

4.1.9 GROUND WATER RESOURCES

4.1.9.1 Describe general Geology and Hydrogeology State.

Write a brief about major geology, aquifer systems and general yield ranges (Annexure-4.1.8 A)

Maps: Hydrogeology, Thickness of weathering, general yields to be incorporated

Write brief about Ground Water Occurrence, development and number of wells (No. of Dug wells, Dug cum bore wells (DCB), No. of Bore wells/No. of Tube wells etc) drilled by different agencies in the District. If available, information of discharge of wells, well efficiencies (derived from pumping tests) may be included (**Annexure-4.1.9 (i) and Annexure – 4.1.9(ii)**)

Well Census data/data on Ground Water abstraction Structures by Irrigation Sector (**Annexure-4.1.9 (iii)**)

4.1.9.2 Ground water regime monitoring

- (i) Existing network of monitoring wells of CGWB /State Departments may be given in Annexure
- (ii) A brief write up on the existing water level scenario including depth to water level maps for two seasons (pre and post monsoon) to be included in the main chapter
- (iii) Long term trend of water level (decadal)
- (iv) Data Constraints (Soil moisture, Geochemical concentration, Recharge of Groundwater, Collapse of hand dug wells, shortage of manpower, siltation of wells, shortage of funds from the govt. non availability of credit system to the farmers.)
- (v) **Monitoring of recharge due to grey water, sewage and effluent.**
- (vi) **Annexure 4.1.9 B to 4.1.9E**
- (vii) **Map showing locations of Monitoring wells**

4.1.9.3 Dynamic Ground Water Resources

- (i) A brief write up on the annual replenishable ground water resources, net annual availability, annual ground water draft of the state (as on 31st March, 2013) and categorization of blocks (over exploited, critical , semi critical and safe) in the state
- (ii) Past ground water development district wise - 2002, 2011.
- (iii) **Annexures-4.1.9 F to 4.1.9 J**
- (iv) *Map on Dynamic ground water resources to be incorporated*
- (v) Map showing number of over exploited blocks/Mandals

4.1.9.4 Groundwater quality issues

- (i) A brief note to be given on areas/districts/ basins with ground water having concentration of parameters (<Arsenic, Fluoride, Salinity (EC), Iron, heavy metals, others etc) beyond permissible limit for drinking water given by BIS.
- (ii) Periodicity of collection of samples for basic constituents and heavy metals.
- (iii) Averages/Ranges of Basic constituents in Ground water
- (iv) Areas impacted by different ground water quality issues
- (v) **Annexure – 4.1.9 K (i) to 4.1.9 L (vi)**
- (vi) **Map showing areas under ground water contamination**

4.1.9.5 Ground water Conservation and Augmentation

- (i) Write brief write up about ground water augmentation practiced adopted under various Central and State Schemes, its effective implementation, monitoring and impact assessment.
- (ii) Roof top rain water harvesting and artificial recharge in Cities and Municipalities etc
- (iii) Total number of Minor irrigation tanks and catchment area, tank spreads and area irrigated under the MI tanks
- (iv) *Map showing location of Artificial Recharge structures constructed under various schemes*
- (v) *Map showing minor irrigation tanks location*
- (vi) **Annexures 4.1.9 M to 4.1.9 P**

4.1.9.6 Groundwater issues and challenges

The ground water quantity and quality issues are to be highlighted and may be analyzed in terms of:

- (i) **Problems posed by nature:** Quantitative (Low rain fall areas, low ground water yields) and qualitative aspects (summaries to be given). Details already given earlier.
- (ii) **Problems caused by anthropogenic activities:** intensive ground water development (OE/Critical/ Semi Critical)/intensive surface water irrigation/intensive mining activities/growing urban complexes/industrial establishments and its impact on ground water quantity and quality.
- (iii) **Problems caused by socio-economic condition:** size and nature of land holdings, backward population, electricity supply
- (iv) **Problems due to lack of scientific input:** drilling techniques, cropping pattern, inefficient irrigation practices.
- (v) **Administrative issues:** State ground water cell, enactment of legislation for control and State Ground Water Regulatory Authorities. Development of groundwater resources, pricing policy for ground water users, Reviving dugwells/borewells for artificial recharge etc, Convergence of activities in recharging ground water etc.,

