Wastewater reuse in a circular economy – Climate change adaptation and mitigation

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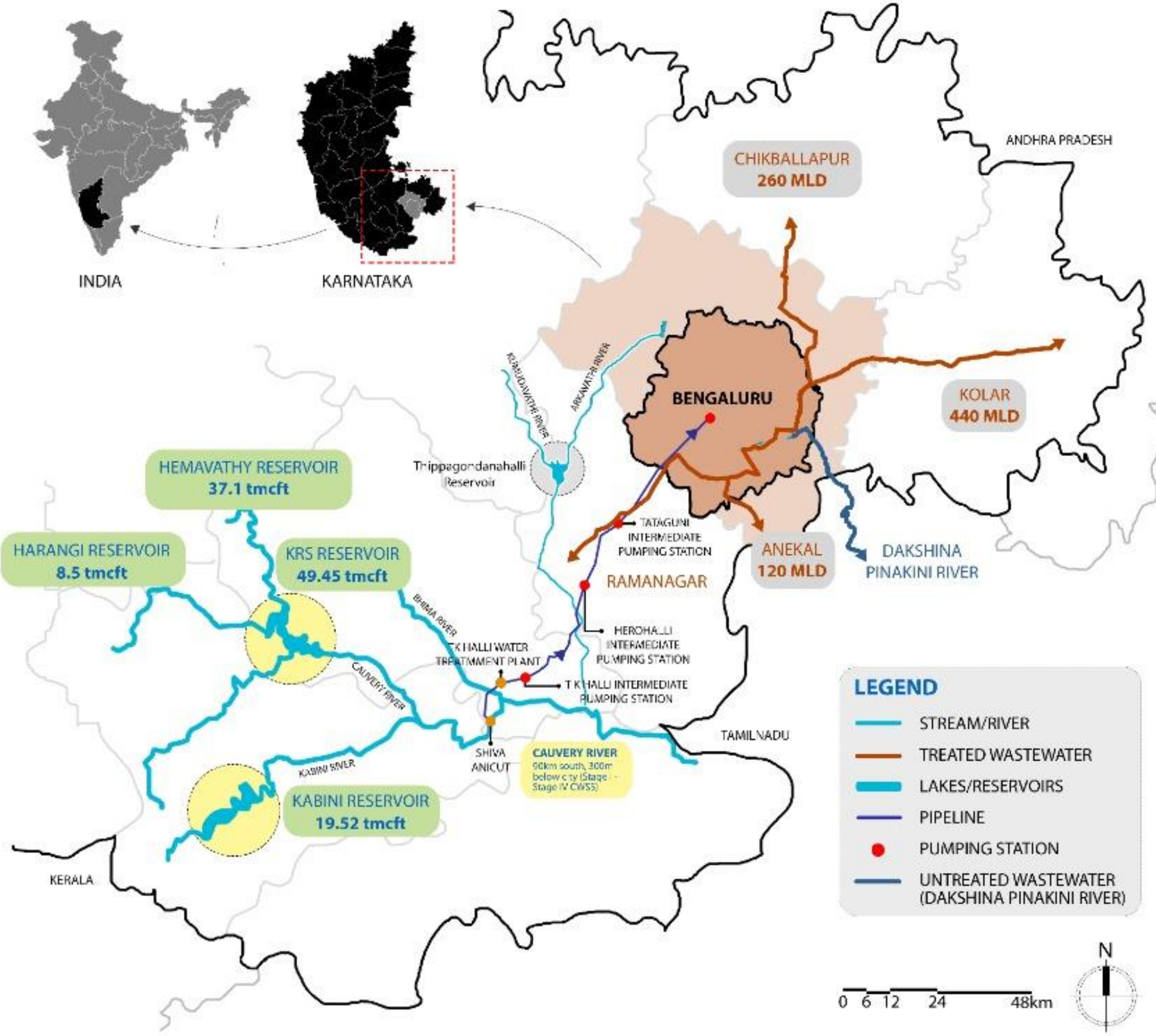
Biome Environmental Trust

Global South Academic Conclave on WASH and Climate linkages

2nd - 4th February 2024, Ahmedabad

BENGALURU - ITS WATER & WASTEWATER

Linking the metropolis to it's drought-prone hinterland



1294 SQKM Bengaluru Municpal area

13 million population as of 2018 (projected to be 20 million in 2031)

1440 MLD is the total amount of water officially **sourced from river Cauvery** by BWSSB

~700 MLD is the deficit water demand **met by groundwater** - via borewells & tankers

1640 MLD is the **quantity of wastewater generated**, estimated at 80% of water supplied

29 WWTPs with 1182.5 MLD **treatment capacity**, and proposal to increase it to 1726.5 MLD (by 2023)

TREATED WASTEWATER TRANSFER **to drought-prone districts** of Kolar, Chikkaballapur and Anekal **for agricultural reuse through GW recharge**

STPs IN BANGALORE

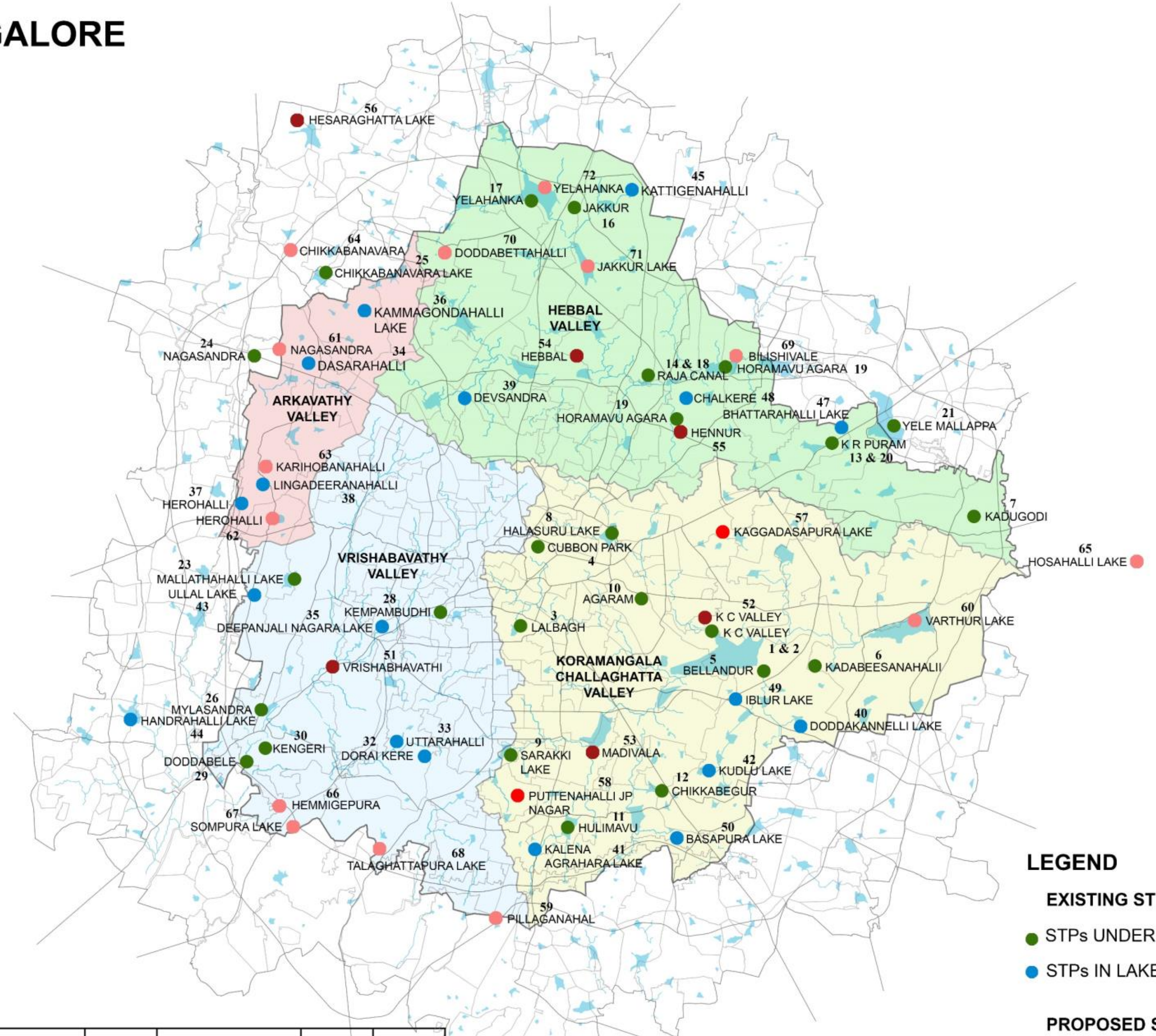
EXISTING STPs

STPs UNDER BWSSB

Sl. No	Name of the STPs	Capacity (MLD)
	K&C Valley	
1	K&C valley	248
2	K&C Valley	60
3	Lalbagh	1.5
4	Cubbon Park	4
5	Bellandur Amani kere	90
6	Kadabeesanahalli Ph-I	50
7	Kadugodi	6
8	Halasuru	2
9	Sarakki	5
10	Agaram	35
11	Hulimavu	10
12	Chikkabegur	5
13	K.R.Puram	20
	Hebbal Valley	
14	Rajacanal - Ph-I	40
15	Hebbal	60
16	Jakkur	15
17	Yelahanka Ph-I	10
18	Rajacanal	40
19	Horamavu Agara	20
20	K.R.Puram Ph-I	20
21	Yelemallappa Chetti kere	15
	Vrishabhavathy Valley	
22	Nagasandra Ph-I	20
23	Mallathahalli	5
24	Nagasandra	20
25	Chikkabanavara	5
26	Mailasandra Ph-I	75
27	V.Valley	180
28	Kempambudhi	1
29	Doddabele	20
30	Kengeri	60
31	Doddabele	40
Total		**1182.5**

