Confederation of Indian Industry

Business and Beyond

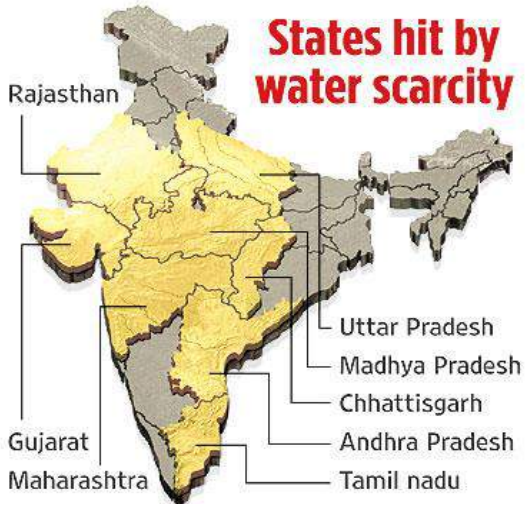
125 Years: 1895-2020

Water Optimization & Wastewater Usage in Thermal Power Plants

4 March 2021

Water Scenario-India

Would the next world war would be over water ?



Surface Water - Polluted
Ground Water - Depleted
Rainfall - Wasted

Industry - Growing
Water Reqd - Increasing
Water Recycle- ? ? ?

Population – Increasing
Demand – Increasing
Consumption-Increasing

Quality of water- Poor
Health Issue- Increasing
India's water future- ???

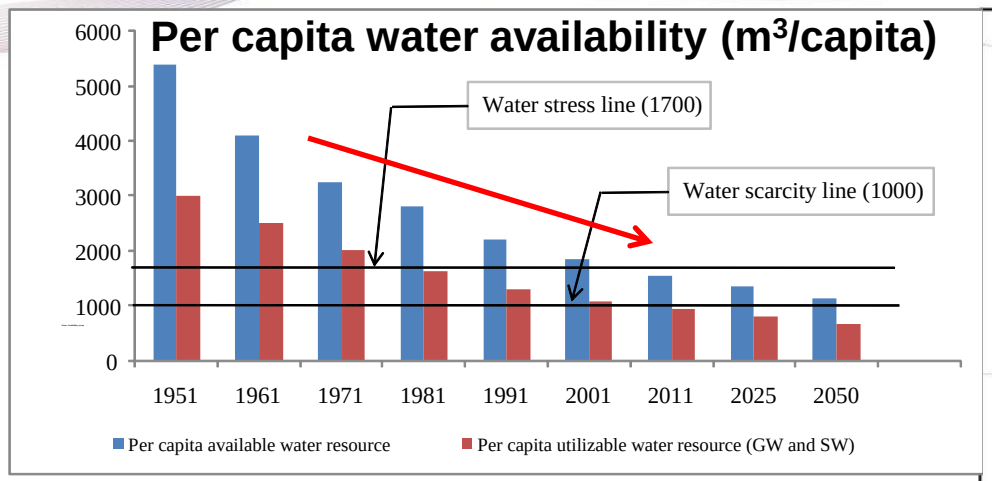
- Establishment of UMPPs will further strain the thin water resources
- Indian industries consumed about 50 billion cubic meters of water
- Large population of people lack access to safe water
- Fresh water available per capita per annum in India has dropped from 5,200 m^3 to 1,816 m^3 in 01 to 1544 m^3 in 2011.According to WHO, mortality is high due to water borne diseases

Water Scarcity- Is a Crisis looming ahead?

India is water stressed measured both in terms of quantity and quality

- Most of the country receives nearly all its rainfall in less than about 1% of the time of an entire year.
- More than 80 percent of river basins are facing stress and scarcity
- Groundwater depletion and deterioration; depleting at a rate far greater than what natural cycles can replenish (even > 1 m/ year)
- Less than 1/3rd of our total sewage gets treated
- About 50% of riverine length shows high pollution measured in terms of BOD alone
- Over 20% of transmissible diseases in India are related to unsafe water

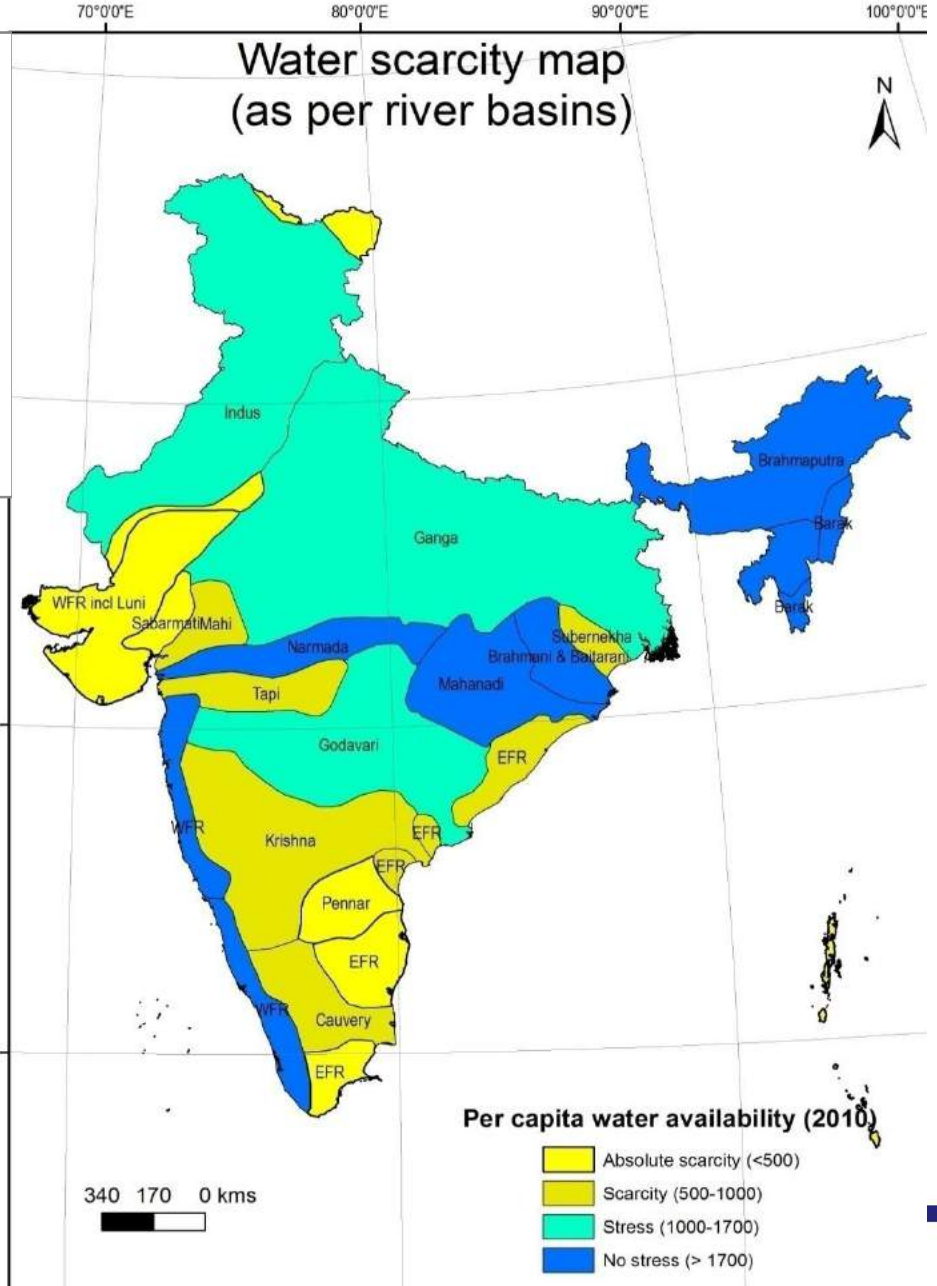
As a result !



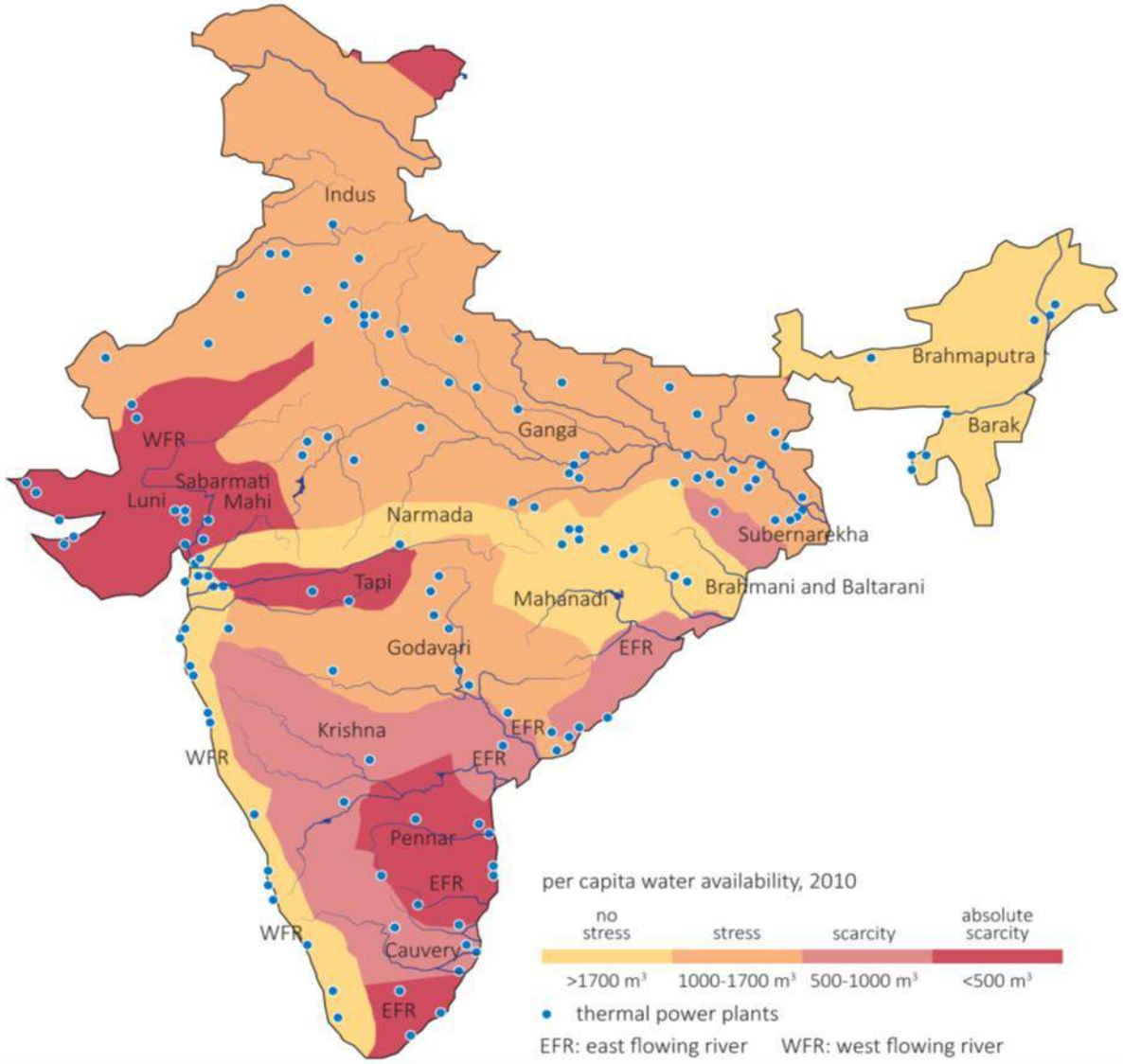
Regions face growing demand-supply gaps.