4.1.9.2 Ground water Management and regulation and Governance

- i. **Ground water Regulation:** Law / Policy/ Regulations if any. Whether any ground water Act for regulation of Groundwater use/ management exists in the state. If so, provide the gist of the act and also indicate any deficiency that exists in the law.

ii. Ground water Governance

Water Resources/GW Resource Information System

- i. Status of Water Resources Information System
- ii. Existing system of Informatics/Dash boards on surface and ground water resources, reservoir water levels, ground water levels, drafts etc.
- iii. Geo-tagging of ground water abstraction structures, Artificial Recharge structures
- iv. Information on Monitoring wells, ground water levels, Pre monsoon, post monsoon and ranges of water levels in the basin/District
- v. Water level and quality measurements through wells, piezometers, DWLR with telemetry, ground water elevation
- vi. **Refer (Annexure-4.9 (i) to (viii)) and Annexure – 4.9 (i) to 4.9 (vi)**

Over-Exploitation of Ground Water Resources:

- Existing Gross Ground Water draft for all Sectors and Stage of GW development
- Sector wise high and low development/consumption of ground water
- Measures taken for arresting over exploitation of ground water
- **Refer (Annexure 4.3 (i) to (v))**

Irrigation efficiency, Crop water budgeting and More crops per drop:

- District wise irrigation by ground water
- Type of Crops and areas under ground water Irrigation
- Micro irrigation adopted and ground water user efficiency
- **Refer (Annexure-ix to x)**

Sustainable ground water development and management

- Integrated Watershed management program
- Recharge structures Check dams, Percolation tanks and farm ponds and others constructed under IWMP and NREGS and its impact
- Quantum of Water Harvested and expected ground water recharge
- Rain water harvesting and artificial recharge to ground water
- Existing Minor irrigation tanks, de-silting and quantum of water harvested and expected ground water recharge and increase in area under irrigation etc.,
- Operation and Maintenance of AR Structures
- **Refer (Annexure 4.5 (i) to 4.5 (v))**

Waste Water:

- Quantum of Waste water generated from domestic sector (urban areas)
- Status of Recycling and Re Use of waste water
- **Refer (Annexure 4.7 (xi))**

Qualitative

- Ground water quality of the District/State
- Parameters analyzed to assess the ground water quality major and trace elements
- Areas identified with high Arsenic, fluoride and Nitrate, salinity and polluted within the district
- Mitigation strategies adopted or being adopted to address the issues of ground water quality in the district/State
- **Refer Annexures 4.4 (i) to 4.4 (vi)**

Capacity Building of Various Stake holders:

- No. of Departments /NGOs directly or indirectly involved in dealing ground water in the District/State
- Capacity building of various Stakeholders

4.1.9.3 Performance Indicators: for comparison across Districts/ Plants/ Units/ Products etc.

- i. Bench Marks/ Norms/ Standards and deviation from the norms/bench marks/standards currently.
- ii. Status of various Performance Indicators

Performance Indicators

Category of Indicators	Indicator	Bench Mark/ Units	District.1	District.2
Measurement system	Density of piezometers for GW monitoring (excess/deficient) compared to required numbers			
	Number of Piezometers fitted with Automatic Water Level recorders			
	Number of Piezometers are directly under telemetric level of Monitoring			
	No. of groundwater abstraction structures in irrigation Sector			
	Number and Percentage of Ground Water abstraction structures under monitoring with water Meter in Irrigation Sector			
	No. of artificial recharge structures geo tagged			
	Total number of GW abstraction structures geo tagged in Drinking Water			
	Total number of GW abstraction structures geo tagged in Irrigation sector			
	Total number of GW abstraction structures geo tagged in Farm sector- Animal Husbandry, Fisheries etc. other than Irrigation			
	Total number of GW abstraction structures geo tagged in Industry sector			
	Total number of GW abstraction structures geo tagged in Forestry			
	Total number of GW abstraction structures geo tagged in Wildlife			
	Average depth to water level (m)			
	Average yearly water level fluctuation (m) (rise/fall)			
Ground Water Conservation, Harvesting and Augmentation	Total Rainfall in the previous Year			
	% of total Rainfall infiltrates/ percolation			
	Quantum of total rainfall infiltrates/ percolation			
	% of Rainfall going run off			
	% of Rainfall going in Evapo transpiration			
	Number of water harvesting structures constructed or rejuvenated as compared to the target (sanctioned projects under IWMP, RKVY, MGNREGS and other schemes)			
	Percentage of water harvesting structures constructed or rejuvenated as compared to the target (sanctioned projects under IWMP, RKVY, MGNREGS and other schemes)			
	Volume of rain water harvested in all RWHs of the district (MCM)			
Volume of ground water recharge (MCM)				

