

4.1.4 River Basins

1.0 SUBJECT MATTER: River Water Resources: Trend, Mapping and Seasonality

River Basins/ Sub-Basins and Watersheds : River Network (Text and GIS based Map/Data with Datum, Projection & Coordinate system, Spatial Resolution, Shape Files etc.)

The main river in the basin/sub-basin and its tributaries/ sub-tributaries of different stream orders may be described here along with the length of the river network, catchment area up to the outlet/ confluence within the State Boundary & average slope of the basin/sub basin as well as the rivers. All these figures/data has to be extracted from GIS based Mapping (Digital Elevation Modeling/ Digital Surface Modeling/ Digital Terrain Modeling) along with the plan-form of the rivers, its meandering, confluences, origin, river islands etc. As per Survey of India regulations Digital Elevation Modeling/ Digital Surface Modeling/ Digital Terrain Modeling may not be permitted to prepare and publish for the International Border areas and notified restricted areas like North Eastern States. In such cases, the land slope and terrain definitions may be derived from the available analogue maps in such difficult areas. (Table. 1)

The main task is to delineate all the basins/ sub basins within the State Boundary and mark all the districts superimposed on the basins /sub basins. All the relevant geo-spatial information is to be analyzed in this spatial domain of a basin /sub basin within the State. This is the first and foremost task, one time exercise for all upcoming Water Years.

Table 1: (Area in lakh hectares/ Slope in %)

Basin/ Sub-basin	Name of River and its Stream Order	Tributaries & Sub Tributaries	Stream Order	Length of Channel Network	Catchment Area and its average slope	Average Slope of Channels	Tidal Reach from the Outlet
Basin A/ Sub-basin	River 1 (Stream Order...)	Tributary 1					
		Sub-Tributary 1					
		Sub-Sub-Tributary 1					
Basin B/ Sub-basin	River 2 (Stream Order...)	Tributary 2					
		Tributary 1					
		Tributary 2					

Stream ordering etc. may have been already done for most of the river systems of the country by the scientific organizations like National Institute of Hydrology, India-WRIS Portal, etc. Therefore, it will be easy to collect the secondary data from such sources for most of the river systems.

- i. Characteristics of each river including catchment area. (Text)

A brief description of the river basin and its morphological characteristics may be elaborated here for understanding. Actual photographs of certain sample areas/spots in the basin/sub-basin may be annexed for having visual clarity/ visualization. The small hydrological units in the basin e.g. watersheds also need to be demarcated where suitable measures for soil and water conservation such as continuous contour trenches (CCT), staggered contour trenches (SCT), check dams (CD), percolation tanks (PT), etc., may be adopted as per ridge to valley approach. **All Basins up to Micro-Watershed level have been already delineated by Soil and Land Use Survey of India (SLUSI), working under Ministry of Agriculture & Farmers Welfare, GOI. A Watershed Atlas has been prepared by them. So, it may be easy to collect all information from SLUSI.**

- ii. Land Use/ Cover (Sub catchment wise) (Text and GIS based Map)

The land use/cover plays a vital role in the response of a basin/ sub-basin to any rainfall event. Also, the rate of soil loss and amount of sediment generated from a catchment depends on this factor. The percentile coverage of various land use units like agriculture or cropped land, urban/built-up land, waste land and land cover units like forest, shrubs, fallow, desert, rocky terrain, water bodies, etc., within the Basin/ Sub basin affects the various hydrological processes like interception, infiltration, evapo-transpiration, runoff, etc., and considered as important physiographic data which determines water availability apart from topography (slope, elevation) and soil characteristics, depth and antecedent moisture condition. (Table. 2)

Table 2: (Area in lakh hectares)

Basin/ Sub-basin and its Area	Barren Rocky Area	Forests, Plantations	Cropped land	Grass Grazing	Mining	Inland Wetland	Fallow	Rural Areas	Urban Areas	Water Bodies	Desert/ Sandy Areas

iii. Hydrological Data Observation Network (Text and GIS based Map/Data)

