Little Andaman Island, South Andaman district, Andaman & Nicobar Island

Geographical Area 200.00 sq. km.
Basin/Sub-basin Andaman Fore Arc Sub basin

Principal Aquifer System Two aquifer groups occur down to the depth of 60 mbgl.

Major Aquifer System **Shallow aquifer (A1):** Constituted of Chalkstone/Claystone.
Deeper aquifer (A2): Constituted of cavernous limestone.

Normal Annual Rainfall 3295 mm

12.2: Aquifer Disposition

Aquifer Disposition Two aquifer system:
Aquifer – I: Depth up to 25 mbgl; Chalkstone/Claystone.
Aquifer – II: 30 – 60m ; cavernous Limestone

Figure 1

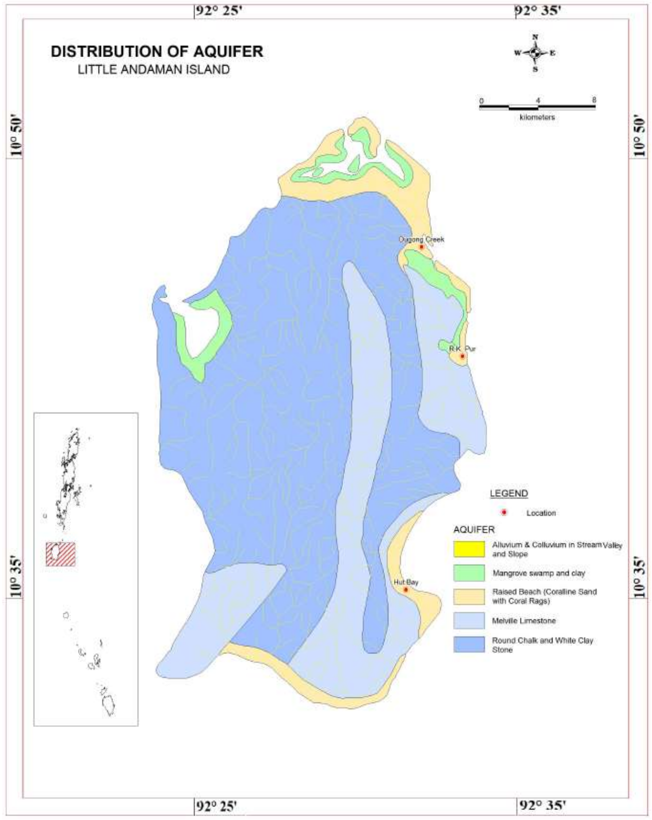


Figure 12.2.1: Distribution of Aquifer in Little Andaman Island

Status of GW Exploration:	Exploratory Dug Wells : 0
12.3: VES investigations by CGWB:	290
Dug wells inventory:	
12.4: Aquifer Characteristics based on hydrogeological and geophysical investigation	
Groundwater Monitoring Status	No monitoring station of CGWB.
12.5: Groundwater Quality	*Phreatic Aquifer (Aquifer – I); Potable and fit for domestic, drinking, irrigation and other Industrial purpose.
Aquifer Potential	
12.6: Groundwater Resource	*GW Availability: 31.2579 MCM *GW Draft: 0.561 MCM *Stage of GW Development: 1.79%
Existing and Future Water Demand	*Present demand for All Usage: 0.561 MCM *Future Demand for Domestic and Industrial Use: 30.61 MCM

12.7: Aquifer Management plan

12.7.1:Groundwater Management Issues

1. This island is endowed with vast ground water, and also surface water resources, so fresh water related issues are insignificant.
2. However, during tsunami and Earthquake the fresh water resources can be damaged significantly as was observed during 2004 tsunami and earthquake.
3. The islanders grow vegetables and agriculture is dependent on ground water irrigation.
4. Tourism in this island is yet to be developed, so very little demand of water is required for floating population.

12.8: Groundwater Management Plan

In view of adequacy of Surface water and groundwater resources in the island, recharge and conservation practices may be adopted in the island for better management.

Actually this island is having abundant fresh water resources so its conservation and utilisation are the main objective for augmentation of irrigation potential. However, the following plans may be undertaken for better management of water resources (Ground and surface water) in the island.