	Percent of areas showing rising GW levels			
	Number and Percentage of safe blocks to total blocks			
	Micro Irrigation: Area covered under Sprinklers and Drip irrigation			
	% of area irrigated under Micro irrigation			
	Number of Government Establishments adopting Water efficient techniques like recycling and re using of waste water			
	Number of Private Establishments adopting Water efficient techniques like recycling and re using of waste water			
	Number of artificial recharge structures			
GW Demand	Total number of GW extraction points registered			
	No. of Dug wells			
	No. of Bore wells			
	Dug cum bore wells			
	Number of GW extraction points not registered			
	% of GW points registered			
	% GW points increased registration coverage compared the last year			
	Total no of industries (all types)			
	Number and Percentage of Industries being regulated under existing ground water Laws			
	Number and Percentage of packaged drinking water units NOC granted and are under monitoring			
	% of Establishments undertaken water audit in the last 5 years			
% share of GW in water use in the District				
GW Balance/ Budget	Area under over exploitation			
	% of District Area under over exploitation			
	Area increased / decreased when compared the last GW survey			
	Number of over-exploited blocks/Mandals to total blocks/Mandals as per latest assessment			
	Number of over-exploited blocks/Mandals to total blocks as per the previous assessment			
	Change in number of Over exploited blocks/Mandals (Increased/decreased) (Latest GW assessment vs Previous GW assessment)			
	Number of over exploited blocks notified for regulation			
	Net ground water availability (MCM) (Latest GW Assessment)			
	Net Ground water Availability (MCM) (Previous assessment)			
	Change in Net GW availability (MCM) (Increase/Decrease) (Latest Vs Previous GW assessment)			
	Existing Stage of ground water development (in %) (Latest GW assessment)			
	Stage of ground water development (in %) (Previous assessment)			
	Change in Stage of ground water development (in %) (Increase/decrease) (Latest vs Previous GW assessment)			
	Long term trend of groundwater level (Decadal)			
	Area irrigated from ground water sources (ha)			
	Increase/Decrease in area irrigated from ground water sources (previous year to Current year)			
	Ground Water Quality	No of habitations affected with different groundwater contamination like As, F, Salinity		
No of habitations which have been provided with alternate water supply where there is contamination of GW				
Waste Water	% of Waste water generated recycled and Re used w.r.to water supplied			
	% of waste water recycled and Re used			

	Number and percentage of establishments (Govt. or private) having storm water management structures			
Participatory Ground Water Management	No. of Water User associations / Ground Water Mgt Committees			
	Number and Percentage of wells under Participatory ground water management			
	No of NGOs involved			
	Online monitoring of GW for public dissemination and feedback			
Investment	Annual investment for GW conservation, augmentation and public awareness per ha or MCM			

ANNEXURE**Annexure-4.1.9 A****Format for General Hydrogeology of the District example)**

State/basin	District	Geology	Principle aquifers/System	Type of aquifer (Consolidated/Semi Consolidated/ Un consolidated)	Area	General Yield range (lps)
	Example	BGC	Granites, Gneisses		80%	1 to 3
	Example	Indo Gangetic Alluvium	Sand, Gravel		20%	3 to 20

Annexure-4.1.9 (i)**Format for Ground Water Structures**

Basin	District	Total No. of Wells drilled	Agency	Maximum depth drilled/explored (m)	Geology/ Principal Aquifer system	Total No. of Piezometers	Agency	Maximum depth drilled/explored (m)	Geology / Principal Aquifer system

Annexure-4.1.9 (ii)**Well Census data/Data on Ground Water abstraction Structures in Irrigation Sector**