Climatic variability is an add-on stressor.

Conflicting demands over a shrinking resource



Water stress level of major water basins and the distribution of thermal power plants



Fact File

- Water plays a crucial role in ensuring smooth operations of a thermal power plant (TPP), water typically used for
  - cooling tower make-up, ash disposal, demineralizing (DM) water make-up, etc.

- India is world's 6th largest energy consumer, accounting for 3.4% of global energy consumption

- Around 21 thermal power units have had to shut down during 2016-17 as against 15 in 2015-16

MOEFCC Notification on Thermal Power Plants

- All plants with Once Through Cooling (OTC) shall install Cooling Tower (CT) and achieve specific water consumption upto maximum of 3.5 m^3/MWh within a period of two from the date of publication of this notification

- All existing CT based plants reduce specific water consumption upto maximum of 3.5 m^3/MWh within a period of two from the date of publication of this notification

- New Plants to be installed after 1st January, 2017 shall have to meet specific water consumption upto maximum of 3.0 m^3/MWh and achieve zero waste water discharged. (draft 16 October 2017)

Source: MOEFCC Notification dated 7 December 2016

NEED TO MANAGE WATER RISKS

DECIDE APPROPRIATE STRATEGIES / SOLUTIONS AT A MEANINGFUL SCALE

Water Neutral and Water Positive status

Water & wastewater management(Reduce Reuse, Recycle)/ harvesting/ recharge at plant

\+

Promoting water conservation/ water use efficiency at watershed

≥ Water used by the plant

Water positive, neutral or negative implies giving back to the ecosystem & community **MORE**, SAME or **LESS** water than what extracted & consumed in the first place

CII-Triveni Water Institute

Vision: Enable India make substantial progress towards achieving water security by 2022

Core Purpose: To transform water conservation and management in India by changing the mind-set and behavior of stakeholders resulting in more effective and sustainable water management practices at the grassroots level.

Advisory Services

- Water Audit
- Water Pinch
- Feasibility Studies
- Wastewater management
- ZLD

Projects and Policy

- Hydrological evaluation
- Watershed evaluation
- Rainwater harvesting
- Water use efficiency
- Wastewater mgmt

Training, Education & capacity building

- Wastewater operators training
- Water resources evaluation using Decision-Support-Systems for planners

Events & Conferences

- National Awards for Excellence in Water Mgmt
- International Conference on Improving Water Use Efficiency

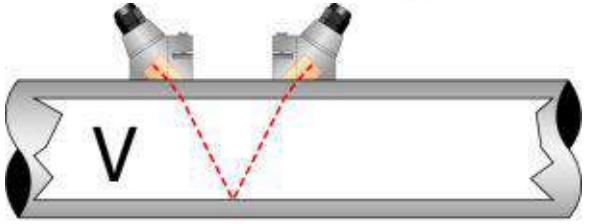
Advisory Services

CII undertakes following services

- Water AUDITS – Industry, Building, Irrigation
- Roadmap Towards Zero Liquid Discharge (ZLD)
- Water PINCH Analysis
- Water Security Frameworks and RATINGS

Advisory Services

- Last mile discipline approach
- Use of **state-of-the-art tools** and techniques –
- Modern technologies for monitoring -ultrasonic flow meters, current meters, portable water quality kits
- Monitoring of the projects on case to case basis



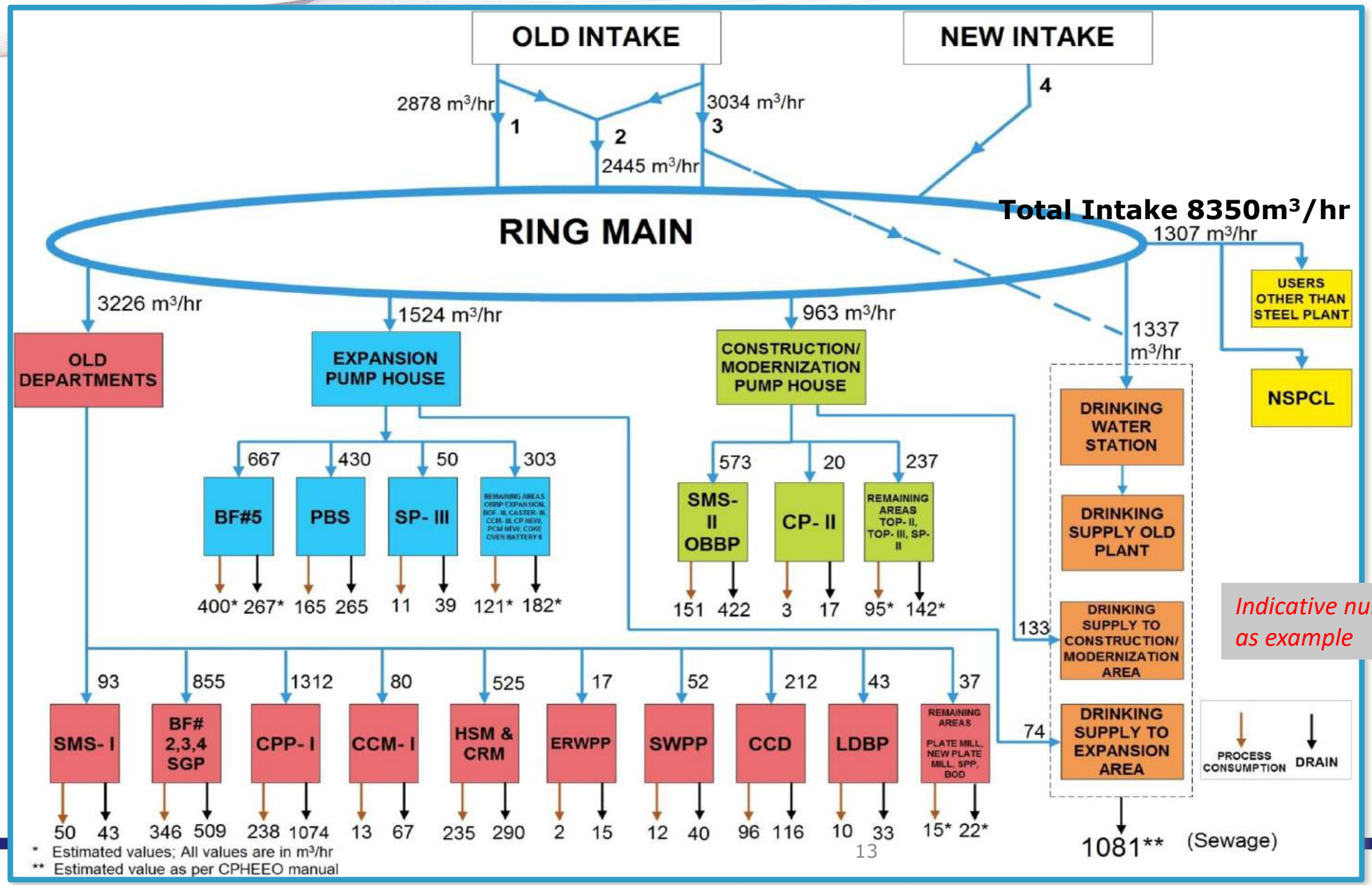
Water Mapping

Measurements to Establish Water Balance

- Depends on type of source.....(Open channel, Closed conduit)
  - Flow meters (Ultrasonic)
  - Measurement in open channels (Current meter)
  - Velocity area methods
  - Special methods for flow measurement
    - Bucket and Stopwatch estimation
    - Volume/Frequency estimation

“What gets measured gets managed”