STPs IN LAKES OWNED BY BBMP

Sl. No	Name of the lake STPs	Capacity
32	Dore kere	1 MLD
33	Uttarahalli lake	500 KLD
34	Dasarahalli lake	1 MLD
35	Deepanjali lake	500 KLD
36	Kammagondanahalli lake	600 KLD
37	Herohalli lake	1.5 MLD
38	Lingadeeranahalli lake	300 KLD
39	Devasandra Lake	1 MLD
40	Doddakanneli lake	1 MLD
41	Kalena agrahara Kere	150 KLD
42	Kudlu Chikkere	500 KLD
43	Ullala lake	300 KLD
44	Handrahalli lake	500 KLD
45	Kattigenahalli lake	250 KLD
46	Kodige singasandra lake	250 KLD
47	Bhattarahalli lake	250 KLD
48	Challakere lake	500 KLD
49	Ibblur lake	250 KLD
50	Basapura lake	200 KLD
Total		**10.55 MLD**



PROPOSED STP

Sl. No	STPs Under Construction by BWSSB	Capacity (MLD)
51	V.Valley	150
52	K&C Valley	150
53	Madivala	4
54	Hebbal	100
55	Hennur	1
56	Hesharghatta	3
Total		**408**
	STPs Proposed under KSPCB	
57	Kaggadasapura	5
58	Puttenahalli	7
Total		**12**
	STPs Proposed under CWSS	
59	Pillaganahally	4
60	Varthur	25
61	Nagasandra	9
62	Herohally	3
63	Karihobanahally	10
64	Chikkabanavara	4
65	Hosahally	6
66	Hemmigepura	13
67	Somapura	8
68	Talaghattapura	5
69	Bilishivale	17
70	Doddabetta hally	7
71	Jakkur	7
72	Yelahanka	6
Total		**124**

Sl.No	Name	Existing	Under Construction	Proposed	Total
1	K&C valley	536.5	159	29	**724.5**
2	V.Valley	426	153	58	**637**
3	Hebbal Valley	220	108	37	**365**
				Total (MLD)	**1726.5**

LEGEND

EXISTING STPs

● STPs UNDER BWSSB

● STPs IN LAKES OWNED BY BBMP

PROPOSED STPs

● STPs UNDER CONSTRUCTION BY BWSSB

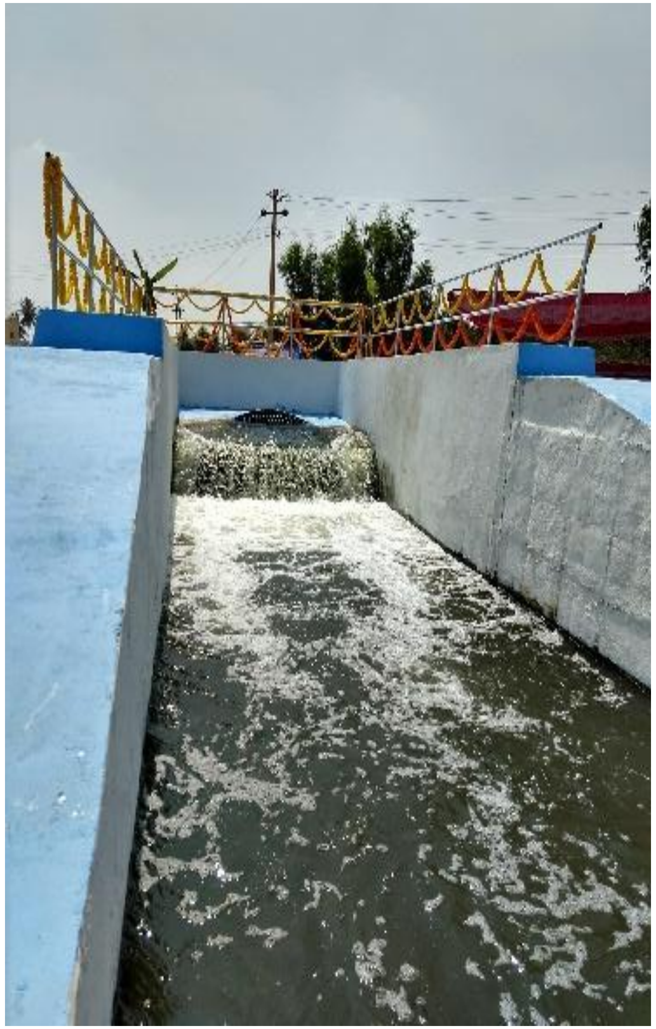
● STPs PROPOSED UNDER KSPCB

● STPs PROPOSED UNDER CWSS

HN Valley Project

To utilize the secondary treated domestic water for filling lakes in the drought affected area of Kolar, Chikkaballapur, Anekal Bangalore Urban and Bangalore Rural districts.

Sewage Treatment Plant	Volume in MLD
Hebbal STP	150 MLD
Hennur STP	40 MLD
Horamavu STP	20 MLD
Total	**210 MLD**