Basin	District	No. of Dug Wells	Acreage/Irrigated area (acre)	No. of Bore wells/tube wells	Acreage/Irrigated area (acre)	No. of Springs	Acreage/Irrigated area (acre)

Basin	District	Total Wells	Purpose of wells	Well Type (Construction)- Irrigation	Ayicut Area	Water Quality - Irrigation	Mode of Lift - Irrigation	Dry/Disused Wells - Irrigation	Percentage of Irrigation wells	Period of Construction - Irrigation
			Irrigation	Domestic	Industrial	Others	Open	Bore	Dug/Bore	Tube

Ayacut Area		Water Quality - Irrigation			Mode of Lift - Irrigation				Dry/Disused Wells - Irrigation				
Ayacut (Acre)	Average Ayacut / Well (Acre)	Good	Moderate	Poor	Electrical	Diesel	Wind	Manual	Open	Bore	Dug / Bore	Tube	Total Dry Wells

Percentage of Irrigation wells	Period of Construction - Irrigation									
	2000-04	1990-99	1980-89	1970-79	1960-69	1950-59	1900-49	1700-1899		

Annexure-4.1.9 B: Existing Network of Monitoring wells (GWMW)

District/ Basin	Number of (GWMS)	Total number of Dug wells as GWMS	Agency/ Department	Geology/ Principle Aquifer system	Total number of Piezometers/ as GWMS	Geology/ Principle Aquifer system	Average DTWL *(m bgl) (pre-monsoon)	Average DTWL (m bgl) (post-monsoon)	Average Fluctuation (m)	Trend (Rise/fall)

*DTWL: Depth to Water Level:

GWMS: Ground water level Monitoring Stations

Annexure-4.1.9 C: Ground water Levels (M bgl):

District/ Basin	May- 17	Aug- 17	Nov- 17	Jan- 17	Rise (+) / Fall (-) from Current water level				Rainfall (in mm) 01/06/2017 to till now			
					May- 17	August- 17	November- 17	January- 17	Actual	Normal	Deviation in %	

(M bgl: Meters below ground level)

Annexure-4.1.9 D: District Wise Pre and Post monsoon average groundwater levels for the years

District/ Basin	2013		2014		2015		2016		2017	
	Pre (May)	Post (Nov)	Pre (May)	Post (Nov)	Pre (May)	Post (Nov)	Pre (May)	Post (Nov)	Pre (May)	Post (Nov)

(M bgl: Meters below ground level)

Annexure-4.1.9 E: Ground Water Level ranges:

District/ Basin	Percentage of Areas with Different Water Level Ranges			
	<3 m	3-6 m	6-9 m	>9 m

Annexure-4.1.9 F: Long Term Water Level trend (Decadal) (m)

Basin	District	Long Term Water Level trend (Decadal) (m)	Rise/fall

Annexure-4.1.9 G Data Adequacy/Constraints

Basin	District	Total Existing Number of Piezometers	No. of Piezometers under Telemetry system of Monitoring	Required Number of Piezometers	Number of additional Piezometers required

*(Note: Each Micro watershed/Basin at least have 3 piezometers one at recharge area, one at discharge area and in the intermediate zone of the basin)***Annexure – 4.1.9 H Ground Water Resources - 2013**

Basin/ District	Annual Replenishable Ground Water (MCM)	Natural discharge/base flows (MCM)	Net annual availability (MCM)	Existing draft for irrigation (MCM)	Existing draft for domestic and industrial use (MCM)	Total draft (MCM)	Stage of ground water development (%)	No of Over- exploited blocks

Annexure-4.1.9 I Ground Water Resources (Block/ Mandal wise)

Basin	Name of Block	Annual Replenishable Ground Water (MCM)	Natural discharge/ base flows (MCM)	Net annual GW availability	Existing Net GW draft for irrigation	Existing net GW draft for domestic and industrial use	Tota l draft	Stage of ground water development	Categorization of block (Over-exploited/ Critical/ Semi- critical/ Safe/ Saline)
i	ii	iii	iv	v	vi	vii	viii	ix	x

The column (iii) of Ann 4.1.9 I to be used for filling up A13 of Chapter 9

The column (iv) of Ann 4.1.9 I to be used for filling up row 2 of table B11 of Chapter 9