The position of all the Hydrological Observation Stations and/or Flood Forecasting Sites in the River Network of each Basin/ Sub-basin and the type of measurement (Gauge, Discharge, Sediment, Quality) also need to be highlighted. The GIS Map should reflect the locations of all Data Observation Points in the Basin (Central/ State etc.) including reservoir inflow forecasting stations superimposed on the entire River Network/ System. Hydrological Data may also be obtained from CWC regarding the H.O. Sites of the Commission. (Table. 3)

Table 3:

Basin/ Sub-basin	Name of River and major tributaries	Total Length of River Network	Number of HO & FF Stations (State/ Central) in a Basin	Type of Measurement (G,D,S,Q)

The river cross sections with bed levels (pre-monsoon, post-monsoon), average bed slope, Highest Flood Level, Stage-Discharge Curve, average velocity at site, sediment/silt load observed, water quality parameters measured etc. available at all the various hydrological observation sites may be included as annexure (or in soft copy, excel sheet)

2.0 Availability & Utilizable Water

i. Basin wise Surface Water Availability within State Boundary: Table 4 given below:

Table 4: Annual Water Availability (BCM) for minimum 30 years (Frequency- Annual Volume in MCM)

Year	(Sub-basin-A, Area) say XYZ, 1590 Sq. Km	(Sub-basin-B, Area) say UVW, 1800 Sq. Km	(Sub-basin-C, Area) say ABC, 3500 Sq. Km	(Sub-basin....., Area) say STR, 2400 Sq. Km	(Sub-basin-N, Area) say QRT, 6400 Sq. Km	Total Basin Water Availability

The final table A1R as reflected in Chapter 9 has to be got filled up here only wherein the total annual runoff of each basin/ sub-basin will be known at the outlet/mouth of each such unit along the river channel which results due to precipitation (meteorological parameters) and its interaction with physiographic factors like LULC, Type of Soil, Pervious Area, Soil Depth and Antecedent Moisture Condition, Ground Water Table, etc. The annual discharge also includes glacial melts within the State Boundary, if any, and base flows generated round the hydrological year.

A1R. Runoff (including Glacial Melts within State Boundary) (in MCM)						REMARKS
Basin/Sub-basin (Area in Km ²)			Discharge (in MCM) in a Water Year at the Outlet			
Basin A/ Sub-basin						
Basin B/ Sub-basin						
Basin C/ Sub-basin						
TOTAL						

i. Water received from the rivers from upstream states: Table 6 given below

Table 6: Annual water received from upstream States (30 years): Unit MCM

Year	Sub-basin-A		Sub-basin-B		Sub-basin-C		Sub-basin.....		Sub-basin.....		Total
	Annual Volume	Upstream State	Annual Volume	Upstream State	Annual Volume	Upstream State	Annual Volume	Upstream State	Annual Volume	Upstream State	

Hydrological Observation Station on the river at the entry point of the State will be having this data; otherwise, upstream site discharge data may help in estimation of the inflow. New sites must be opened at such locations to measure the inflow discharge from upstream State/Country where HO Stations do not exist at present. It may happen that the inflow point is un-gauged i.e. measurement of flow is not done at present or not feasible and the contributing catchment of the flow lies outside the State. Under such circumstances the Rainfall-Runoff Hydrological modeling can be done to have a fair idea of total inflow within the State for any rainfall event. If there are sources of Glacier outside the State, then water available from melting of such glaciers will also be included as inflow. This will be equal to the Outflow of the Upstream State at that point.

A2. Inflow from upstream State/ Country along the River Course: (in MCM)		
Basin/Sub-basin	(Inflow in MCM)	REMARKS
Basin A/ Sub-basin		
Basin B/ Sub-basin		
Basin C/ Sub-basin		
TOTAL		

iii. Intra basin and Inter basin transfers: Table 7 as given below

Table 7: Intra basin and Inter basin transfers (Annual volumes in MCM) (30 years)

Year	Water Transfer (Inter or Intra basin Transfers considering State Boundary)								Total Import	Total Export	Net Import / Export
	Import / Export (Inter-State, Inter-Basin)	Basin/ Sub-basin	Import / Export (Inter-State, Intra-Basin)	Basin/ Sub-basin	Import / Export (Intra-State, Inter-Basin)	Basin/ Sub-basin	Import / Export (Intra-State, Intra-Basin)	Basin/ Sub-basin			