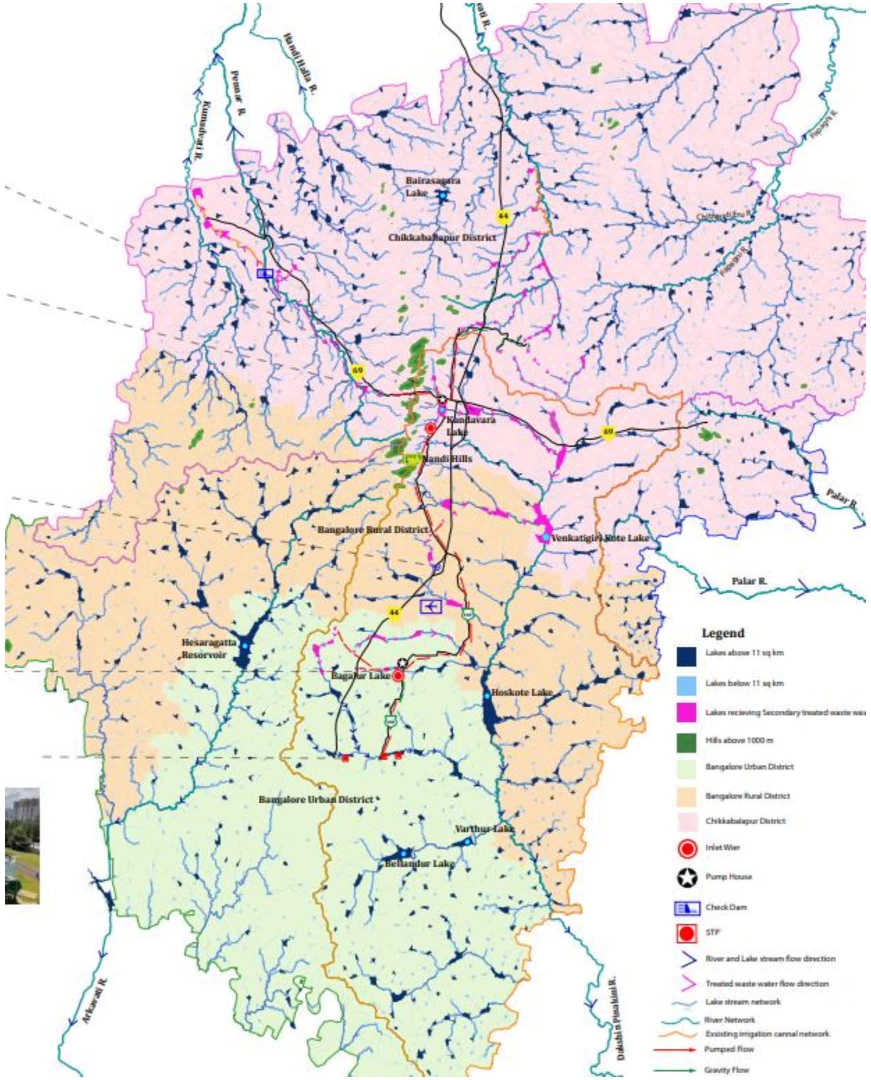


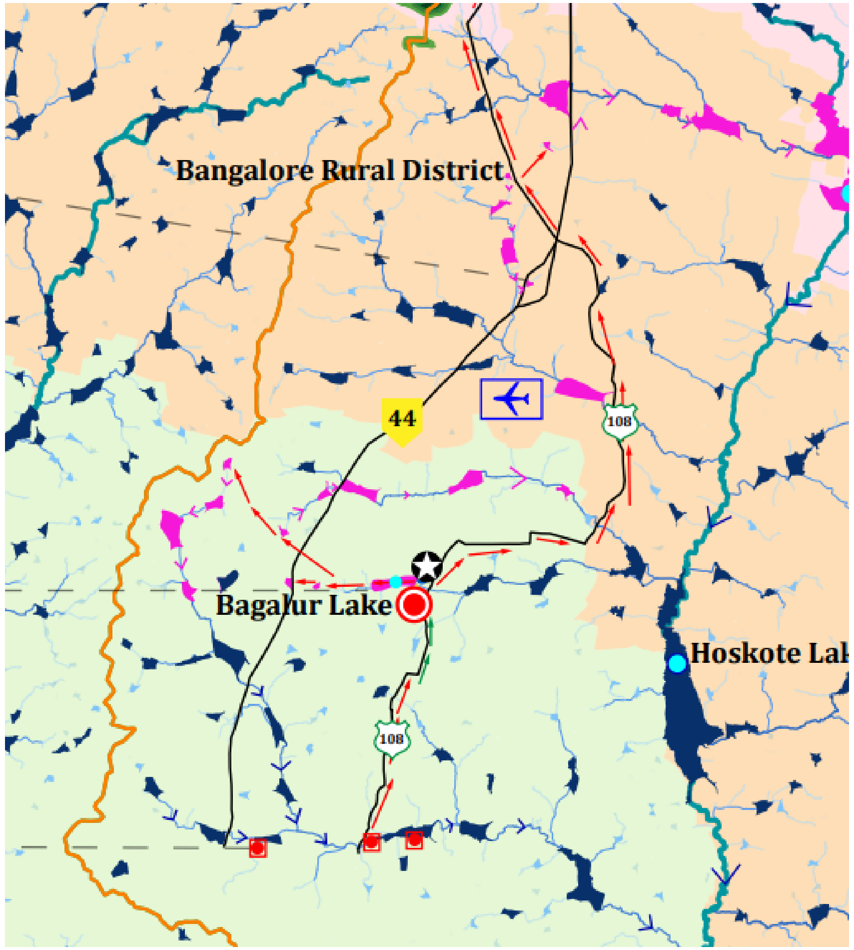
Bagalur Lake, Pumping Station and Inlet of Treated Water to the lake

Lift irrigation of 210 MLD of Bangalore city's Hebbal-Nagawara valley's treated domestic water to 65 lakes of ChikkaBallapur, Bangalore Urban and Bangalore Rural districts.