The column (v) of Ann 4.1.9 I to be used for filling up of row 4 of table B11 of Chapter 9

Annexure- 4.1.9 J: Stage of Ground water development over years

Basin	District	Stage of Ground Water development (%)					
		2003	2005	2009	2011	2013	2015

Annexure-4.1.9 K Sector wise high and low development/consumption of ground water

Basin/ District	Heavy ground water consumption Sector	Low ground water consumption Sector	Increase or decrease in consumption of ground water in heavy ground water consumption sector from the previous GW resources (2011/2013)

Annexure-4.1.9 L: Measures taken for arresting over exploitation of ground water

Basin/ District	Number of Over exploited mandals Notified for GW regulation	Total area under over exploitation of GW (Sq.kms)	Number of artificial recharge structures constructed in Over Exploited mandals	Volume harvested/ Recharged (MCM)	Area under drip and Sprinkler Irrigation in Over exploited Block/ Mandal Ha	Percentage/ Volume of water saved from the drip /sprinkler irrigation	Area under Participatory ground water management Ha

Ground Water Quality:

Annexure-4.1.9 M: Average/Range of Basic Constituents in the Ground water

Basin	District	<i>pH</i>	<i>EC</i>	<i>TH</i>	<i>Ca</i>	<i>Na</i>	<i>K</i>	<i>Mg</i>	<i>HCO₃</i>	<i>Cl</i>	<i>SO₄</i>	<i>NO₃</i>	<i>F</i>

Annexure-4.1.9 N: Parameters analyzed (Heavy Metals) (mg/l)

Basin	District	Ni	Zn	Mn	Cu	Co	Cd	Pb	Fe	Cr	As(arsenic)

Annexure-4.1.9 O: Areas of high Arsenic

Basin	District	Mandal	No. of Villages affected	Total area contaminated by arsenic

(Include a map showing area and villages affected by high concentration of Arsenic)

Annexure-4.1.9 P: Areas of high fluoride

Basin	District	Mandal	No. of Villages affected	Total area contaminated by fluoride

(Include a map showing area and villages affected by high concentration of fluoride)

Annexure-4.1.9 Q: Areas of high Nitrate

Basin	District	Mandal	No. of Villages affected	Total area contaminated by Nitrate

(Include a map showing area and villages affected by high concentration of Nitrate)

Annexure-4.1.9 R: Alternate sources of supply areas affected by ground water quality

Basin	District	Mandal	No. of Villages covered under alternate sources of supply	Source of Supply	Quantum of Supply MCM

Annexure-4.1.9 S Data on Rain Water Harvesting/Artificial Recharge structures

District/ Basin	No. of Check dams constructed	Volume of water Harvested (MCM)	Volume of Ground Water Recharged (MCM)	No. of Percolation Tanks Constructed	Volume of water Harvested (MCM)	Volume of Ground Water Recharged (MCM)	No. of farm ponds constructed	Volume of Water Harvested (MCM)

Others	Volume of Water Harvested (MCM)	Volume of Ground Water Recharged (MCM)	No. of Piezometer constructed to assess the impact	If constructed, GW Level (m bgl)		Fluctuation (m)	Rise/fall in water level (m)
				Pre Monsoon	Post monsoon		

Annexure 4.1.9 T: Impact assessment of Rain water harvesting/Artificial recharge structures

Basin	District	Annual Quantum of ground water Recharge due to ARS (m ³ /day)	Rise in GW water level (m)	% improvement in the Stage of ground water development	Additional area irrigated with recharge water (ha)

Annexure-4.1.9 U: Artificial Recharge Structure and its impact assessment (ARS)-Urban

Municipality	No. of Govt. establishment having Roof top rain water harvesting structures	Quantum of ground water recharged (MCM)

Annexure-4.1.9 V: Detailed Information on Existing Minor Irrigation Tanks and its impact

District/Basin	Total Number of Minor Irrigation Tanks	Total area irrigated under MI Tanks (Ha)	Total No. of Tanks De-silted	Volume of de-silting (MCM)	Volume of Water harvested due to de silting	Expected GW Recharge due to de-silting (MCM)	Expected increased irrigated area due to de-silting (ha)