Table A11 will include the total quantity of water transferred through Canals etc. from water surplus Basin/Projects in other States round the Water Year. This water would also be entering through some basin/sub-basin within the State and need to be considered in that spatial unit accordingly. The intra-basin transfer is internal redistribution of water resources within the State and may also be brought out in the annexure. The State Boundary, Basin boundary and Transfer Links has to be looked into to ascertain whether its inter-basin/inter-state, intra-basin/inter-state, inter-basin/intra-state or intra-basin/ intra-state water transfer. The last two indicates redistribution of internal water resources only.

A11. Inter-basin transfers (IBT) from Projects in other States (Import): (MCM)		REMARKS
In Basin A/ Sub-basin		
In Basin B/ Sub-basin		
In Basin C/ Sub-basin		
TOTAL		

Table B9 indicates that portion of the Inter-Basin Transfer through Canals earmarked for the State through which it is passing. For example, a Trans-boundary canal may carry discharge for two or three recipient States and in such cases utilizable/utilized portion of water for a State is the portion earmarked for that State only.

B9. Utilization of Inter-basin Water transfers from Projects in other States (Import) (MCM) (From Table A11)		REMARKS
In Basin A/ Sub-basin		
In Basin B/ Sub-basin		
In Basin C/ Sub-basin		
TOTAL		

The volume of water exported to other States/Countries through the Inter-basin Transfer Link after catering to certain demands in the present State need to be tabulated here as Outflow.

D1. Inter-basin transfers to other States (Export) (MCM)		REMARKS
Project A in Basin A/ Sub-		
Project B in Basin B/ Sub-		
Project C in Basin C/ Sub-		
TOTAL		

iv. Environmental Flows: Table 8 and 9 given below

The estimation of spatio-temporal requirements of e-flows in the various stretches of river network has to be ascertained and compared with the natural flow/supply/releases in the streams. This exercise has to be carried out for each of the Sub-basins.

Table 8: *Environmental Flow: Demand and Supply (Annual volume in MCM) for reporting Year 20XX

Location 1		Location 2		Location 3		Location N		Basin Total	
Requirement	Releases	Requirement	Releases	Requirement	Releases	Requirement	Releases	Requirement	Releases

* If data for pre-monsoon, monsoon and post monsoon season is available the same may be provided

Table 9: Status of Environmental Flow estimation for the Reporting Year

S. No.	River Basin/ Sub-basin	Key Stretches/ Hotspots	Status of e-flow assessment				Timeline for e-flow integration with River Basin Plan	Key agencies involved
			e-flow recommendation		e-flow assessment yet to initiate	Capacity needed for e-flow studies		
			Wet season e-flows (MCM)	Dry season e-flows (MCM)				

v. Water Quality: Table 10 given below

Table 10: Water Quality status in the basin for the Reporting Year

S. No.	Basin / Sub-basin	Key locations	Water Quality Status	Key Issues					Plan for addressing pollution	Key agencies involved
				Domestic Sewage generated	Domestic Sewage treated/ reused	Industrial Effluents generated	Industrial Effluents treated/ reused	Number of major drains out falling into the river		

Water Quality is a very significant aspect of Water Resource. Within river basins or sub-basins, there may be a spatio-temporal variability in the water quality of various stretches of stream segments. The same may be mapped for various time periods within the year and comparison may be done among the various years to get an idea of the degradation/improvement in health of the river ecosystem particularly at hotspots or critical locations. Percentage reuse of sewage & effluent after treatment is a very good indicator of surface water quality.

vi. Water Yield: Detailed Hydrological Analysis of Sub basins/ Availability of Water in Sub basins (Text and Table 11.)