Comprehensive Water Balance



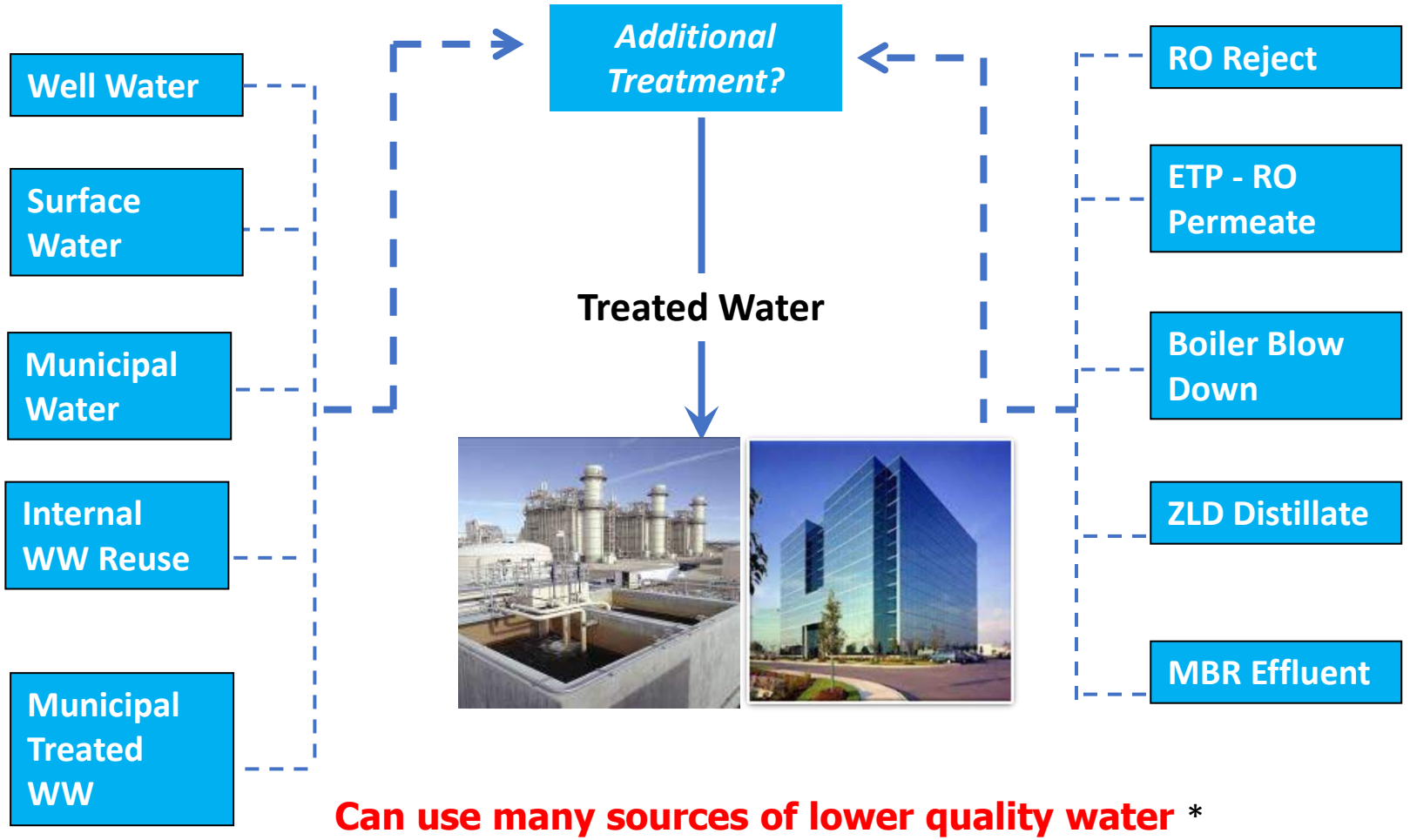
Indicative numbers as example

Water Quality Sampling and Testing

- Grab/composite Sampling and monitoring
- Testing (relevant parameters of water, Wastewater discharge etc.)
- Compliance & regulation (BIS 10500; CPCB/SPCB etc.)
- Opportunities for reuse/recycle

Standard Methods :APHA; BIS

Looking for alternative sources



Can use many sources of lower quality water *

*** With proper system design and treatment**

Zero Liquid Discharge Approach

Zero Liquid Discharge

- ZLD plant operates without discharge of any wastewater.
- For old coal-based plants, the prerequisites include:
  - Separation of process drains from storm water drains
  - Complete ash water recirculation system (AWRS) including toe drain water.
  - System augmentation with AWRS, Effluent Treatment Plant, Sewage TP and RO system wherever required.

Effluent Generated & Re-Use Philosophy

- Cooling Water Blowdown :
  - Ash Handling
  - Service Water
  - Coal Dust Suppression
  - Fire Water System
- DM Plant & CPU Regeneration Waste
  - Can be used for Ash Sluicing.
- Back Wash Waste from Filters
  - Recirculated to the inlet of Clarifier and Water recovered
- Sludge from PT Plant & Service Water Treatment
  - Sludge disposed to the Ash Slurry Sump and decanted water recovered from Ash Pond
- Sewerage
  - Used for Horticulture after Treatment

Key Benefits of Water Audit

Key Benefits

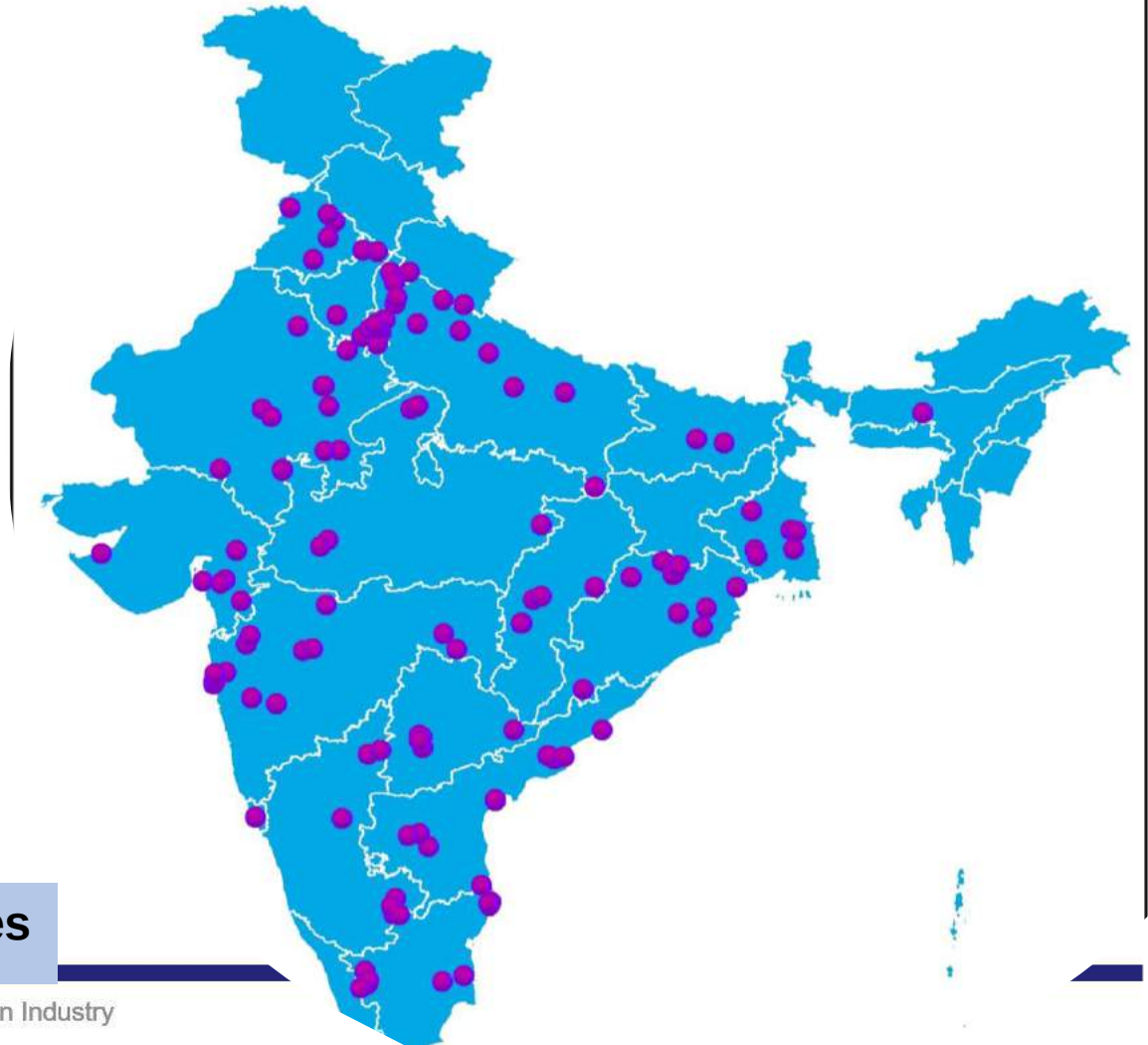
- Water Adequacy
- Reduction in fresh water use
- Reduction in pollution loads
- Wastewater reuse and recycling opportunities
- Regulatory compliance
- Moving towards beyond compliance to achieve world class status

Water Audits Spread

CII-TRIVENI WATER INSTITUTE

CII

250+ Water Audits



Potential annual water savings estimated as **200 billion litres**

Project Completed Under EEC

SURVEY & STUDY FOR DEVELOPMENT OF GUIDELINES FOR BEST PRACTICES IN WATER & WASTEWATER USAGE IN COAL BASED THERMAL POWER PLANTS