1. Site specific artificial recharge practices may be undertaken for sustainability of ground water.

2. There should be adequate check dam to conserve the outflow of spring water and surface water to sea. The water can be utilised to augment the irrigation potential of the island

12.9:AR & Conservation Possibilities

- Ground water resources in Little Andaman Island should be augmented by means of artificial recharge. Roof top harvesting structures must be made mandatory for all.
- Rain Water conservation and usage should be advocated, facilitated and incentivized.
- Recycle & Reuse to be made mandatory to the extent feasible to reduce raw water requirement
- Exploring the feasibility of utilizing Infiltration Galleries and Collector wells in drainage channels for water supply

13. Aquifer Information and Management System
South Andaman Island, South Andaman District, Andaman & Nicobar Islands

(460 Sq.km area covered under NAQUIM)

13.1: General Information

U.T. Name	Andaman & Nicobar Islands
District name	South Andaman district
Island Name	**South Andaman Islands(Portblair & Ferrarganj)**
Location	

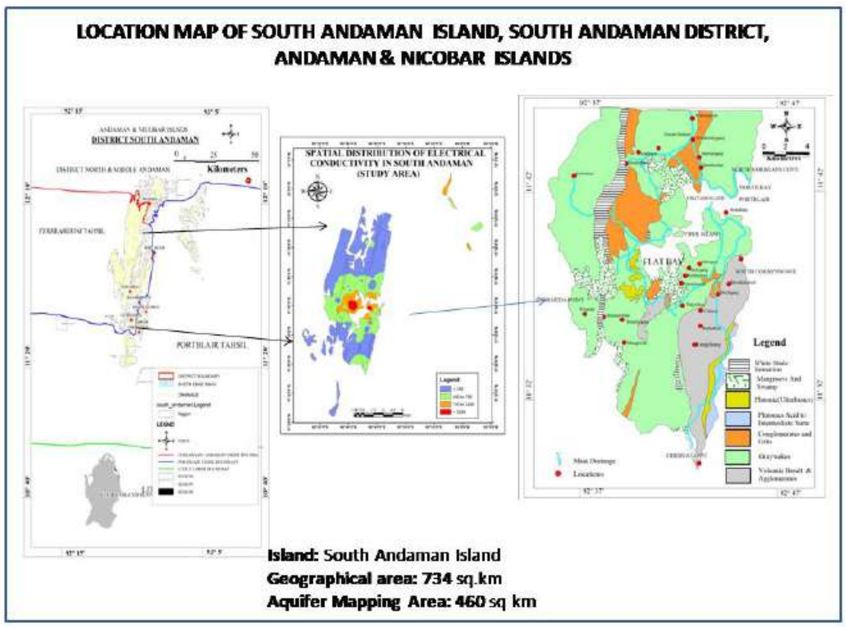


Figure 13.1.1 Location Map of South Andaman Island, South Andaman district, Andaman & Nicobar Island

Geographical Area	460.00 sq. km.
Basin/Sub-basin	Andaman Fore Arc Sub basin
Principal Aquifer System	Weathered sedimentaries & fractured ultrabasics.
Major Aquifer System	Two aquifer systems exist.
Normal Annual Rainfall	3295 mm

13.2: Aquifer Disposition

Aquifer Disposition

Two types aquifer system:

Aquifer – I : Depth upto 30 m; weathered mantle of sedimentary & igneous rocks

Aquifer – II: Depth 45 – 54 m; Fractured ultrabasic, highly crushed.

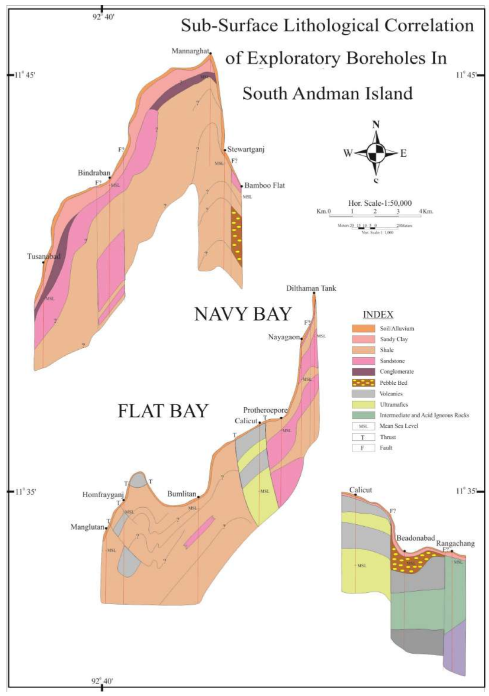


Figure 13.2.1 Aquifer disposition in parts of South Andaman Island

Status of GW Exploration: Exploratory Wells : 02
Observation Wells : 0

13.3: VES investigations by CWB: 0

Dug wells inventory:

13.4: Aquifer Characteristics based on hydrogeological and geophysical investigation

Aquifer – I: Depth upto 30 m; weathered mantle of sedimentary & igneous rocks; Yield: 5 to 12 litres per second.

Aquifer – II: Depth 45 – 54 m; Fractured ultrabasic, highly crushed; Yield: negligible to 5 litres per second, and shows high variations.

Groundwater Monitoring Status: 58 NHS Dug Wells

13.5:Groundwater Quality

*Phreatic Aquifer (Aquifer – I); Potable and fit for domestic, drinking, irrigation and Other Industrial purpose.

*Deeper Aquifer (Both Aquifer II) this water is well suited for domestic consumption Including drinking.

13.6: Groundwater Resource

*GW Availability: 15.7473 MCM

*GW Draft: 4.0025 MCM

*Stage of GW Development 25.41%

Existing and Future Water Demand

*Present demand for All Usage: 4.0025 MCM

*Future Demand for Domestic and Industrial Use: 11.305 MCM

13.7: Aquifer Management plan

13.7.1: Groundwater Management Issues

1. Portblair, the capital of A&N Islands is located in South Andaman Island. Since independence ,continuously due to exodus of people from mainland in search of livelihood, as also for rehabilitation of refugees from East Pakistan, and other parts of India, the population of all the Islands in Andaman & Great Nicobar in Nicobar district in general and South Andaman in particular had increased and the population is rising gradually. Apart from this the floating population of South Andaman especially that in Portblair and environs has been increasing heavily for business and tourism. Besides lot of islanders from other islands also visit the capital for official and medical purposes. Because of all these reasons an imbalance has been noticed in daily per capita water availability & supply, and the gap is being widened day by day.
2. Major part of the island is covered by sedimentary rocks which are generally imperviouous and yield insignificantly.
3. Ground water resources are limited and only in pockets it is available so chances of over exploitation due to heavy extraction is inevitable.
4. Potential surface water sources are limited and these are dependent on rainfall.
5. Because of climatic change often relatively fewer rainfalls is received. With the recession of monsoon the rain dependent surface water reservoirs go dry and in rural areas the spring yield is dwindled.
6. Because of huge forestry the areas for development of water resources are also limited.

13.8: Groundwater Management Plan

Since ground water resources are limited and the islands receive copious rainfall, the fresh water resources are managed through rainwater harvesting in reservoir and ponds. However, due to limitation of utilisable land resources due to the presence of dense forestry as also environmental regulations, water resources management has not been done full proof by the A&N Administration. Due to ongoing climatic change and heavy population pressure the gap in demand and availability has been widened day by day. The R&D work by CGWB has enabled the A&N Administration to adopt many new plans based upon ground water, rainwater harvesting, spring development to manage the water resources to a great extent. The following plans were envisaged to tackle the crisis of water resources in the Island.

1. To augment water supply in the rural areas adopting the artificial recharge cum conservation of ground water.
2. Inter island transfer of spring water from Rutland Island to Port Blair.
3. Development of freshwater lake.
4. Augmentation of freshwater supply through desiltation of existing reservoirs, ponds/lakes, wells in and around Port Blair and their protection.
5. Construction of small and medium dams in rural areas.
6. Construction of new ponds in rural areas and in the environs of Port Blair.
7. Rejuvenation of springs
8. Adopting artificial recharge practices in groundwater worthy areas for sustainable Management.

13.9: AR & Conservation Possibilities

Ground water resources in South Andaman Islands should be augmented by means artificial recharge. Roof top harvesting structures must be made mandatory for all.