Table 11: Water Availability in the Sub-basins (Annual): in MCM

Name of Sub-basin	Runoff from rainfall / snowmelt within the Sub-basin	Inflow from upstream Countries/ States	Water mandatorily to be released for downstream States as per Agreements / Tribunal Award	Groundwater Availability in the Dynamic Zone	Water available through Desalination	Water Availability	Rate of sediment flow	Total Sediment flow per year	Catchment Area Treatment (CAT)	
									Area treated through Watershed development	Rate of sediment flow after CAT

- vii. The total discharge flowing out of the State Boundary through various basin/sub-basins need to be entered in Table D2. Of course if the total annual water flowing out from the System through the rivers is more than the desirable amount, then the additional volume of water can be treated as Utilizable Water for the State, which is now running down because of non-storage or non-utilization or interstate water sharing commitments with the downstream states, if any.

D2. Discharge flowing out to downstream States (MCM)			REMARKS
		Desirable*	
Basin A/ Sub-			
Basin B/ Sub-			
Basin C/ Sub-			
TOTAL			

* Desirable e-flow: There is no single 'best' EF methodology that can be universally applied under all circumstances. The e-flows estimates vary significantly from one method to other. The Building Block Method (BBM) is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition and is also recommended by the MoEF&CC.

Outflows greater than Desirable Quantity (e.g. considering Inter-State/International Water Sharing Tribunal Award/Treaty) can be considered Utilizable Water for the State under consideration if appropriately harnessed by useful interventions within the Basins.

3.0 Issues and Challenges (Text)

- i. Status of Aquatic Biodiversity in the State: Occurrence & Threats (Text and Table 12)

Table 12: Status of Aquatic Biodiversity: Occurrence and Threats

S. No.	River Basin/ Sub-Basin	Key Endemic & Threatened Species	Status (Rare, Endangered, Threatened)	Population and Distribution Range	Key threats to species and their habitats ¹ in respective Distribution Ranges	Plans for mitigating threats in specific Distribution Range	Key Agency involved

Note: *Endemic species are those that are exclusive to a particular distribution range or are native to a region (country/state/landscape). Threatened species are those whose population is on a declining trend and have been accorded legal protection under the IW (P) Act, 1972.*

- ii. Flood Management (Table 13), Urban Flooding.

Table 13: Flood Management in the Basin/ Sub-basin

S. No.	River Basin/Sub-Basin	Type of Floods (GLOFs, cloud burst; rainfall, drainage congestion, dam break)	Vulnerable districts with flood prone area	Total number of vulnerable villages	Population impact on an annual basis	Status of Flood early warning systems	Flood mitigation strategies (Past, present and future)			
							Structural	Capital investments; Annual O&M	Non structural	Capital investments; Annual O&M

- iii. Water Quality Degradation
- iv. Drought Management
- v. Catchment Area Treatment (CAT) through Watershed Development

4.0 River basin Problem Tree/ Root Cause Analysis: Cause, Effect & Interventions (Text)

5.0 Governance / Management

- a. Statute / Law / Policy/ Regulations if any:
 - i. Constitutional Provisions, Water related Acts & Laws (Text)
 - ii. State Water Policy and other policy related to water etc. (Text)
 - iii. Water Regulation & Inter-State Water Sharing Agreements, Tribunal Awards, if any (Text)
 - iv. Water Tariff structures/ Water Pricing in domestic, industrial and irrigation sector (Table 14.)

Table 14: Water Tariff Structure

S. No.	Name of Basin/ District	Domestic Sector		Industrial Sector		Irrigation Sector	
		Rate Rs/1000 litres	Agency to collect charges	Rate Rs /1000 litres	Agency to collect charges	Rate Rs / 1000 m ³	Agency to collect charges

- b. Institutions governing the resources and structure
 - i. Institutions on Water Governance: Authority, Departments, HODs, Boards etc (Text)
 - ii. Existing Institutional/ Manpower Structure of various Departments related to Water (Text)
 - iii. Role & Responsibilities of various Government Departments responsible for the development of water resources, allocation of water among various sectors and efficient utilization of water in different sectors (Text)
 - iv. Status about the follow-up and implementation of National Water Policy and other surface water management guidelines: (Text)
 - v. Status of Water Use Efficiency targets that were set by NCIWRDP in 1998-1999 and constraints in achieving them (Text)
- c. Areas of Peoples/Private Participation if any: Partnership with stakeholders- Watershed Committees, WUA, and Public-Private Partnership (PPP) (Text)
- d. Schemes & Financing (Text): [Also, relevant tables on Water Financing and Economics may be looked into Chapter 7 and filled up with appropriate data/information]