at

KTPS (195 MW), Rajasthan,

STPS (250 MW), Gujarat,

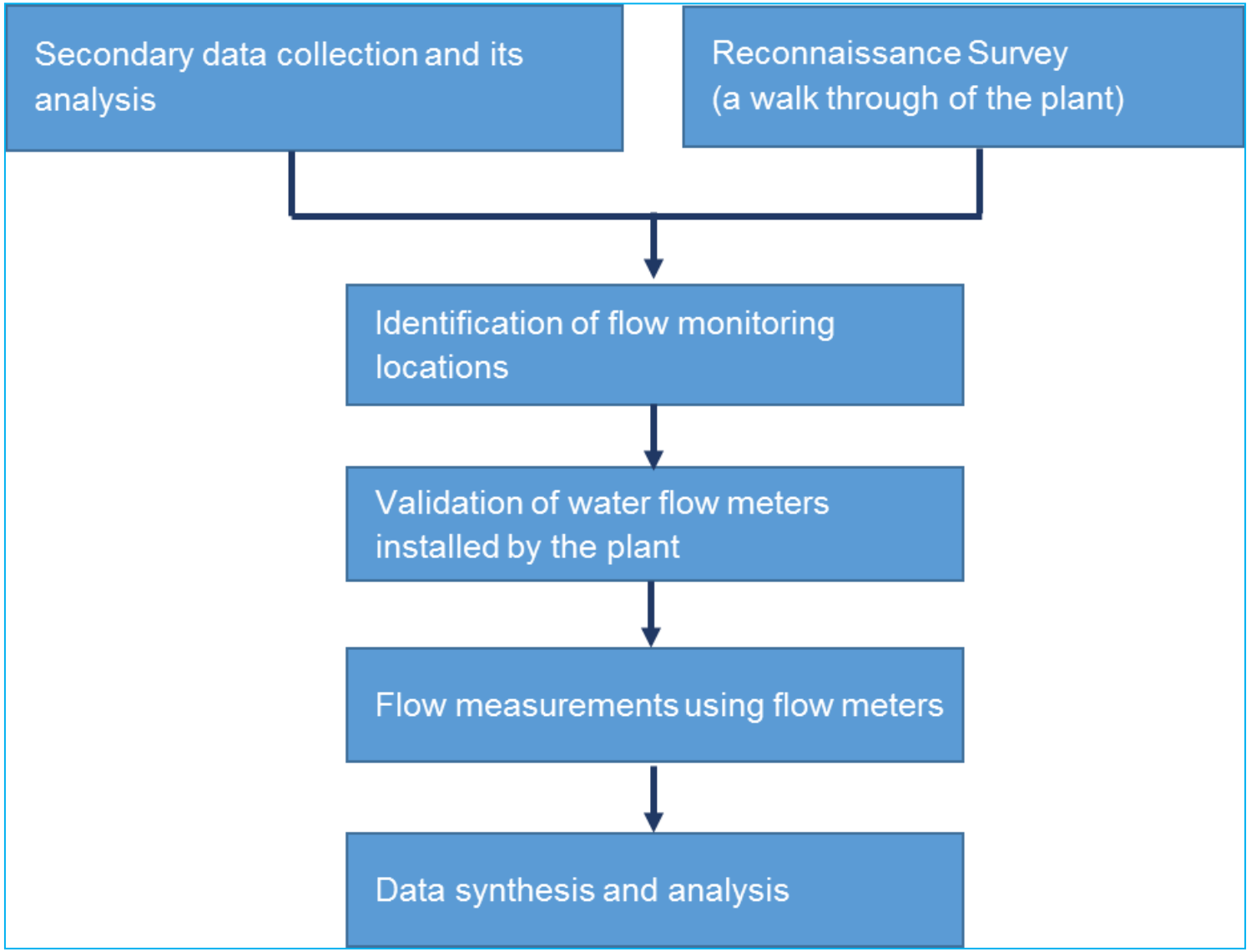
BTPS (500 MW), Maharashtra &

Barh STPS (660MW), Bihar

Methodology

- Understanding overall water distribution
- Data collection
- Flow Measurements
- Raw water & waste stream analysis
- Understanding of critical control parameters and water quality requirements at users end
- Identification of specific water saving projects
- Discussions with plant team

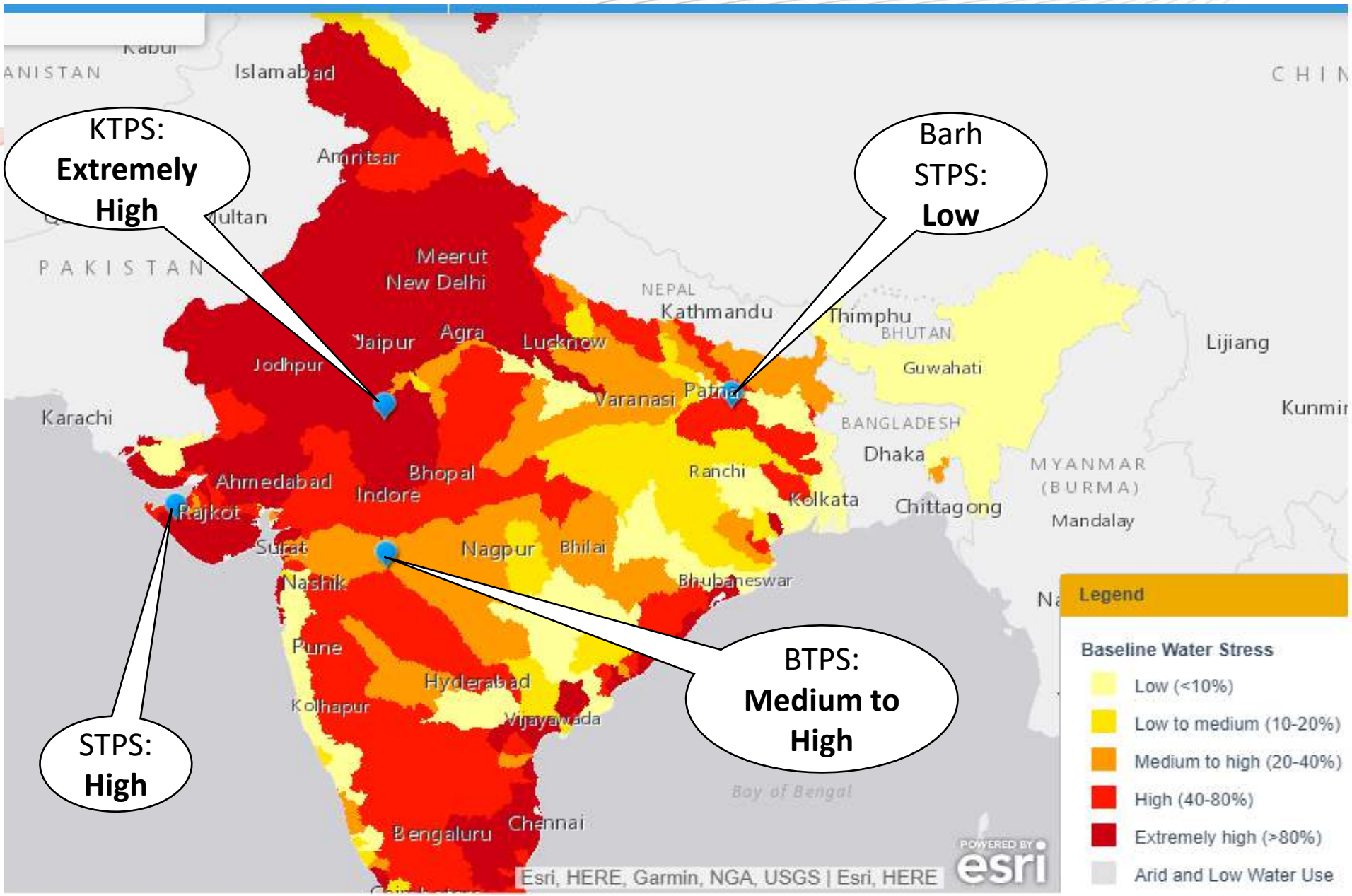
Steps followed during the study



Capacity & Water Supply source

Name	State	Unit	Capacity (MW)	Water Source	Remarks
Kota Thermal Power Station	Rajasthan	VII	195	SW	River Water (Chambal)
Sikka Thermal Power Station	Gujarat	III	250	SW & Sea Water	Sea Water for condenser cooling & GWIL supply (River Narmada) for other purposes
Bhusawal Thermal Power Station	Maharashtra	IV	500	SW	River Water (Tapi)
Barh Super Thermal Power Station	Bihar	V	660	SW	River Water (Ganga)

Baseline Water Stress



Overall performance & comparison chart - KTPS, STPS, BTPS & Barh STPS

Thermal Power Plants Performance Indicators	Basic Limiting Parameters	Kota Thermal Power Station, Kota Unit VII	Sikka Thermal Power Station, Sikka Unit III	Bhusawal Thermal Power Station, Bhusawal Unit IV	Barh STPS V Unit
Power Generation capacity	MW	**195**	**250**	**500**	**660**
Overall Water Stress Risk Class*	80-100% (Low)	45% High	65% (Medium)	70% (Medium)	80% (Low)
Plant Load Factor (PLF) %	100	**94.56**	**95.75**	**85.69**	**64.51**
Specific Water Consumption (m^3/MWh)	3.5	**3.63**	**0.16****	**3.07**	**2.85**
Condenser Cooling	Wet	Wet Cooling (IDCT)	Wet Cooling (IDCT)	Wet Cooling (NDCT)	Wet Cooling (IDCT)
Cooling Water	Soft Water	Clarified Water	Sea Water	Soft water	Clarified Water
Cycles of Concentration	5	**4.5**	**1.3**	**6**	**4.5**
Fly ash disposal system	Dry	Dry	Dry#	HCSD	Wet
Bottom ash disposal system	Dry	Wet	Paste	Wet	Wet
Ash Water Recirculation System (AWRS)	100%	Not Recycled	Not Recycled	Not Recycled	Recycled
FGD	Yes	NA	NA	NA	NA
Effluent Recycling (Including N-pit)	100%	Not Recycled	NC	Recycled	Recycled
Water Flow Measurements	100%	No meter	Flow metered installed in Narmada intake only	Flow meter installed almost all the major consumption areas	Flow meter installed in major consumption areas
ZLD	Yes	No	No	No	No
NC - Not commissioned; #currently it is dry fly ash disposal but provision is in place for wet disposal depending on the fly ash storage capacity in silos.					
NA - Not available; **Only fresh water considered in computing the specific water consumption					

Specific water consumption - KTPS, STPS, BTPS & Barh STPS

Breakup of Specific water consumption SWC (m^3/MWh)				
Description	**KTPS (195 MW) Unit VII**	**STPS (250 MW) Unit III**	**BTPS (500 MW) Unit IV**	**Barh STPS (660 MW) Unit V**
Cooling tower make up water	2.49	7.83#	1.85	2.36
Ash Handling plant	0.23	0.03	0.48	Ash Water Recirculation System (AWRS)
DM water	0.04	0.06	0.03	0.02
Coal Handling Plant	0.08	0.002	0.12	Recycled Water (RW)
Service water	0.37	0.02	0.001	0.001
Fire Water	0.35	0.02	0.05	Recycled Water (RW)
HVAC	0.001	0.001	0.001	0.009
Potable water	0.05	0.001	0.06	0.06
Others (backwash, regeneration, gardening etc.)	0.01	0.02	0.48	0.05
Return to river Ganga	NA	NA	NA	0.35
Overall SWC (m^3/MWh)	**3.63**	**7.99**	**3.07**	**2.85**

Sea water used as cooling medium with CoC 1.3

SWC after implementing schemes

Name of Power Station	Water Saving potential (m^3/annum)	Existing SWC (m^3/MWh)	SWC after implementation of water saving projects (m^3/MWh)
Kota Thermal Power Station, Unit VII, 195 MW	1325315	3.63	2.94
Sikka Thermal Power Station, Unit III, 250 MW	83415	0.16	0.11
Bhusawal Thermal Power Station, Unit IV, 500 MW	1839600	3.07	2.58
Barh Super Thermal Power Station, Unit V, 660 MW	429240	2.85	2.44