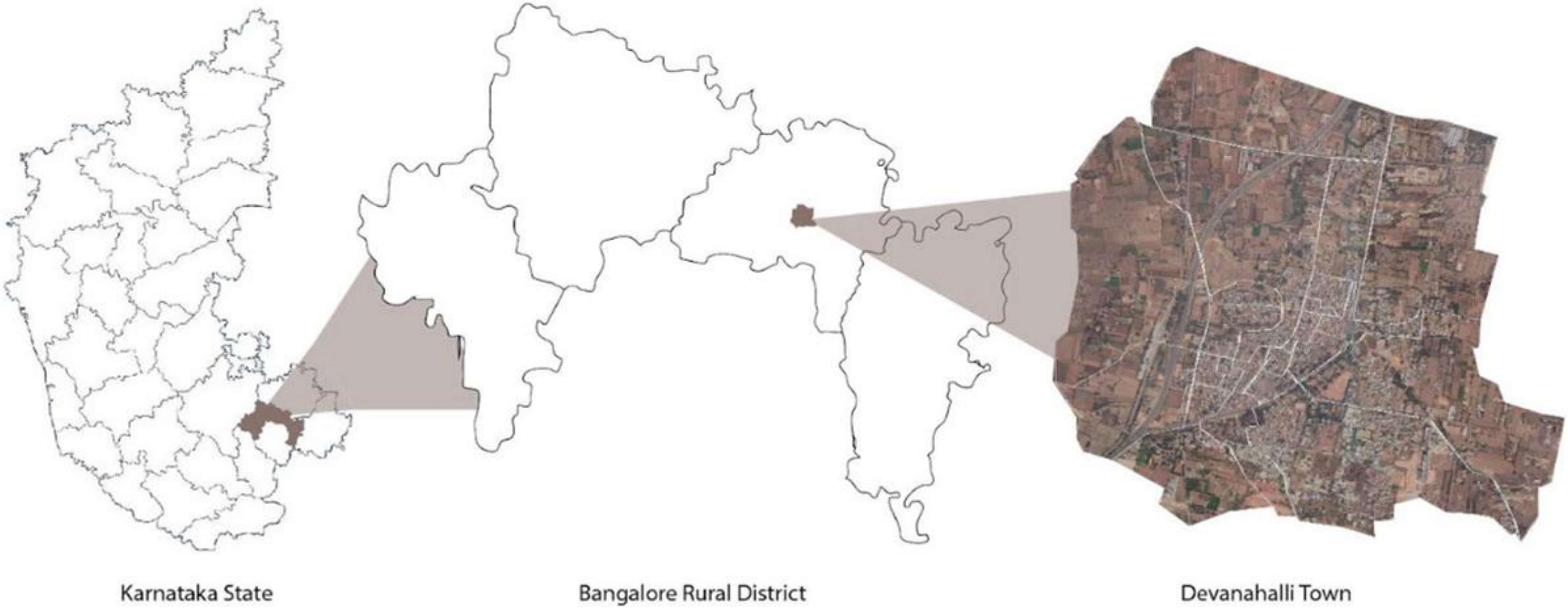
DELIVERY CHAMBER NEAR LAXMISAGAR TANK

H N Valley Project – 210 MLD to fill 65 lakes





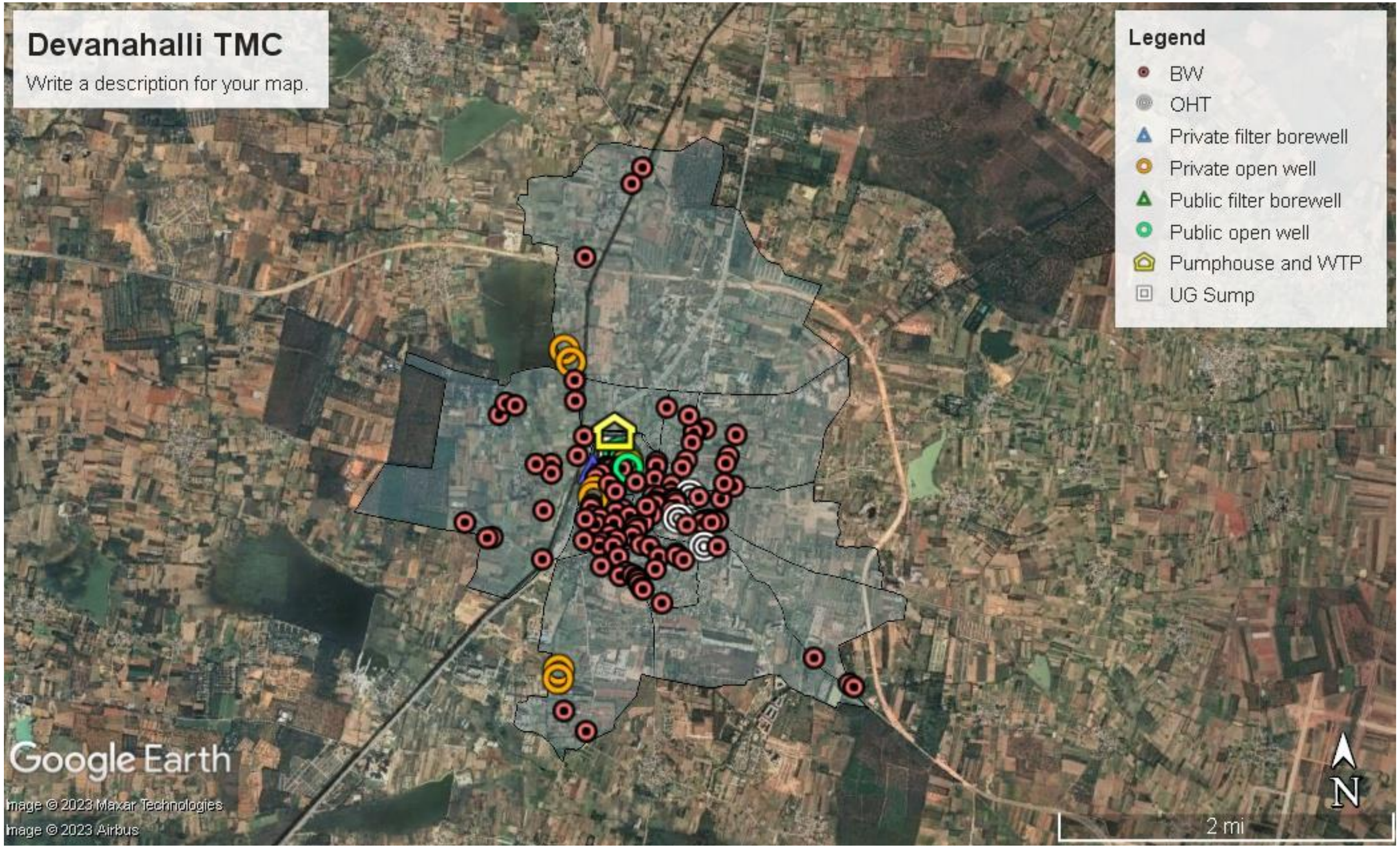
Devanahalli Town



Devanahalli is a small town located in Bengaluru rural district of karnataka.. It is located at a distance of 35 KM from Bengaluru and is known for the Kempegowda International Airport, located at 10 KM from Devanahalli town.

The area of Devanahalli town is about **16.63 square kilometres**. It has **23 wards** with a population of approximately **38000** in 2023. (**28,051** as per Census India 2011).

Devanahalli Water supply at Present



Present Situation : dependent on Ground water for its water supply and the borewell depth has reached more than 1000 feet, many borewells go dry and new borewells are dug every year.

Borewells : There are 122 borewells out of which 31 are not working. **Water Demand :** The Town Municipal Council (TMC) supplies around **2090 KL** of water per day to the households at **55 LPCD** for the current population of **38000**.

Around **13 RO Units** for drinking water.

ಕ್ರ. ಸಂ	ವಾರ್ಡ್ ಸಂಖ್ಯೆ	ಕೊಳವೆ ಬಾವಿಯಿರುವ ಸ್ಥಳ	ಕೊಳವೆ ಬಾವಿ ಕೊರೆದ ವರ್ಷ	ಕೊಳವೆ ಬಾವಿಯ ಆಳ ಅಡಿಗಳಲ್ಲಿ	ಕೇಸಿಂಗ್ ಆಳ ಅಡಿಗಳಲ್ಲಿ	ಕೊಳವೆ ಬಾವಿಯ ಪ್ರಸ್ತುತ ಸ್ಥಿತಿ.		ಕೊಳವೆ ಬಾವಿಯ ಆರ್.ಆರ್. ನಂ:	ವಿದ್ಯುತ್ ಸಂಪರ್ಕದ ಸಾಮರ್ಥ್ಯ	ಪಂಪು ಮೋಟಾರ್ ವಿವರ	ಜಿ.ಐ. ಪೈಪ್‌ಗಳ ಸಂಖ್ಯೆ	ಕೇಬಲ್ ವಿವರ	ಕೊಳವೆ ಬಾವಿಯ ಜಿ.ಪಿ.ಎಸ್. ಸಂಖ್ಯೆ	
						ಚಾಲನೆ ಇದೆ.	ಚಾಲನೆ ಇಲ್ಲ						ಅಕ್ಷಾಂಶ	ರೇಖಾಂಶ
1	1	ಪ್ರಸನ್ನಹಳ್ಳಿ ರಸ್ತೆ ಕೊನೆಯಲ್ಲಿನ ಅರಳೀಮರದ ಕಟ್ಟೆ ಹತ್ತಿರ (ಹೊಸದಾಗಿ ಕೊರೆದಿರುವುದು)	2013	1150	180	ಇದೆ	–	3206	5	7.5/72	300	300	13.22796	77.70696
2	1	ಪ್ರಸನ್ನಹಳ್ಳಿ ಪಾರ್ಕ್	2005	160	80	ಇದೆ	–	1300	5	7.5/10	7	42	13.22973	77.70501
3	1	ಬಿ.ಡಿ.ಓ ಆಫೀಸ್ ಮುಂಭಾಗ	2012	900	140	ಇದೆ	–	ಇಲ್ಲ	15	15/30	35	420	13.24216	77.70844
4	1	ಉಪಾಧ್ಯಕ್ಷರ ಮನೆ ಮುಂಭಾಗ	2014	950	120	ಇದೆ	–		15	15/30	38	456	13.24131	77.7101
5	1	ಡಿ.ವಿ.ಎಂ ಕಾಲೋನಿ ಗಣೇಶ ದೇವಸ್ಥಾನ/ರೀ ಹೋಲ್	2006 & 2020	1300	160	ಇದೆ	–	1255	15	17.5/40	45	540	13.24094	77.71171
6	1	ಡಿ.ವಿ.ಎಂ ಕಾಲೋನಿ ಆಂಜನೇಯ ದೇವಸ್ಥಾನ	2020	1300	160	ಇದೆ	–		10	7.5/72	50	600	13.24022	77.71204
7	2	ಗೌರಿರವಿ ಬಡಾವಣೆ ಅಧ್ಯಕ್ಷರ ಮನೆ ಮುಂದೆ	2016	900	120	ಇದೆ	–	ಇಲ್ಲ	15	15/30	38	456	13.2389	77.71381
8	2	ಶಾಂತಿನಗರ ಪಾರ್ಕ್ & ರೀ ಹೋಲ್	2005 & 2020	1100	120	ಇದೆ	–	429	15	17.5/40	50	600	13.2426	77.71579
9	2	ಶಾಂತಿನಗರ ಟ್ಯಾಂಕ್ ಹಿಂಭಾಗ – 1	2011	900	120	ಇದೆ	–	3408	15	15/30	40	480	13.24314	77.71516
10	2	ಶಾಂತಿನಗರ ಟ್ಯಾಂಕ್ ಹಿಂಭಾಗ – 2	2012	900	110	ಇದೆ	–	422	15	15/30	40	480	13.24297	77.71512
11	3	ಆಂಜನೇಯ ಸ್ವಾಮಿ ದೇವಸ್ಥಾನ	2010	850	80	ಇದೆ	–	ಇಲ್ಲ	15	15/30	42	504	13.24388	77.70826
12	3	ಗೋರಿಪಾಳ್ಯ ಸದಸ್ಯರ ಮನೆ ಪಕ್ಕ	2020	1000	150	ಇದೆ	–	ಇಲ್ಲ	15	17.5/40	50	600	13.24423	77.70846
13	3	ಟಿಪ್ಪು ಸುಲ್ತಾನ್ ರಸ್ತೆ ರಾಜರಾಟ್ ಮನೆ ಹತ್ತಿರ	2001	400	80	ಇದೆ	–	1515	15	12.5/24	19	228	13.24437	77.70691
14	3	ಟಿಪ್ಪು ಸುಲ್ತಾನ್ ರಸ್ತೆ ಮಲ್ಲರಪ್ಪ ಮನೆ ಹತ್ತಿರ & ರೀ ಹೋಲ್	2006 & 2020	900	80	ಇದೆ	–	1514	15	17.5/30	43	516	13.24623	77.70707
15	3	ಹೊಲ್ಲಪ್ಪನವರ ಬೀದಿ ಗಣೇಶ ದೇವಸ್ಥಾನ ಪಕ್ಕ	2014	950	120	ಇದೆ	–	ಇಲ್ಲ	15	17.5/30	45	540	13.2463	77.70839
16	3	ಪಟೇಲ್ ಶೆಟ್ಟಪ್ಪ ಬೀದಿ ಬಾಬು ಮನೆ ಮುಂದೆ	2001	350	80	ಇದೆ	–	537	5	7.5/20	250	250	13.24575	77.70801
17	3	ಲಕ್ಷ್ಮೀನಾರಾಯಣಪ್ಪನವರ ಮನೆ ಹಿಂಭಾಗ	2001	300	60	ಇದೆ	–	3914	5		250	250	13.24649	77.70773
18	3	ಟಿಪ್ಪು ಸುಲ್ತಾನ್ ರಸ್ತೆ ನಟಿಗೇರಪ್ಪ ಮನೆ ಮುಂದೆ	2005	950	180	ಇದೆ	–	3916	5	7.5/30	45	540	13.24718	77.70757
19	3	ಕಲ್ಯಾಣಿ ಮುಂಭಾಗ	2016	1000	170	ಇದೆ	–	ಇಲ್ಲ	15	7.5/50	45	540	13.24744	77.70764
20	3	ಲೀಲಾವತಿ ಮನೆ ಮುಂಭಾಗ	2020	1000	190	ಇದೆ	–	ಇಲ್ಲ	20	20/40	50	600		
21	3	ಮುಜಮ್ಮನಪಾಳ್ಯ ದೇವಸ್ಥಾನದ ಪಕ್ಕ	2021	1100	160	ಇದೆ	–	ಇಲ್ಲ	20	20/40	41	492		
22	4	ಮುದ್ದಯ್ಯನವರ ಬೀದಿ ಬಾಬುಮನೆ ಮುಂಭಾಗ	2014	550	150	ಇದೆ	–	1740	15	17.5/40	38	492	13.2468	77.70978

‘Sihineeru kere’ lake – Reviving local water systems

17 acre lake - source of sweet water supply to Devanahalli Town

given in Table 1.