6.0 Measurement, Monitoring and Data Constraints / Management

- a) Hydrological Observation network (Text and GIS based Map)
- b) Other Network (Text and GIS based Map)
- c) Database Management System details (Text)
- d) Data Constraints (Text)
- e) Sediment monitoring and management: Reservoir sediment monitoring and management, river morphological changes may also be included. This should cover the issue of sand mining as well (Text)
- f) State-level data dissemination protocol (for sharing the data from State-owned observation stations) based on Hydro-Meteorology Data Dissemination Policy 2013 (Text)

7.0 Performance Indicators: For Comparison across Basins/Sub-Basins: Table A

Table A: Key Performance Indicators for River Basins/Sub-basins (every water year)

Performance Indicator	Norm / Benchmark , if any	Basin A/ Sub-basin	Basin B/ Sub-basin
Measurement/ Water Quantity				
Number of H.O. Sites per unit catchment area (nos. / Sq. km.)				
Number of H.O. Sites per unit length of river network (nos. / km)				
Unutilized surface water flowing out of basin as % of total water availability at outlet (%)				
Unutilized surface water flowing out of basin as % of total utilizable water at outlet (%)				
Ground Water				
Average depth of Ground Water Table in the basin/ sub-basin (in M) Pre Monsoon (as per land use)				
Average depth of Ground Water Table in the basin/ sub-basin (in M) Post Monsoon (as per land use)				
Groundwater withdrawal as a percentage of groundwater recharge (%)	< 100%			
Problems and Issues				
Percentage of basin area as flood prone (%)				
Percentage of basin area as drought prone (%)				
% of over-exploited and critical blocks to total blocks (%)	0%			
Land Use - Land Cover				
Rain-fed cropped area as a percentage of basin area (%)				
Irrigated agriculture area as percentage of basin area (%)				
Area cultivated by standard cropping as per agro-climatic zoning to the total area under cultivation (%)	100%			
Agricultural Area as percentage of basin area (%)				
Urbanized area as percentage of basin area (%)				
Forest Area as percentage of basin area (%)				
Surface water irrigated area as a percentage of basin area (%)				
Ground water irrigated area as a percentage of basin area (%)				
Water Quality				
Average Water Quality Index considering relevant WQ Parameters				
Whether regular monitoring of silt load done in rivers (Y/N)	Y			
Rate of soil loss in the basin/sub-basin (T/Ha/year)				
Waste Water				
Percentage of domestic waste water treated (%)	100%			
Percentage of domestic treated water reused/recycled (%)	100%			
Percentage of Industrial effluent treated (%)	100%			
Percentage of treated Industrial effluent reused/recycled (%)	100%			

Percentage of untreated wastewater flowing into the river (%)	0 %			
Water Productivity				
Total live storage created so far, as % of water availability (%)				
Per capita live storage created (cum. /person)				
Per capita water availability (m ³ /person/year)	>1700 m ³ /person/year			
Water Management Plans				
Percentage of river basin brought under IWRM (%)	100%			
Percentage of river basin brought under Catchment Area Treatment Plan (%)	100%			
Water Conservation				
No. of water bodies restored as % of total no. of water bodies identified for restoration (%)	100%			
Economic Indicators				
Investment per Hectare in River Basin/Sub-basin for Soil and Water Conservation in the previous year				
Policy				
Whether National Water Policy is being implemented?				
Is the State having its own State Water Policy?				

8.0 Reforms undertaken/being undertaken/Proposed, if any (Tex): For e.g. HP-I, HP-II, NHP etc.

9.0 Road Map of activities / tasks proposed for better governance with timelines and agencies responsible for each task/activity, if any (Text)

- a. Better Governance
- b. Better Source/ Supply Management
- c. Better Demand Management
- d. Water Quality & Sediment Flow Management
- e. Water Economics & Financing
- f. Sustainable Water Budgeting