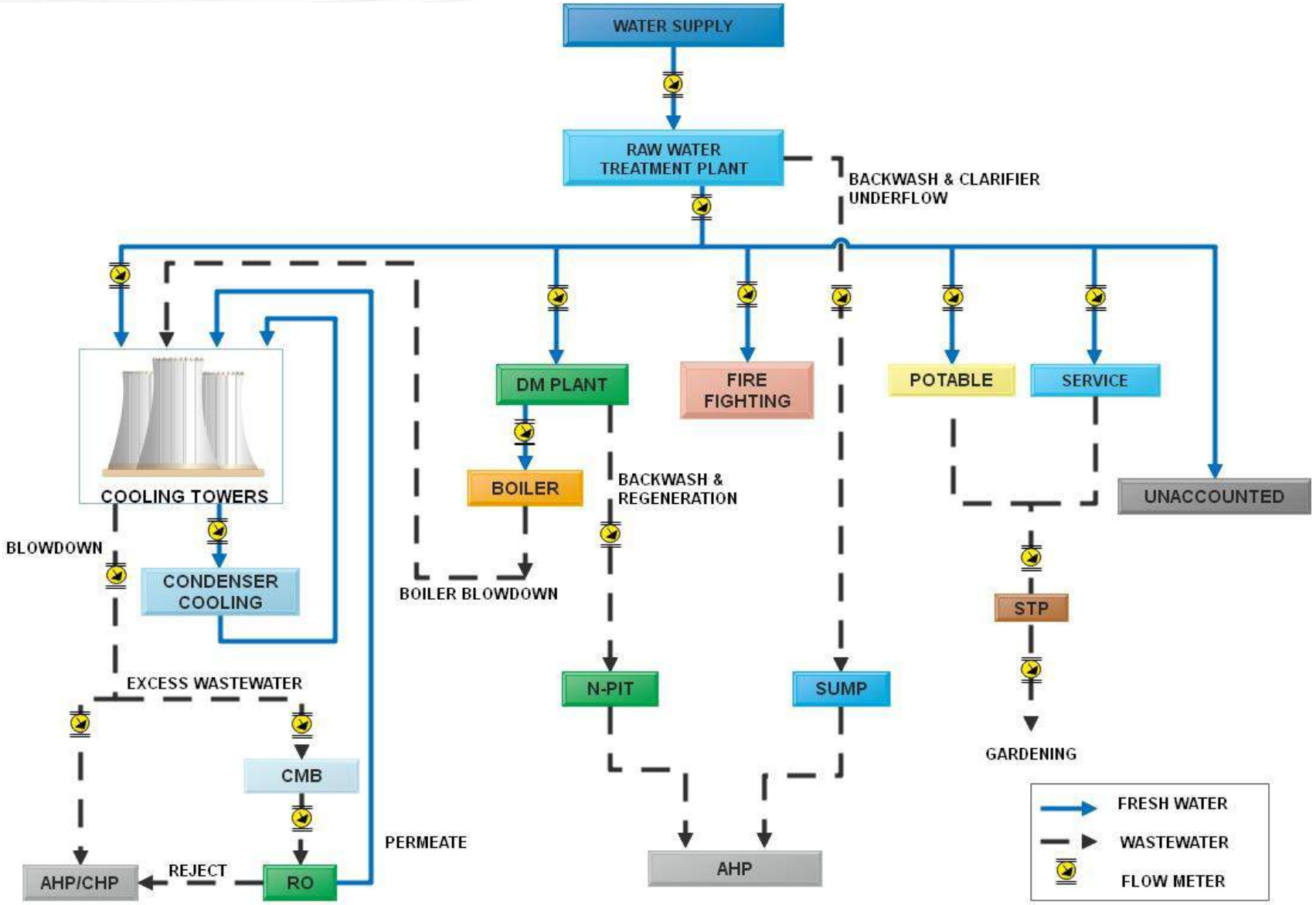
Water Management System in Thermal Power Plants

Major Water Consumption Areas in TPP

- Cooling water make-up
- Ash handling system make-up,
- Power cycle make-up,
- Coal handling plant (CHP),
- Potable water use,
- Landscaping water use and
- Service water use

Flow Meter Locations for TPP

- Raw water intake
- Raw water treatment plant
- RWTP backwash & clarifier underflow
- Cooling tower make up
- Ash Handling plant
- Coal handling plant
- DM plant
- Fire fighting
- Service water
- Potable water
- Cooling Tower blowdown
- DM backwash & regeneration
- RO Plant
- STP Inlet & Outlet
- CEMB inlet & Outlet



Standard Water Balance of 2X500 MW, 2X660 MW & 2X800 MW thermal Power station

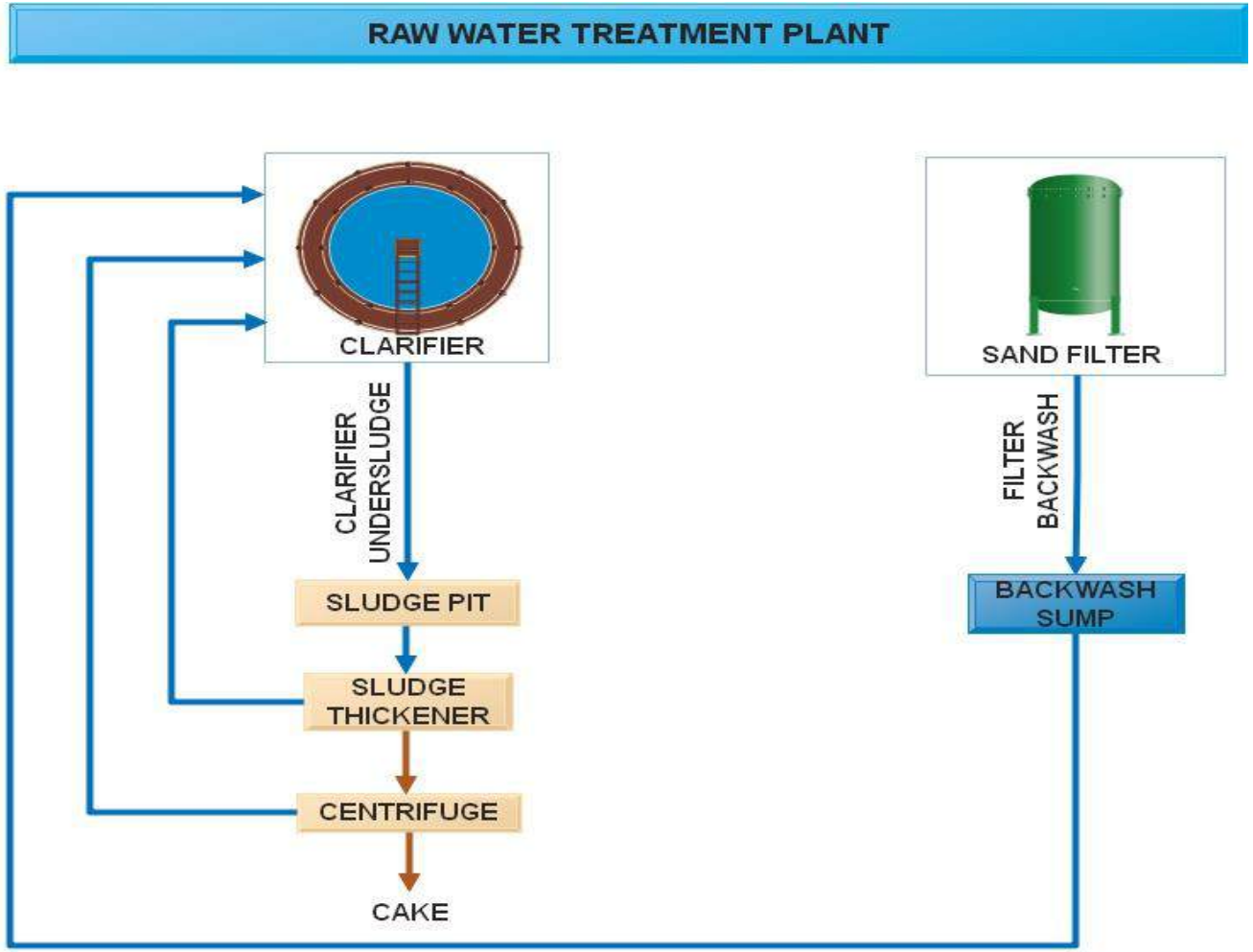
Description	2*500 MW coal based TPP		2*660 MW coal based TPP		2*800 MW coal based TPP	
	Water requirement (m^3/day)	SWC (m^3/MWh)	Water requirement (m^3/day)	SWC (m^3/MWh)	Water requirement (m^3/day)	SWC (m^3/MWh)
Plant Input Water	**72000**	**3.00**	**94800**	**2.99**	**115200**	**3.00**
Cooling tower make up	61200	2.55	73560	2.322	87840	2.288
Ash Handling Plant	1200 & Recycled Water	0.05 & Recycled water	4680 & Recycled Water	0.147 & Recycled Water	7320 & Recycled Water	0.190 & Recycled Water
Coal Handling Plant	1560	0.065	4320	0.136	5160	0.134
DM Plant	1560	0.065	1920	0.061	2400	0.063
Service Water	1560	0.065	4320	0.136	5160	0.134
Potable Water	960	0.04	1200	0.038	1440	0.038
Fire Fighting	Recycled Water	Recycled Water	Recycled Water	Recycled Water	Recycled Water	Recycled Water
Others (Clarifier sludge, HVAC Backwash & regeneration etc.)	3600	0.15	4320	0.136	5280	0.138
FGD	360 & Recycled Water	0.015 & Recycled water	480 & Recycled Water	0.015 & Recycled water	600 & Recycled Water	0.015 & Recycled water