14. Aquifer Information and Management System
Rutland Island, South Andaman District, Andaman & Nicobar Islands

(80 Sq.km area covered under NAQUIM)

14.1: General Information

U.T. Name	Andaman & Nicobar Islands
District name	South Andaman district
Island Name	**Rutland Island**
Location	

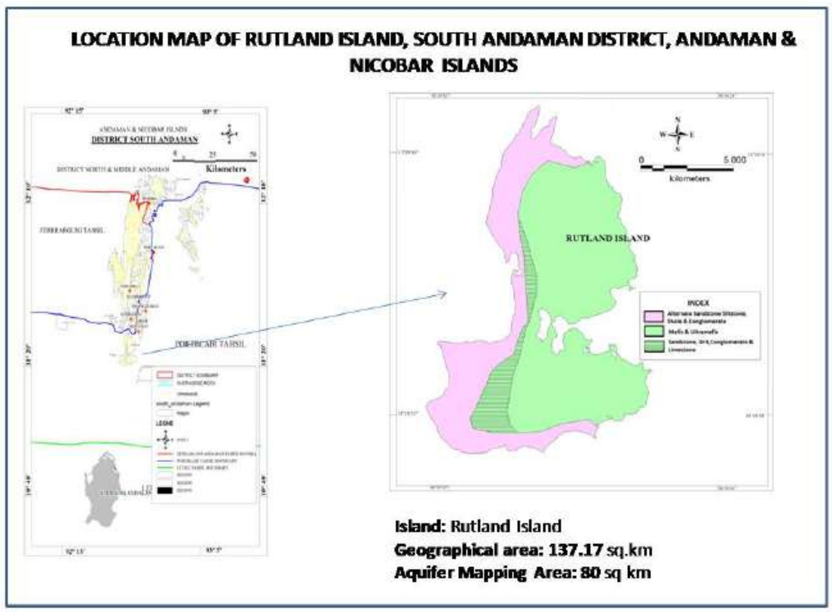


Figure 14.1.1: Location Map of Rutland Island, South Andaman district, Andaman & Nicobar Island

Geographical Area	80.00 sq. km.
Basin/Sub-basin	Andaman Fore Arc Sub basin
Principal Aquifer System	Weathered sedimentaries & fractured ultrabasic.
Major Aquifer System	Major Two type of aquifer system.
Normal Annual Rainfall	3295 mm

14.2: Aquifer Disposition

Aquifer Disposition

Aquifer system:
Aquifer – I: Depth up to 6 mbgl; Marine sedimentaries.
Aquifer – II: Depth up to 80 mbgl; Fractured Ophiolites.

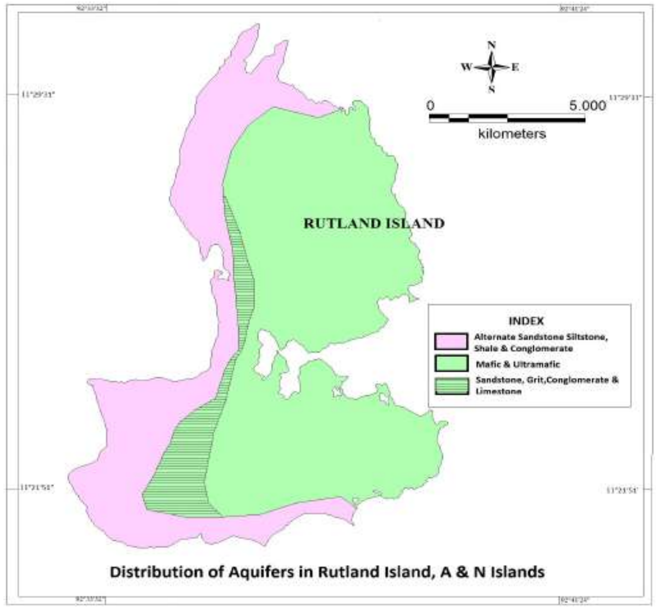


Figure 14.2.1: Distribution of Aquifers in Rutland Island

14.3: Status of GW Exploration: **VES investigations by CWB:** **Dug wells inventory:**	Exploratory Wells : 0 Observation Wells : 0 Deposit Wells : 0 Piezometers : 0
14.4: Aquifer Characteristics based on hydrogeological and geophysical investigation	Shallow aquifers in marine sedimentaries occur at a depth of 6 mbgl; yield ranges between 4000 to 5000 litres per day. Deeper aquifers in fractured Ophiolites occur up to a depth of 80 mbgl; yield ranges between 80,000 to 1, 00,000 litres per day.
Groundwater Monitoring Status	No monitoring stations of CGWB exist.
14.5: Groundwater Quality	*Phreatic Aquifer (Aquifer – I); Potable and fit for domestic, drinking, irrigation and other Industrial purpose.
Aquifer Potential	
14.6: Groundwater Resource	*GW Availability 21.3765 MCM *GW Draft 0.0075 MCM *Stage of GW Development 0.035%
Existing and Future Water Demand	*Present demand for All Usage: 0.0075 MCM *Future Demand for Domestic and Industrial Use: 21.367 MCM