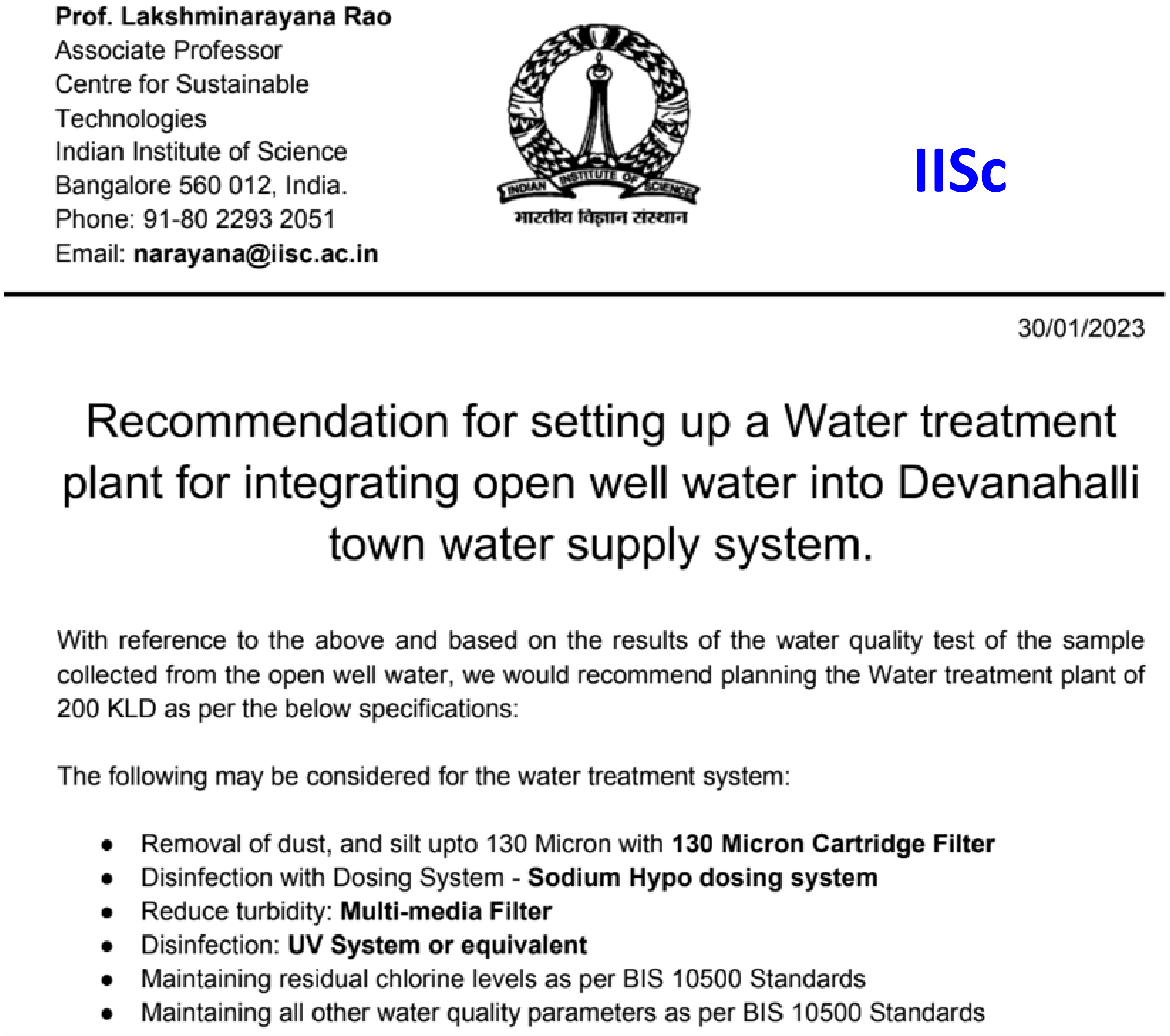
Table 1 : Use based classification of surface waters in India

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1. Total Coliforms OrganismMPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 2mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25oC micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

Integrating Shallow Aquifer to Water Supply System - May 2023

DPR in Oct 2022

Design of WTP



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30/01/2023

Recommendation for setting up a Water treatment plant for integrating open well water into Devanahalli town water supply system.

With reference to the above and based on the results of the water quality test of the sample collected from the open well water, we would recommend planning the Water treatment plant of 200 KLD as per the below specifications:

The following may be considered for the water treatment system:

- Removal of dust, and silt upto 130 Micron with **130 Micron Cartridge Filter**
- Disinfection with Dosing System - **Sodium Hypo dosing system**
- Reduce turbidity: **Multi-media Filter**
- Disinfection: **UV System or equivalent**
- Maintaining residual chlorine levels as per BIS 10500 Standards
- Maintaining all other water quality parameters as per BIS 10500 Standards

IISc

Trans Water System Private Limited

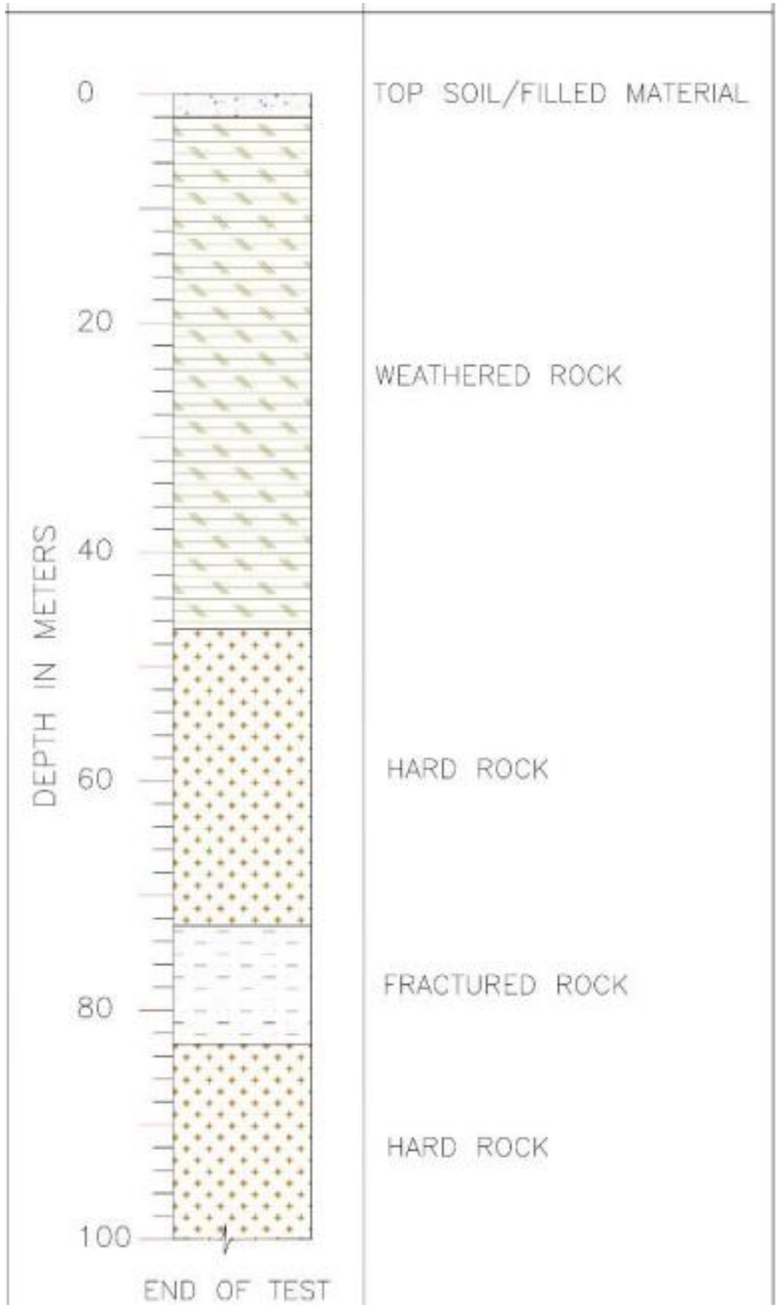
Treatment Stages

1) 130 Micron Cartridge Filter - 3 Inch
2) Dosing System - Sodium Hypo

Visit by IISc on 24/06/2022

Lithology

- Determining shallow unconfined aquifer zone



Shallow (Filter) Borewells Drilling May 2023

01 Digging a pit for circulation of water while drilling the filter borewell hole

02 Fixing of Motor

03. 4 rods will be arranged for balancing & to place drilling equipment

04. Fixing of shaft for drilling of bore well (approximately 7" dia & 2' deep)

05. Green Pipe is the inlet from storage tank. Black and yellow hose pipe is outlet from drilling machine to circulate the water