Annexure -4.1.9 W (i) Data on Minor Irrigation Tanks

Basin	District	Total Number of tanks	Catchment area (Sq kms)	Tank Spread Area (Sq kms)	Storage (m ³ /day) MCM	Registered Ayacut (Ha)

Ground Water Resources Informatics**Annexure-4.1.9 X (i) Surface Water Informatics**

District/ Basin	Name of the Reservoir/	Reservoir Type	Full Reservoir Level (m)	Storage @FRL (MCM)	Dead Storage level (m)	Dead Storage Capacity (MCM)	Present Reservoir Level (m)	Present Reservoir Storage Capacity (MCM)

Annexure-4.1.9 X (ii) No. of Monitoring Stations installed with AWLR/Telemetry

No. of Ground Water Monitoring Stations	No. of Stations having Automatic water level recorders (AWLR)	Agency/ Department	Number of stations under telemetry of Monitoring	Agency/ Department

Annexure – 4.1.9 X (iii): Annual existing ground water demand and supply for Irrigation (MCM)

Basin	District	Demand for Irrigated Crops			Supply for Irrigated crops			TOTAL
		1. Water Intensive Crops	2. Less Water Intensive Crops	3. Horticulture Crops	1. Water Intensive Crops	2. Less Water Intensive Crops	3. Horticulture Crops	

Note: Ground Water Draft for irrigation can be calculated either from the number of ground water abstraction structures and corresponding draft or crop water requirements of each crop and extension/area of crop. (GEC Methodology)

Annexure – 4.1.9 X (iv): Annual existing ground water demand and supply for Drinking (MCM) -Urban

Basin	District	Demand			Supply			TOTAL
		City A	City B	Towns	City A	City B	Towns	

Note: Ground Water Draft can be calculated either from the number of ground water abstraction structures and corresponding draft or Per capita consumption/per capita allocation

Annexure – 4.1.9 X (v): Annual existing ground water demand and supply for Drinking (MCM)-Rural

Basin	District A	Demand		Supply			TOTAL
		District B	Towns	District A	District B	Towns	

Annexure-4.1.9 X (vi): No. of Ground water abstraction structures geo tagged in irrigation sector

Basin	District	No. of bore wells (irrigation)	No. of bore wells geo tagged	Existing actual drafts from the bore wells geo tagged

[Include a Map showing locations of Ground water abstraction structures (for irrigation) geo-tagged]

Annexure-4.1.9 X (vii): No. of Artificial Recharge structures

District/ Basin	Number of artificial Recharge structures	Number of artificial recharge structures geo tagged

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(Include a Map showing locations of Artificial Recharge structures geo tagged)

Annexure-4.1.9 X (viii): No. of Minor irrigation tanks geo tagged

District/ Basin	Number of Minor Irrigation Tanks	Number Minor Irrigation Tanks geo tagged

(Include a Map showing locations of Minor Irrigation Tanks geo tagged)

Ground water Irrigation

Annexure-4.1.9 X (ix): Area and type of crops under Ground water Irrigation

District/Basin	Area under Command Irrigation (ha)	Types of Crops (Water intensive/Less Water Intensive) or both*	Area under Non Command/GW Irrigation (ha)	Types of Crops (Water intensive/Less Water Intensive) or both*

**Mention only whether Water Intensive crop/less water Intensive crop. No details of crop types required*

Annexure-4.1.9 X (x): Areas under Micro Irrigation

District/Basin	Area under Non Command/GW Irrigation (ha)	Types of Crops (Water intensive/Less Water Intensive) or both*	Area covered with drip and Sprinklers (ha)	Percentage of GW Saved

**Mention only whether Water Intensive crop/less water Intensive crop. No details of crop types required*

Annexure-4.1.9 X (xi): Waste water-Urban

Municipality/ Basin	Quantum of Water supply to the Municipality (MLD)/Day	Source of Supply and quantum (MLD/Day)	Waste Water generated (MLD/DAY)	Quantum of Waste Water Treated (MLD/Day)

Annexure 4.1.9 X (xii): Capacity Building

Basin	District/Basin	No. of NGOs working in water/ground water sector trained last five years	No. of water User associations trained last five years	No. of Minor irrigation tanks being managed by WUA trained last five years