Wastewater Management

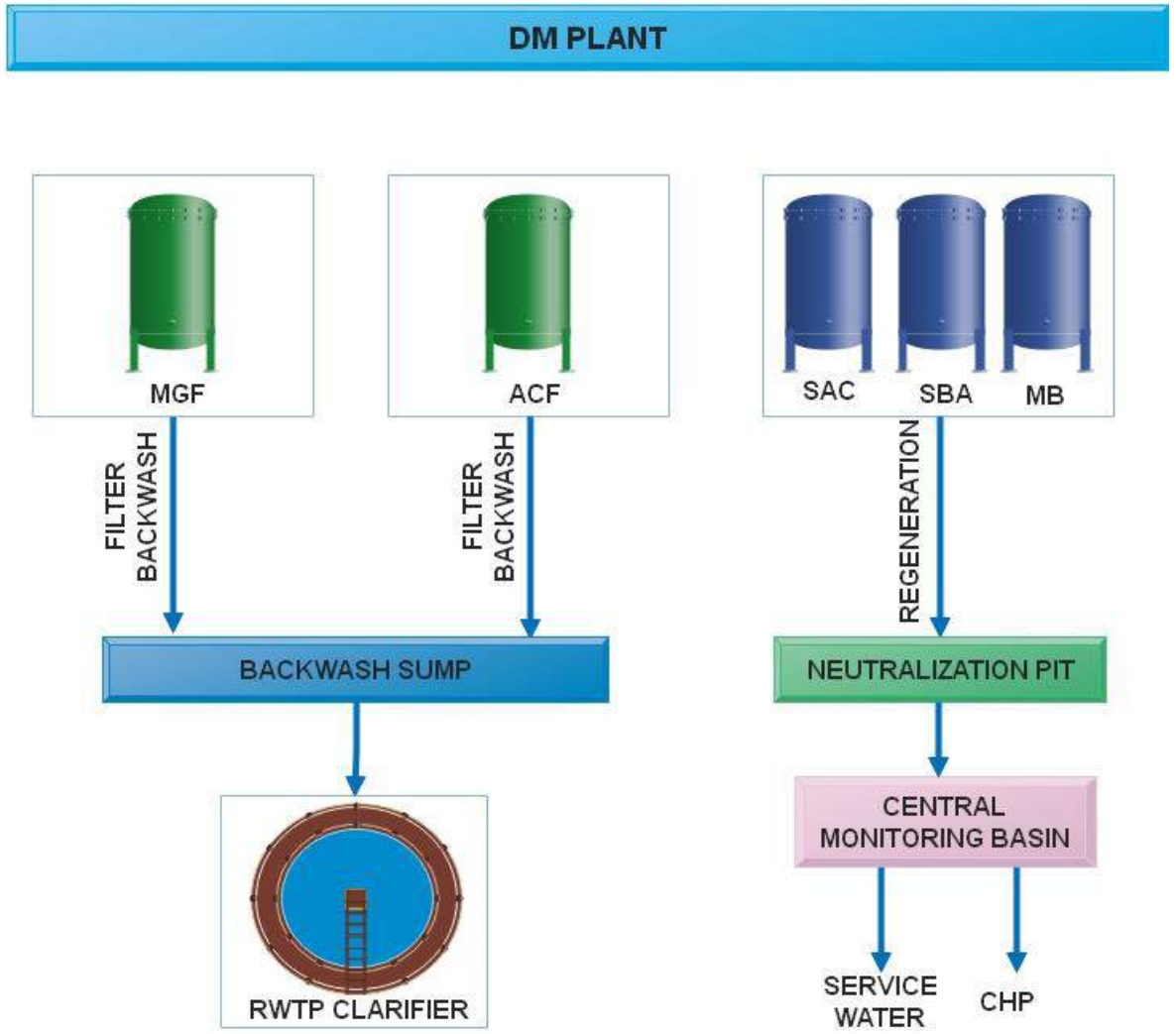
Possible Wastewater streams from TPP

- Raw water treatment plant wastewater treatment system
- DM plant wastewater treatment system
- Coal handling plant wastewater treatment system
- Domestic wastewater treatment system
- Oily wastewater treatment system
- Cooling tower blow down
- Ash Handling plant wastewater treatment system
- Boiler blowdown water treatment system

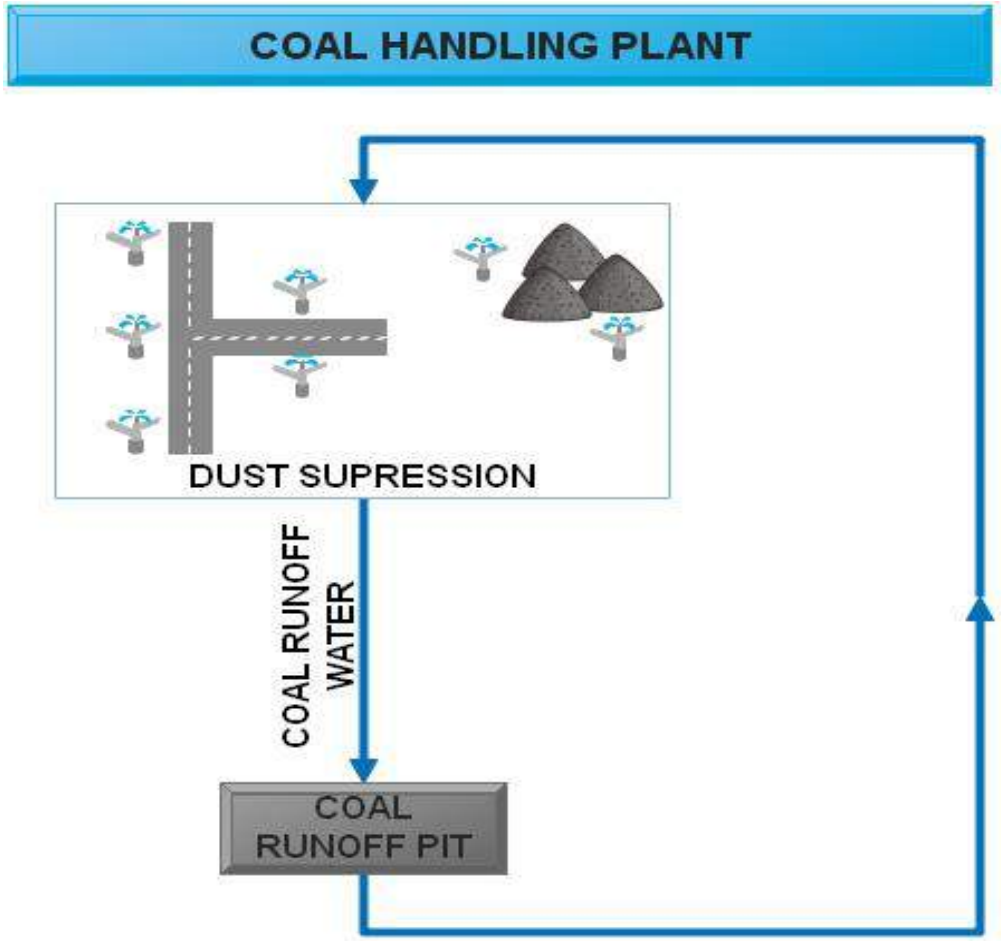
Raw water treatment plant wastewater treatment system