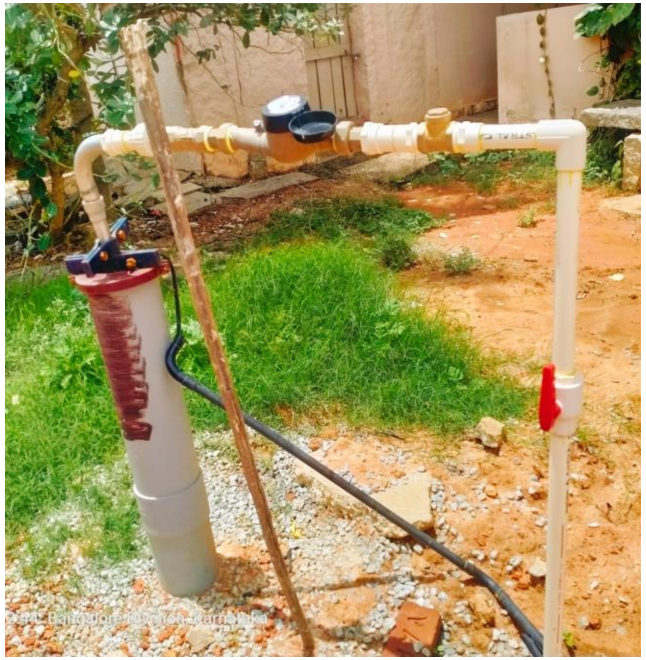
06. 3 feet rod will be added one after the other till they get the hard rock

07. Drilling slits in PVC pipe

08. Filling the gap with Jelly. Pumping out Muddy water with Air compressor

Integrating Shallow Aquifer through Filter borewell and Open well to Water Supply system and Metering