14.7: Aquifer Management plan

14.7.1: Groundwater Management Issues	Good amount of groundwater flow as subterranean flow to the sea.

14.8: Groundwater Management Plan

Need for immediate transportation of water from Rutland through ship and barges –

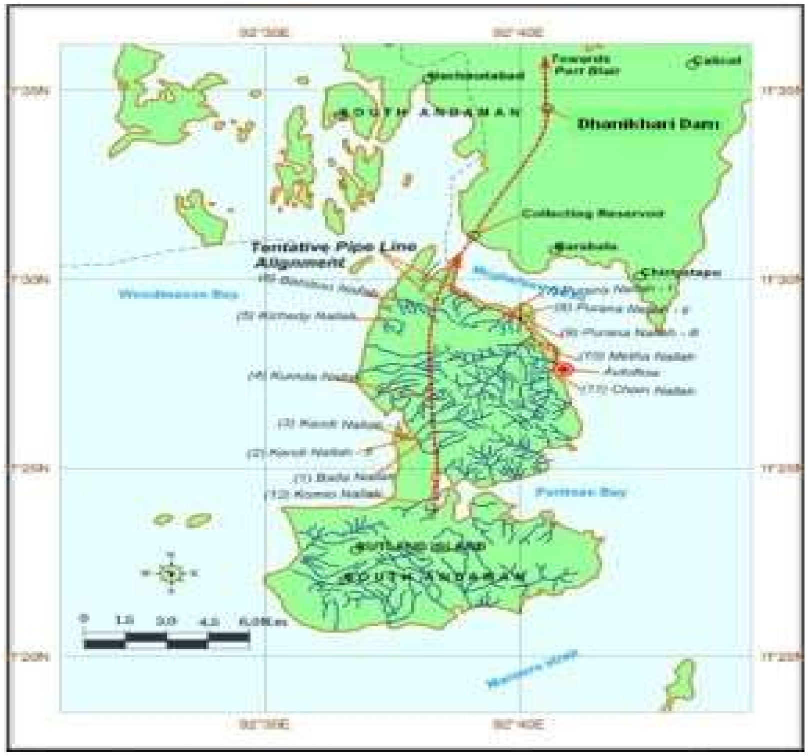


Figure 14.8.1: Plan of Interisland transfer of spring water from Rutland

- To mitigate the severe scarcity of Port Blair the water transportation through ship and barges immediately started since 28.4.2002 and it continuing till date.
- Regularly a sizable quantity of water is supplied to the interisland and mainland ships and boats at various jetties and Haddo port. As a part of management it was decided that the water to from Rutland could be utilized for supply at the Port and jetties so that the similar quantity of water can be used in Port Blair city.
- Formerly the water supply was being met from the Chain nala source which is occurring in the North-Eastern side of the Island. A temporary jetty was constructed which was damaged by 2011. The water supply from Chain Nala was being managed by Andaman & Lakshadweep Harbour Works (ALHW). After connection of few spring sources in the West and North, the pipe lines were underlain up to Rifle Man Point jetty. From 2012 the water supply through ships and barges are continuing till date.

- Spring sources in the West and North in Rutland Island are connected by the pipe lines while the mighty sources in the North-east and North like Meetha Nala, Chain Nala, Komio nala etc are yet to be tapped. For ensuring the sustainability, all the sources are required to be tapped.

14.9: AR & Conservation Possibilities

- Harnessing the huge potential of the copious rainfall and harvesting the same to the maximum extent feasible.
- Utilizing locally available materials and wisdom.
- Harnessing and rejuvenating the springs.
- Rejuvenation of the existing fresh water bodies and enhancing their storage capacity.
- Adopting artificial recharge, wherever, absolutely necessary.