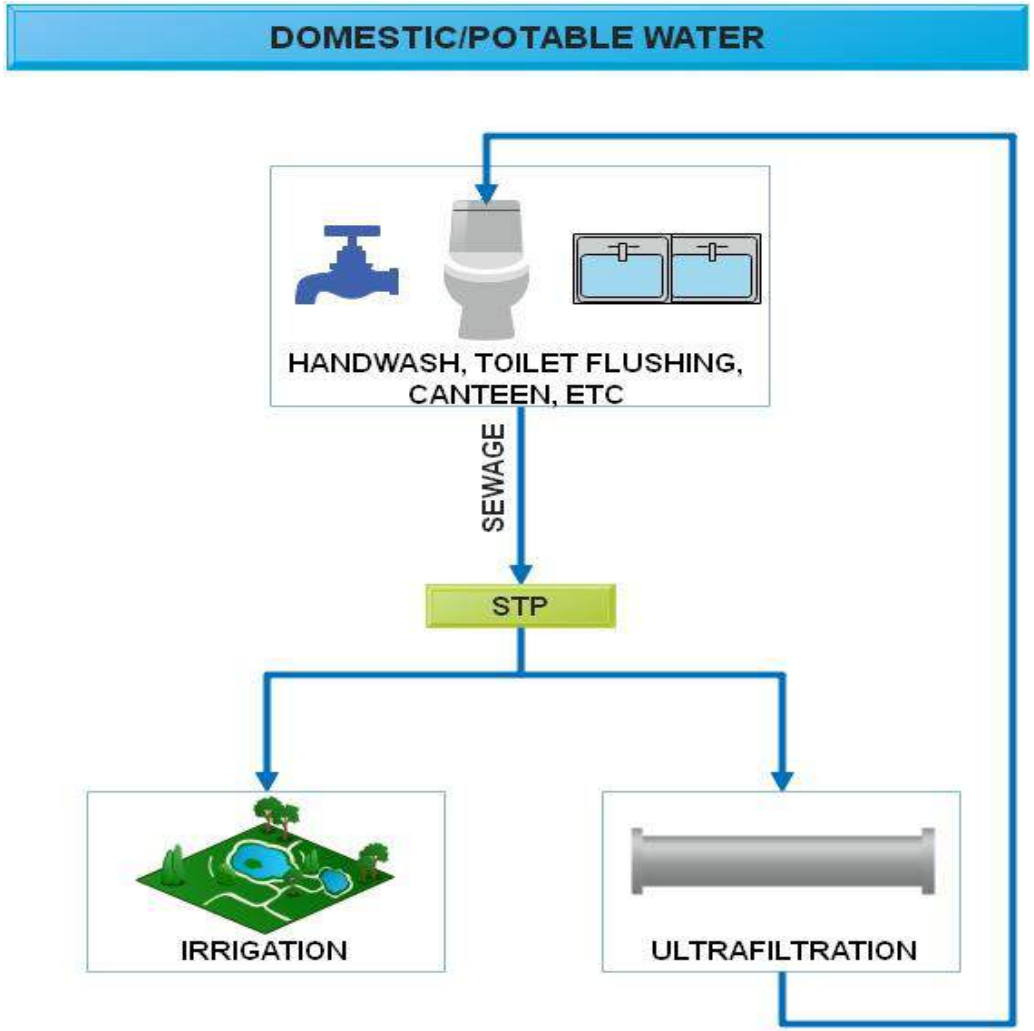
DM plant wastewater treatment system



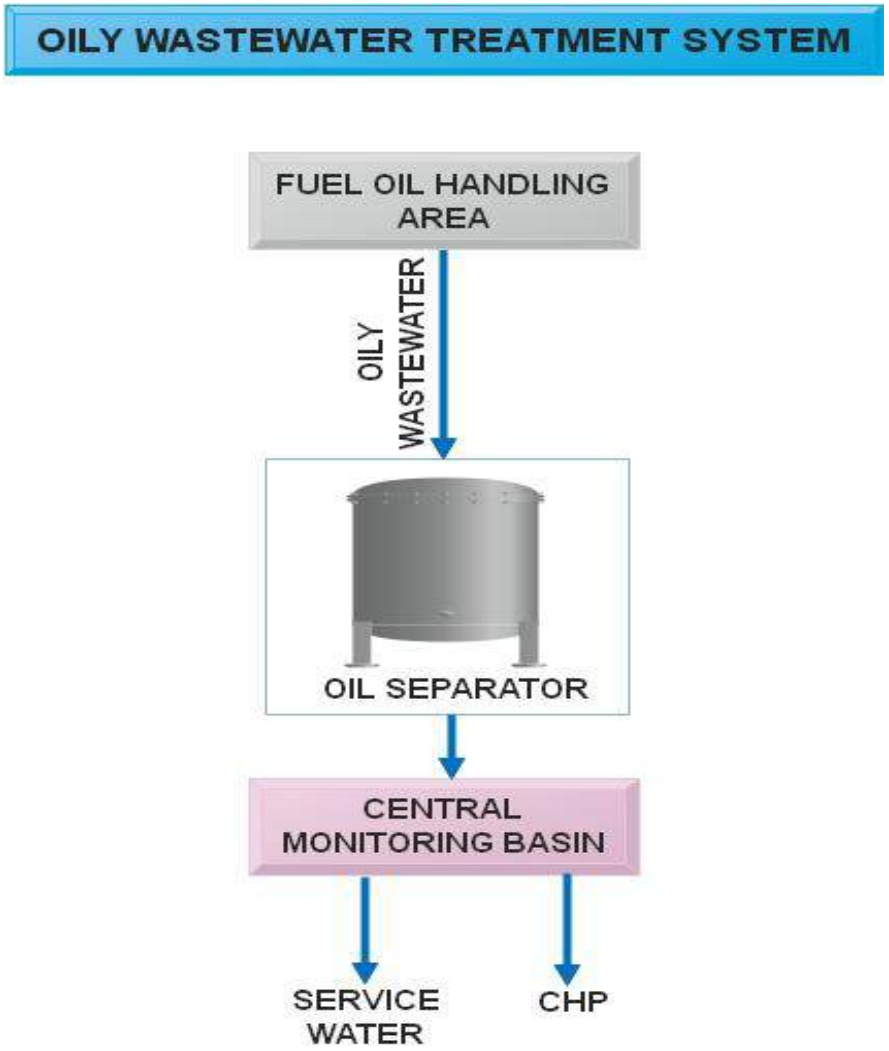
Coal handling plant wastewater treatment system



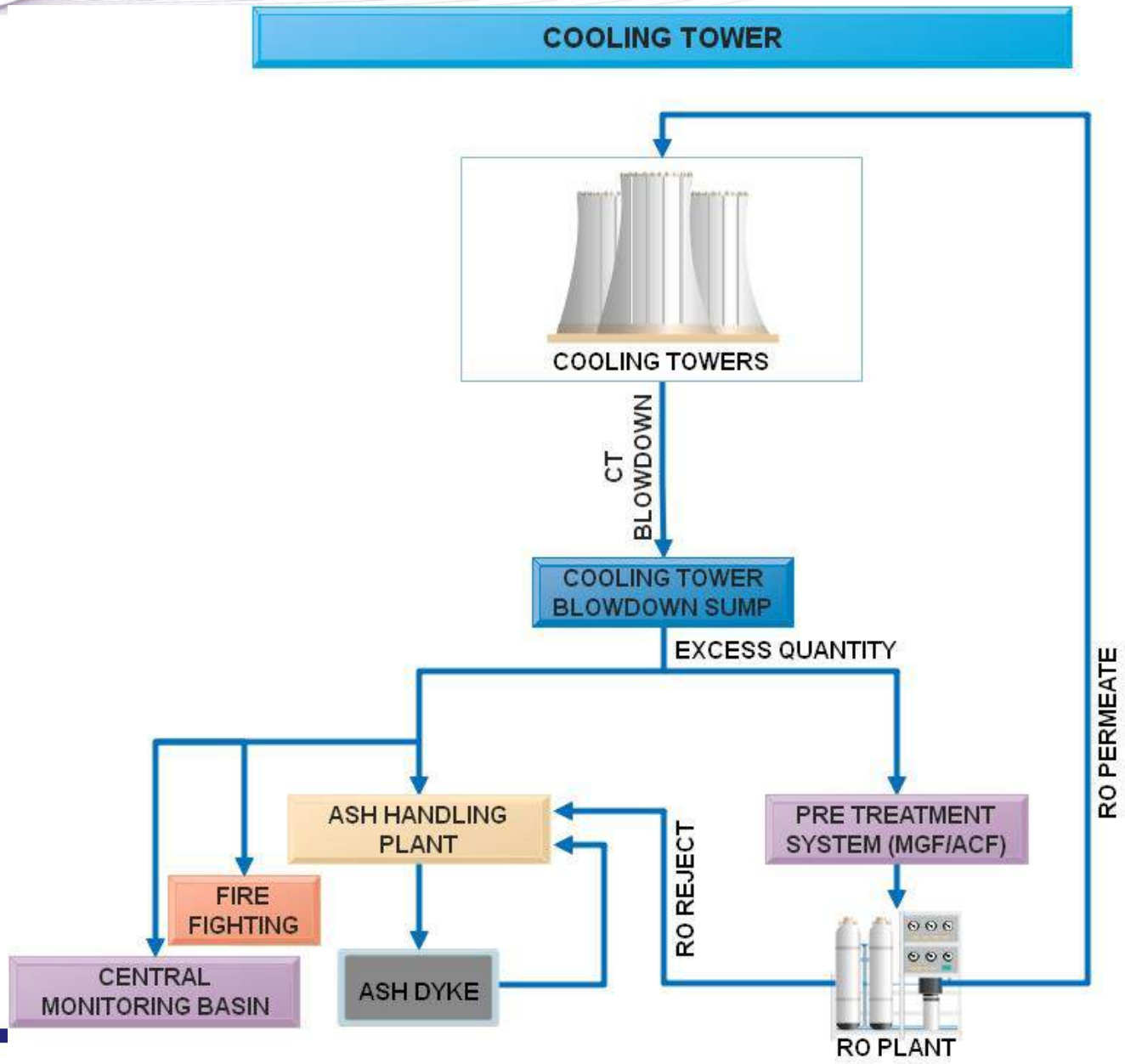
Domestic wastewater treatment system



Oily wastewater treatment system



Cooling tower blow down



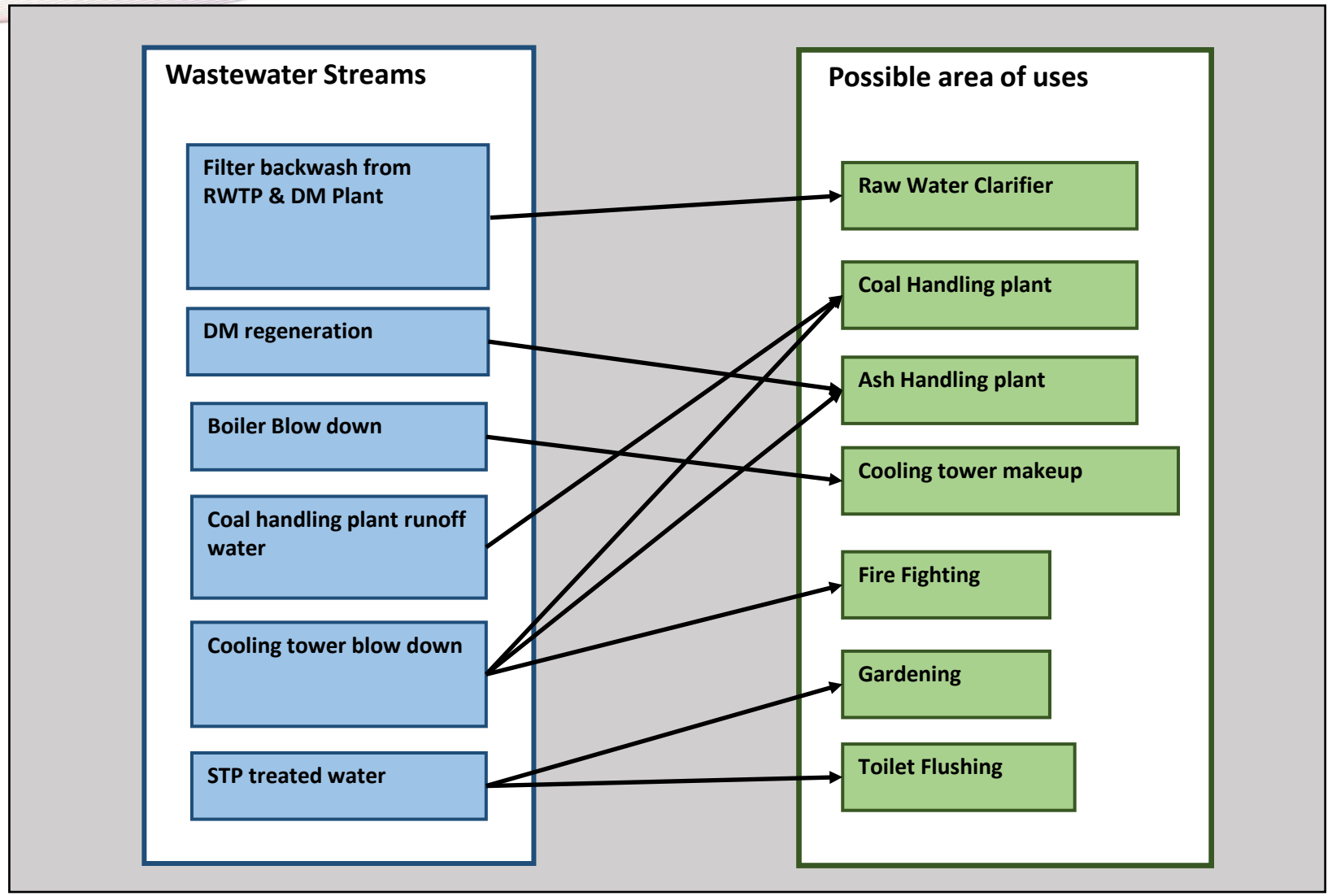
Ash Handling plant wastewater treatment system

The ash & water slurry is disposed to the ash dyke. If there is no water recovery system available in the plant from ash dyke then it is recommended to install the water recovery system from ash dyke through infiltration wells and further utilize it for ash flushing.