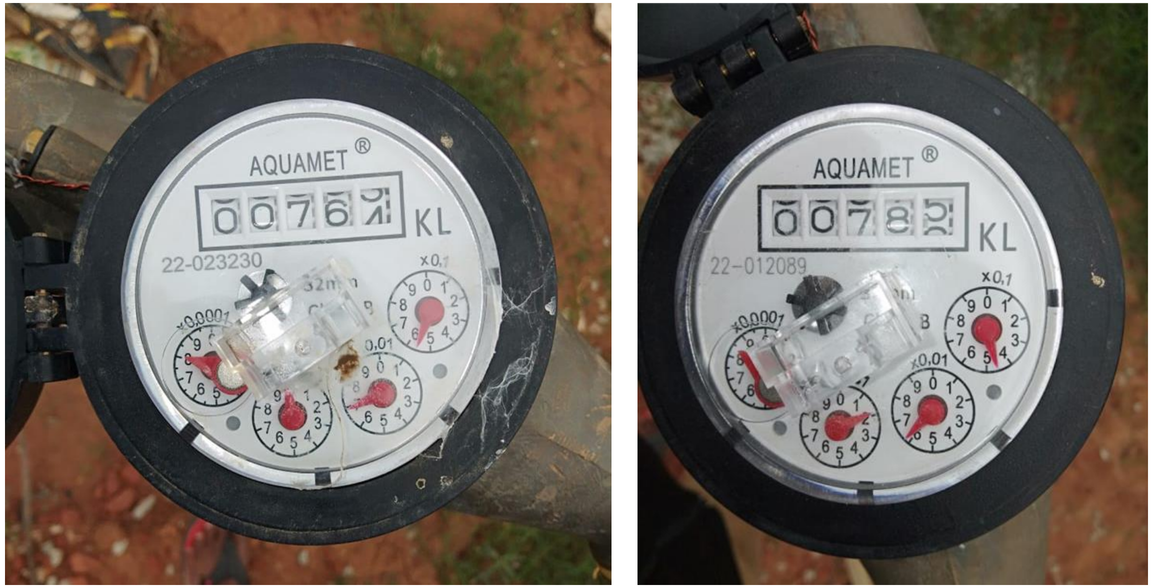
Filter borewell - 85 feet deep



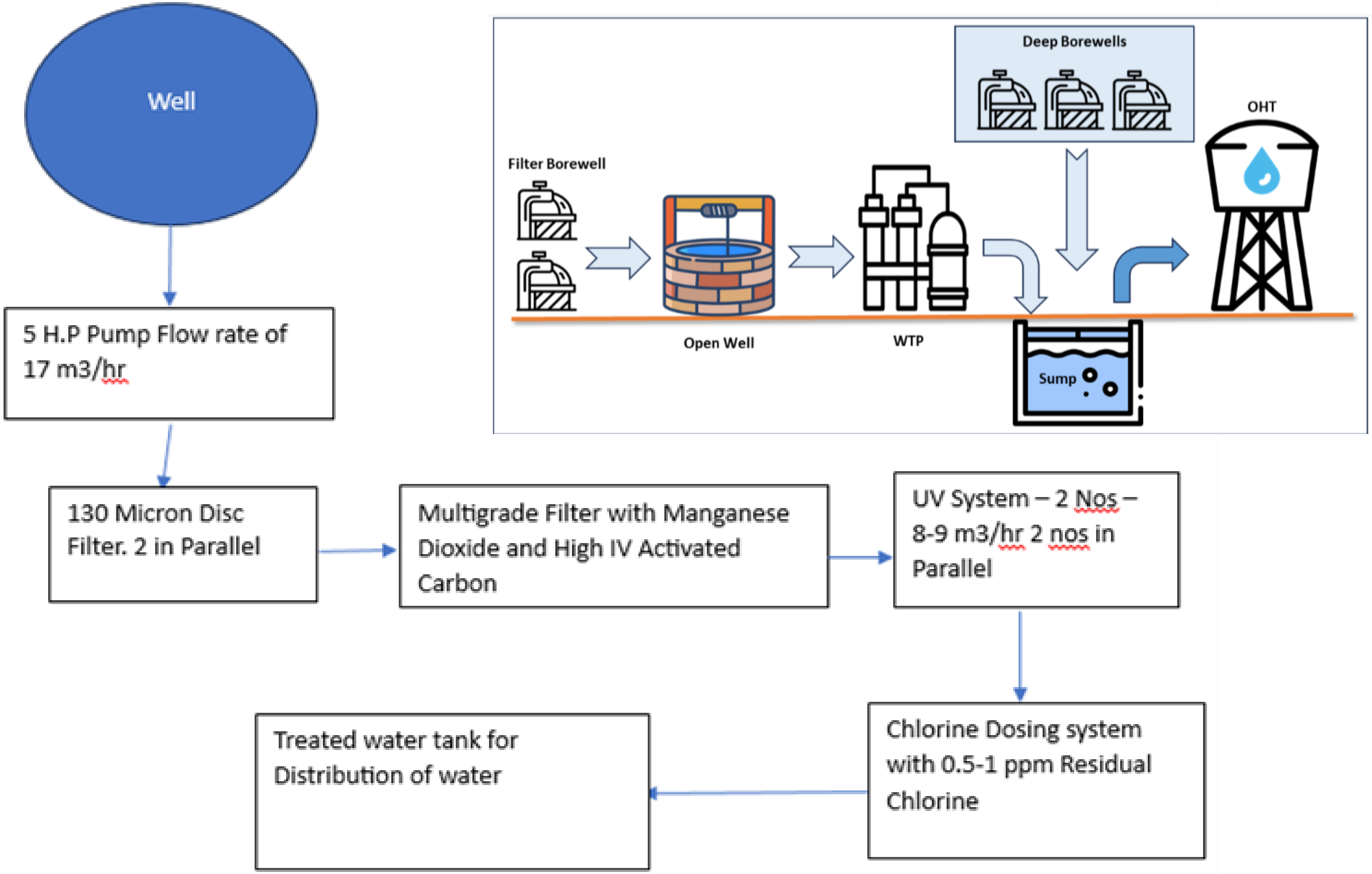
Filter borewell - 100 feet deep

Pump house for the open well

Water flow meters for Filter borewells and WTP Output



Flow Chart - Integration of Shallow Aquifer to Water supply



Well

5 H.P Pump Flow rate of 17 m3/hr

130 Micron Disc Filter. 2 in Parallel

Multigrade Filter with Manganese Dioxide and High IV Activated Carbon

UV System – 2 Nos – 8-9 m3/hr 2 nos in Parallel

Chlorine Dosing system with 0.5-1 ppm Residual Chlorine

Treated water tank for Distribution of water

Water Treatment Plant

120 micron Disc Filter

Backwash water to Lake

Multi media filter with activated carbon

UV disinfection

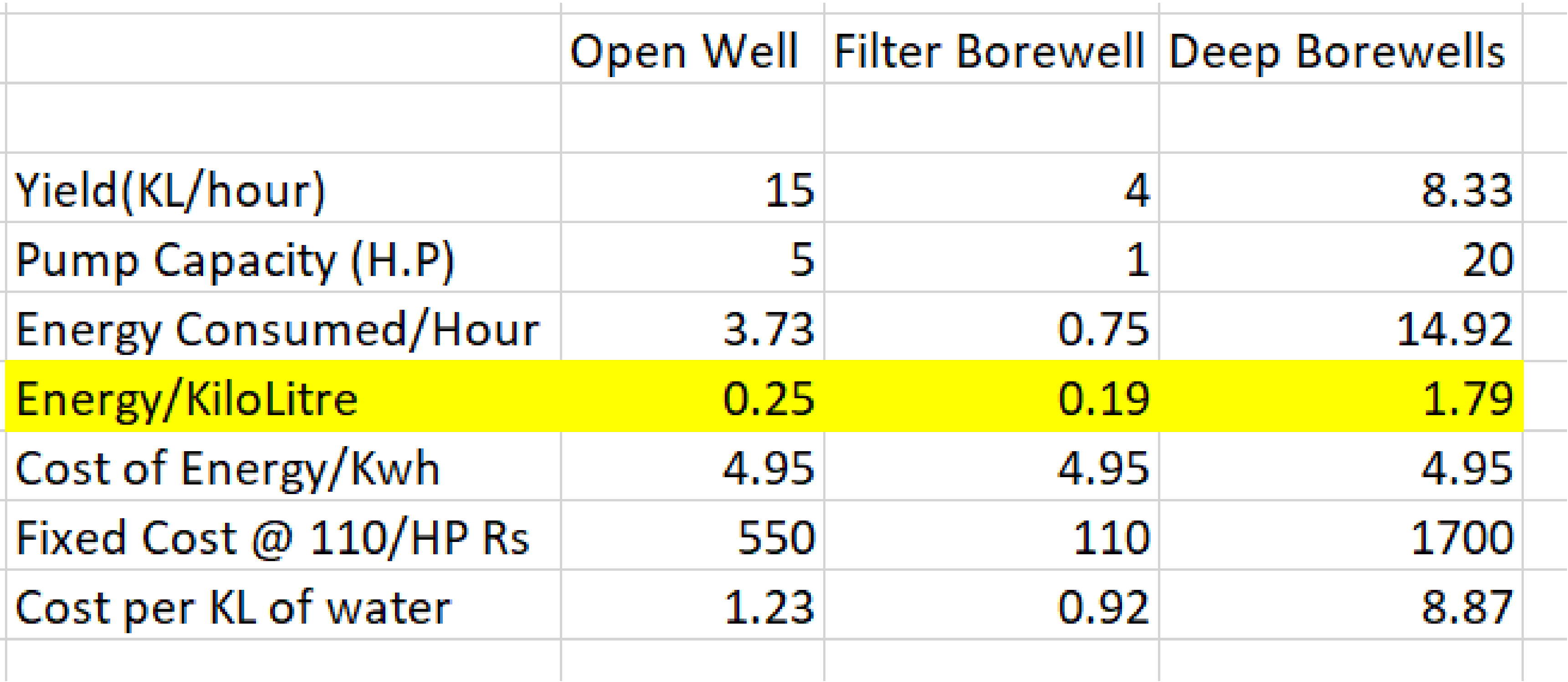
Chlorine doser

Contribution from Shallow Aquifer to Devanahalli Town Water Supply

Summary of treated water supply from shallow aquifer to Devanahalli Town

Sl.No.	Description	in KL	in Litres	Percentage
1	Water pumped from Filter borewell near lake	5348	5348000	17.77%
2	Water pumped from Filter borewell near old house	6637	6637000	22.05%
3	Water pumped from open well	18119	18118900	60.19%
	Total water treated and supplied	**30104**	**30103900**	
	Number of Days	**189**	**Days**	
	Average water treated and supplied per day	**159**	**KLD**	

Energy used and Carbon Emission reduction

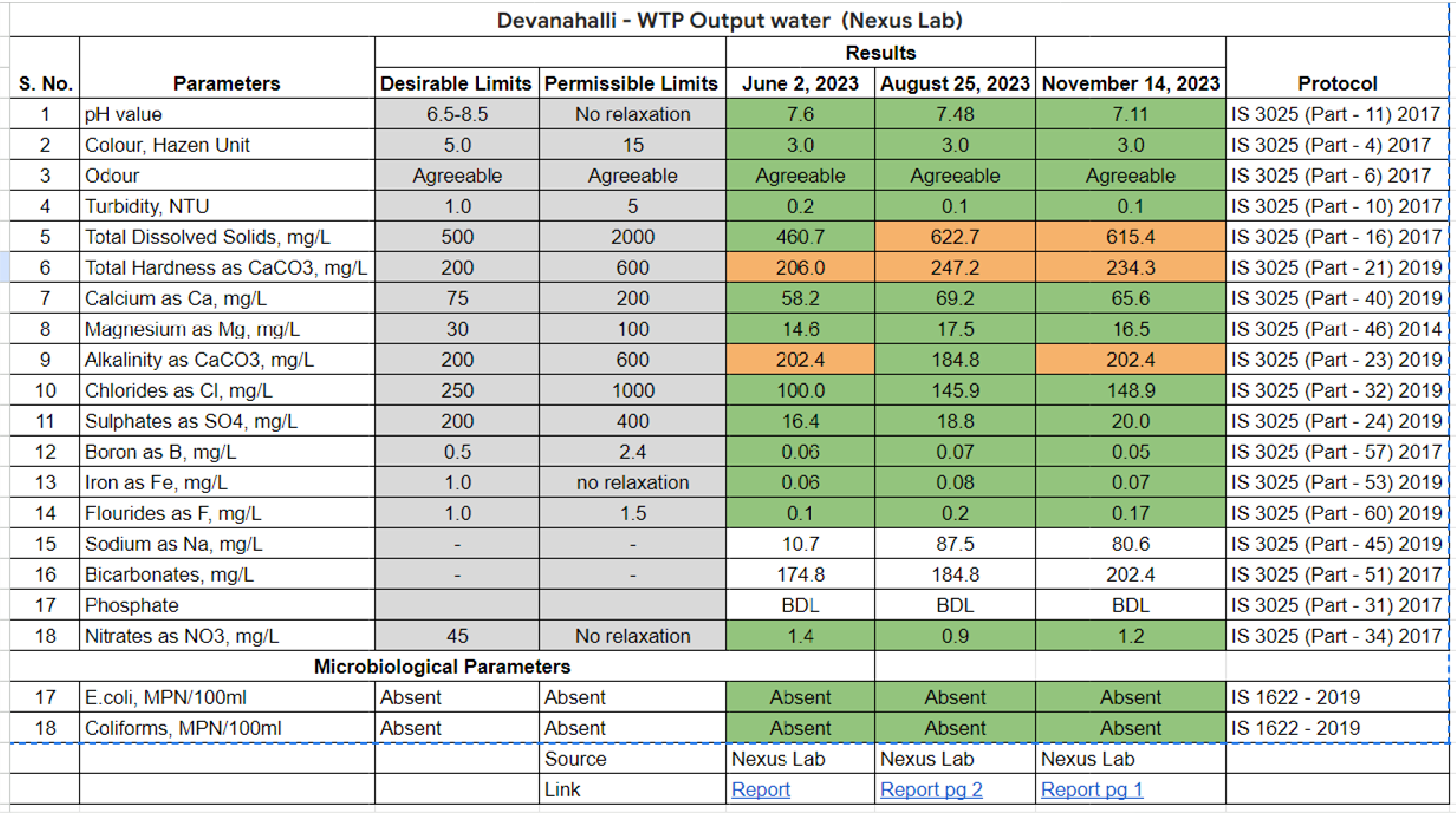


	Open Well	Filter Borewell	Deep Borewells
Yield(KL/hour)	15	4	8.33
Pump Capacity (H.P)	5	1	20
Energy Consumed/Hour	3.73	0.75	14.92
Energy/KiloLitre	0.25	0.19	1.79
Cost of Energy/Kwh	4.95	4.95	4.95
Fixed Cost @ 110/HP Rs	550	110	1700
Cost per KL of water	1.23	0.92	8.87