Boiler Blowdown

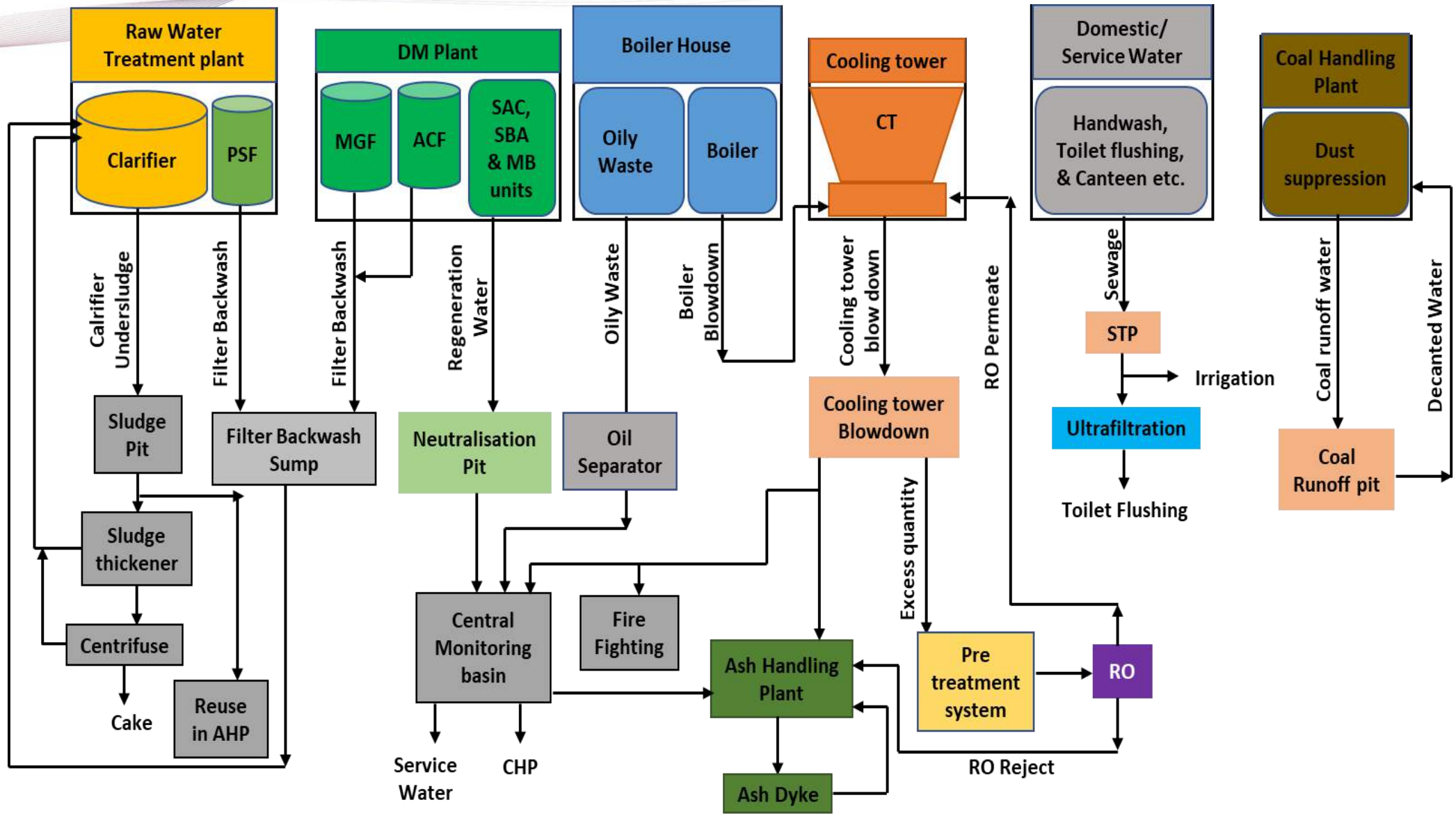
Boiler blowdown should be used for cooling tower make up

Wastewater Matrix



The cooling tower blowdown quantity and the Sewage can be treated up to tertiary level for its utilization in the cooling tower makeup and other low-end applications inside the plant

Overall wastewater management



Innovative Technologies

- Innovative technologies for wastewater recycling, water flow and quality monitoring.
  - Real time data monitoring system (Central Server with wireless data transfer)
  - High Cycles of Concentration (CoC) operation in Circulating Water System
  - High Concentration Slurry Disposal (HCSD) system for Ash disposal system
  - Sewage Treatment Plant for treatment of plant & township sewage
  - Substitution of water-cooled condensers by air cooled condensers
  - Adoption of Dry bottom Ash handling system
  - Mist Aerators in taps to reduce Domestic Water Consumption
  - Dual plumbing system for utilizing recycled water for toilet flushing
  - Minimization of Evaporation losses

Industry Best Practices

Best available technologies implemented across industries for efficient water and wastewater management.

- Real time monitoring of Distributed Water usage in the plant through Water SCADA system
- Zero Liquid Discharge in the Super Critical Thermal Power Plant
- Rooftop Rainwater Harvesting System in Industry
- Municipal Industry Interface (Sewage Treatment Plant)
- Ash water Recirculation (AWRS) and Toe drain recirculation (TDR) System
- Reducing the water intake by adopting High CoC of CW system
- Adoption of Zero Liquid Discharge (ZLD) Policy in all Power Plants
- HDPE Lining for reservoir is provided for preventing seepage loss

Real time monitoring of Distributed Water usage in the plant through Water SCADA system (GMR Warora Energy Limited, 2X300 MW, Maharashtra)

PROJECT TITLE	**Real time monitoring of distributed water usage in the plant through Water Supervisory control and data acquisition (SCADA) system**
OBJECTIVE	Area-wise accounting of Water Consumption and monitoring of localized water consumption trends and patterns
RESULTS	✓ Area-wise water consumption and cost ✓ Distributed water usage pattern ✓ Water consumed per unit of product ✓ Leak identification (unaccounted flow)
HOW ACHIEVED	✓ Identification of Water distribution & consumption points throughout the plant by Cross Function Team (CFT) ✓ Installation of flowmeters at identified points ✓ Communication of flowmeters with Centralized Water SCADA system ✓ Alarm & trend configuration, Report generation & dashboard designed in Water SCADA ✓ Monitoring of real-time and historical water flows through Water SCADA

Zero Liquid Discharge in the Super Critical Thermal Power Plant (Talwandi Sabo Power Limited, 3X660 MW, Punjab)

PROJECT TITLE	Zero Liquid Discharge in the Super Critical Thermal Power Plant
OBJECTIVE	Reduction in specific raw water consumption by recycling effluent and using to cooling tower makeup
RESULTS	✓ Water savings of 0.38 million m^3/year ✓ Saving of Rs 0.82 million/year ✓ Reduction in water consumption by 0.04 m^3/MWH
HOW ACHIEVED	✓ Recycling of CEMB water after treatment in Zero Discharge Unit (ZDU) ✓ One pipeline required to lying from Central Effluent Monitoring Basin (CEMB) recycle pump to Zero Discharge Plant.

Rooftop Rainwater Harvesting System in Industry (Saint Gobain, Chennai)

PROJECT TITLE	Rooftop Rainwater Harvesting System in Industry
OBJECTIVE	Collection of rooftop rainwater in a reservoir
RESULTS	✓ Water harvested: 1,50,000 m^3/year ✓ Fresh water cost savings of Rs 5 million/year
HOW ACHIEVED	✓ Total rooftop area available for harvesting is 1,20,000 m2 ✓ Average annual rainfall is 1,200 mm ✓ Runoff coefficient is 0.9 ✓ Investment: Rs 20 million ✓ Payback period: 48 months

Municipal Industry Interface (Sewage Treatment Plant), Hindustan Zinc Limited, Udaipur

PROJECT TITLE	Udaipur's First Sewage Treatment Plant under PPP (Public Private Partnership) Project
OBJECTIVE	Recycling of the treated sewage for low/high end applications
RESULTS	✓ Water savings of 7.3 million m^3/year ✓ Treated water is used for cooling tower make up and other low-end applications. ✓ Segregation of Sewage through separate dedicated pipeline from city and reaching to STP without entering the water body. ✓ First of its kind in Rajasthan state under Public Private Partnership (PPP) model
HOW ACHIEVED	✓ Recycling of municipal sewage after treatment in through Moving Bed Bio-Reactor (MBBR) process ✓ On an average, Udaipur city generates about 70 million litres of sewage per day and handling this sewage was one of the major concerns. ✓ Currently, most of the sewage is being discharged into Ahar River leading to Udai Sagar lake, resulting in negligible dissolved oxygen, foul odour, presence of faecal coliforms and Eutrophication in the water bodies and thereby affecting overall aquatic life and aesthetic look. ✓ STP has been constructed on 'Design Build Own Operate and Transfer' basis. ✓ Helps in making Udaipur's water bodies (Udai Sagar, Ahar River) free from contamination to a great extent (around ~30% reduction in total sewage flow into river/lakes). ✓ After successful implementation of phase I, plant is increasing the capacity of Sewage Treatment Plant from 20 to 45 million litres of sewage per day. Expansion project is under progress and shall be commissioned by Dec.'18.

Key Recommendations

- Install electromagnetic flow meters at prominent water supply & consumption points and connect them to real time monitoring or SCADA based water monitoring system to compute scientific & authentic water balance
- Segregate & treat the wastewater streams based on their pollutant load and reuse it accordingly
- Install HCSD system for wet ash disposal. In case the plant has lean slurry ash disposal system, then the ash water recirculation system from ash dyke should be in place.
- Increase the CoC in cooling towers to reduce the blow down and makeup water quantity.
- Fire water system should be used dedicatedly for fire applications not for the other plant applications.
- Recovery of water from raw water clarifier under sludge through a thickener or reuse under sludge in ash handling system.

Key Recommendations

- Recycle filter backwash water from Raw water treatment plant's pressure sand filters and MGF & ACF filters from DM Plant.
- Treat wastewater generated from plant in the CEMB and use it for low-grade applications like dust suppression, toilet flushing etc.
- Install Continuous Effluent Monitoring System (CEMS) at discharge of CEMB and connect the same to CPCB/SPCB server as per compliance.
- Collect plant & township (If any) sewage separately and use it for horticulture or other low-end applications after appropriate treatment.
- Adopt innovative schemes for water management and conservation (Recycle, Reuse and Reduce options).
- Introduce cross-functional work group for water and wastewater management in the plant.
- Plan implementation of schemes with time & target (management decisions).
- Undertake regular water audit

Thank You

Confederation of Indian Industry

125 Years: 1895-2020

Charting Change, Enabling Development