Table 5: Physicochemical and microbiological Parameters

SL No.	Characteristic	IS 10500 Requirement (Acceptable Limit)	IS 10500 Permissible Limit in the Absence of Alternate Source	Samples					
				Bagalur Tank	Devanahalli Tank	Borewell to open well	Open well	Water Treatment Plant Outlet	Sump outlet
1	pH Value	6.5-8.5	No relaxation	8.7	9.4	7.9	8	8.3	8.1
2	Turbidity, NTU, Max	1	5	1.6	3.3	0.4	2.1	0.3	2.1
3	Total Dissolved Solids	500	2000	294	388	508	303	301	456
4	Total Suspended Solids	-	-	22	18	16	10	14	8
5	Fluoride	1.0	1.5	0.4	0.4	0.3	0.2	0.1	0.1
6	Nitrates	45	No Relaxation	1.1	3.4	0.5	0.4	1.3	0.6
7	Nitrites	-	-	0.1	0.2	0.1	0.1	0.2	0.1
8	Total Nitrogen	-	10	2.5	2.8	1.2	2.6	1.4	2.8
9	Ammonia	0.5	No relaxation	0.1	0.1	0.1	0.1	0.2	0.2
10	Sulphate	200	400	46	68	48	42	55	38
11	Ortho-phosphates	-	-	0.7	0.1	0.06	0.06	0.07	0.2
12	DO	-	-	6.9	5.8	7.8	7.1	5.6	7.9
13	COD	-	-	79	120	88	76	100	72
14	BOD	-	-	5.2	6.3	3.8	4.1	6.6	3.1
15	Total Coliform	Shall not be detectable in any 100 ml sample	-	900	1500	800	800	200	700

Water Quality Test Results - Nexus Lab



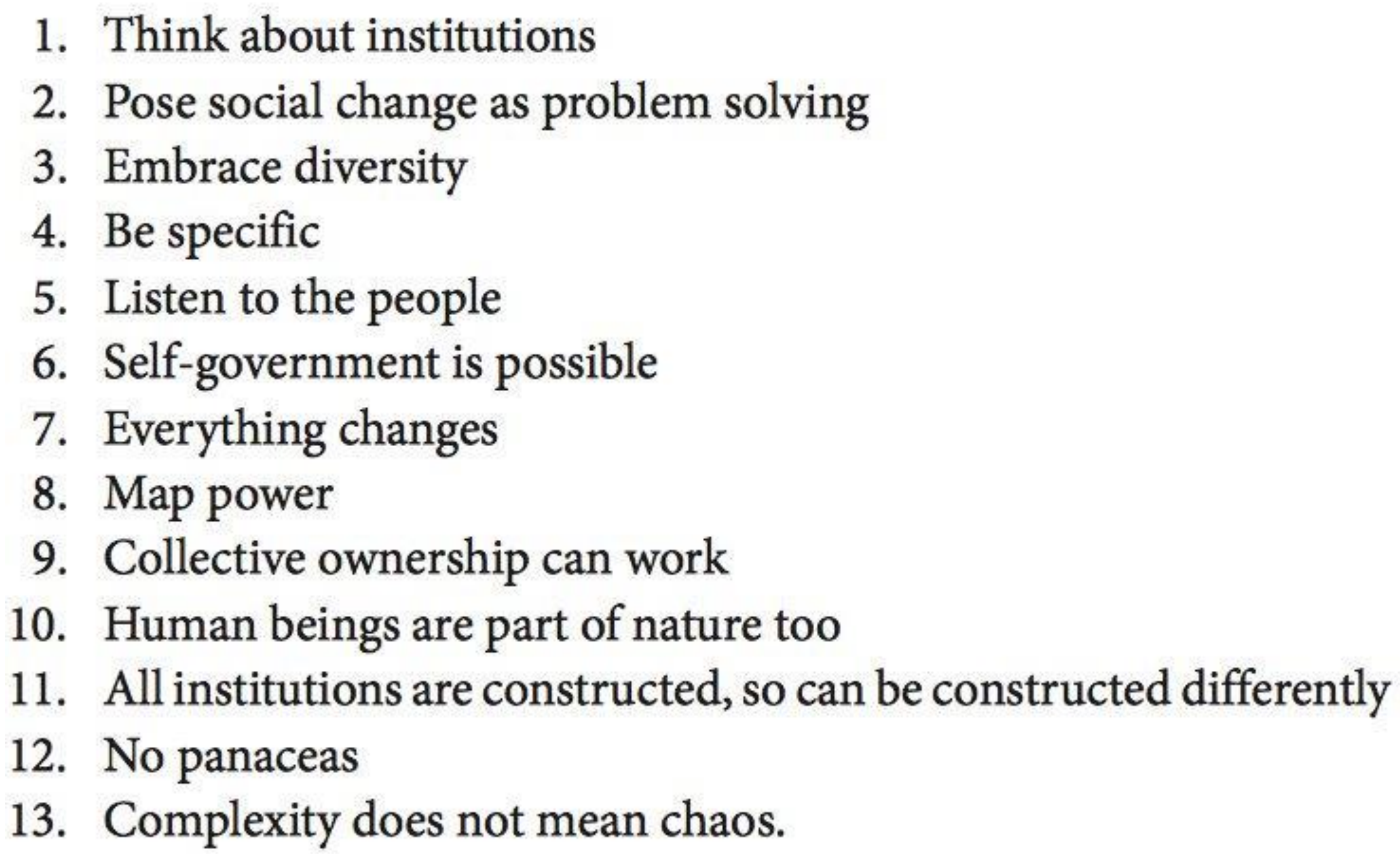
Devanahalli - WTP Output water (Nexus Lab)

S. No.	Parameters	Desirable Limits	Permissible Limits	Results			Protocol
				June 2, 2023	August 25, 2023	November 14, 2023	
1	pH value	6.5-8.5	No relaxation	7.6	7.48	7.11	IS 3025 (Part - 11) 2017
2	Colour, Hazen Unit	5.0	15	3.0	3.0	3.0	IS 3025 (Part - 4) 2017
3	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	IS 3025 (Part - 6) 2017
4	Turbidity, NTU	1.0	5	0.2	0.1	0.1	IS 3025 (Part - 10) 2017
5	Total Dissolved Solids, mg/L	500	2000	460.7	622.7	615.4	IS 3025 (Part - 16) 2017
6	Total Hardness as CaCO3, mg/L	200	600	206.0	247.2	234.3	IS 3025 (Part - 21) 2019
7	Calcium as Ca, mg/L	75	200	58.2	69.2	65.6	IS 3025 (Part - 40) 2019
8	Magnesium as Mg, mg/L	30	100	14.6	17.5	16.5	IS 3025 (Part - 46) 2014
9	Alkalinity as CaCO3, mg/L	200	600	202.4	184.8	202.4	IS 3025 (Part - 23) 2019
10	Chlorides as Cl, mg/L	250	1000	100.0	145.9	148.9	IS 3025 (Part - 32) 2019
11	Sulphates as SO4, mg/L	200	400	16.4	18.8	20.0	IS 3025 (Part - 24) 2019
12	Boron as B, mg/L	0.5	2.4	0.06	0.07	0.05	IS 3025 (Part - 57) 2017
13	Iron as Fe, mg/L	1.0	no relaxation	0.06	0.08	0.07	IS 3025 (Part - 53) 2019
14	Flourides as F, mg/L	1.0	1.5	0.1	0.2	0.17	IS 3025 (Part - 60) 2019
15	Sodium as Na, mg/L	-	-	10.7	87.5	80.6	IS 3025 (Part - 45) 2019
16	Bicarbonates, mg/L	-	-	174.8	184.8	202.4	IS 3025 (Part - 51) 2017
17	Phosphate			BDL	BDL	BDL	IS 3025 (Part - 31) 2017
18	Nitrates as NO3, mg/L	45	No relaxation	1.4	0.9	1.2	IS 3025 (Part - 34) 2017
Microbiological Parameters							
17	E.coli, MPN/100ml	Absent	Absent	Absent	Absent	Absent	IS 1622 - 2019
18	Coliforms, MPN/100ml	Absent	Absent	Absent	Absent	Absent	IS 1622 - 2019
			Source	Nexus Lab	Nexus Lab	Nexus Lab	
			Link	Report	Report pg 2	Report pg 1	

Conclusions

- The shallow unconfined aquifer presents a potential storage and remediation of water for domestic purpose in a city
- Diluted treated used water has the potential to restore ecology, provide livelihoods and then recharge aquifers for further water use
- Improved treatment quality of used water with stringent standards of treatment provide a potential for higher order reuse
- Both climate adaptation through reuse of water and climate mitigation through lower carbon emissions in using aquifer water may be possible with systems design.

Elinor Ostrom’s approach



1. Think about institutions
2. Pose social change as problem solving
3. Embrace diversity
4. Be specific
5. Listen to the people
6. Self-government is possible
7. Everything changes
8. Map power
9. Collective ownership can work
10. Human beings are part of nature too
11. All institutions are constructed, so can be constructed differently
12. No panaceas
13. Complexity does not mean chaos.

Thank You

CWAS CENTER FOR WATER AND SANITATION
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Global South Academic Conclave on WASH and Climate Linkages