



**GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS**

**MANUAL ON WATER SUPPLY AND
TREATMENT SYSTEMS
(DRINK FROM TAP)**

**PART A: ENGINEERING - PLANNING, DESIGN AND
IMPLEMENTATION
FOURTH EDITION - REVISED AND UPDATED**

**CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL
ENGINEERING ORGANISATION**

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Part A- Engineering

ABBREVIATIONS AND SYMBOLS

3LPE	Three Layer Polyethylene
3Ts	Tariffs, Taxes and Transfer
ABS	Acrylonitrile Butadiene Styrene
AC	Asbestos Cement
AC	Alternating Current
ACV	Air Cushion Valve
ADB	Asian Development Bank
ADC	Analog to Digital Convertor
AFD	Agence Française de Développement
AI	Artificial Intelligence
AIC	Average Incremental Cost
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
AMRIT	Arsenic and Metal Removal through Indian Technology
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APFC	Automatic Power Factor Control
APHA	American Public Health Association
APT	Aquifer Pump Test
ASR	Aquifer Storage & Recharging System
ASR	Aquifer Storage & Recovery wells
ASTM	American Society for Testing and Materials
ATC	Automatic Temperature Compensated
BC	Black Cotton
BCM	Billion Cubic Meter
BDL	Below Detectable Limits
BEE	Bureau of Energy Efficiency
BEP	Best Efficiency Point
BIS	Bureau of Indian Standards
bkW	Brake Kilowatts
BMC	Bombay Municipal Corporation
BPT	Break Pressure Tank
BWRO	Brackish Water
BWSC	Bar Wrapped Steel Cylinder
BWSSB	Bangalore Water Supply and Sewerage Board

Part A- Engineering

CI	Cast Iron
C2C via C	Catchment-to-Catchment-via-Consumer
CACA	Closed Air Circuit Air Cooled
CACW	Closed Air Circuit Water Cooled
CAD	Computer Aided Drawing
CBRI	Central Building Research Institute
CCT	Chlorine Contact Tank
CD	Casing for Deep Well
CDI	Capacitive Deionization
CDP	City Development Plan
CFD	Computational Fluid Dynamics
CFRO	Counterflow Reverse Osmosis
CGWA	Central Groundwater Authority
CGWB	Central Ground Water Board
CID	Cast Iron Detachable Joints
CIP	Clean In Place
CM	Casing for Medium Well
CMS	Centralised Monitoring and Control Centre
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CPC	Cetylpyridinium Chloride/ Hexadecyl Pyridinium Chloride
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CPVC	Chlorinated Polyvinyl Chloride
CS	Casing for Shallow Well
CSIR	Council of Scientific & Industrial Research
CSR	Company Social Responsibility
CWBP	City Water Balance Plan
CWC	Central Water Commission
CWPRS	Central Water & Power Research Station CWR Clear Water Sump
CWT	Clear Water Tank
D	Internal Diameter
DI	Ductile Iron
DA	Dynamic Analysis
DAF	Dissolved Air Floatation

Part A- Engineering

DAPRV	Direct Acting Pressure Relief Valve DBPDisinfection By-Product
DC	Direct Current
DD	Domestic Demand
DDA	Demand Dependent Analysis
DE	Diatomaceous Earth
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DMA	District Metered Areas
DO	Dissolved Oxygen
DOL	Direct Online
DOM	Dynamic Operating Model
DP	Differential Pressure
DPCV	Dual Plate Check Valve
DPD	Di-Ethylphenylene-Di-Amine
DPR	Detailed Project Report
DSS	Decision Support System
DTP	Draft Tender Paper
DUSL	Design Useful Service Life
ES	Effective Size
EC	Electro-Chlorination
EC	Emerging Contaminant
ED	Electro-Dialysis
EDC	Endocrine Disrupting Compound
EEPROM	Electrically Erasable Programmable Read-only Memory
EF	Environmental Flows
EFW	Electric Fusion Welded
EOT	Electrically Operated Traveling Crane
EPS	Extended Period Simulation
ERW	Electric Resistance Welded
ESR	Elevated Service Reservoir
FRP	Fibre Reinforced Plastic
FBE	Fusion Bonded Epoxy
FCRI	Fluid Control Research Institute
FCV	Flow Control Valve
FD	Froude Number

Part A- Engineering

FFAW	Free Flowing Artesian Well
FFAWD	Free Flowing Artesian Well Device
FGL	Finished Ground Level
FHTC	Functional Household Tap Connections
FL	Full Load
FLC	Full Load Current
FS	Flat Sheet Membranes
FSI	Floor Space Index
FSL	Full Supply Level
FTK	Field Test Kit
GI	Galvanized Iron
GRP	Glass Reinforced Plastic
GA	Genetic Algorithms
GAC	Granular Activated Chlorine
GCP	Geographic Control Point
GDWQ	Guidelines for Drinking Water Quality
GEM	Groundwater Exploration and Mapping
GEMS	Global Environmental Monitoring System
GI	Galvanized Iron
GIS	Geographic Information System
GOI	Government of India
GoM	Government of Maharashtra
GPR	Ground Penetrating Radar
GPS	Global Positioning System
GRP	Glass Reinforced Plastic
GSR	Ground Service Reservoir
GWP	Global Water Partnership
GWPI	Groundwater Potential Index
GWpz	Groundwater Resources Potential Zone Maps
GWQM	Ground Water Quality Monitoring
GWRA	Ground Water Resource Assessment
HAA	Haloacetic Acid
HAM	Hybrid Annuity Model
HAP	Analytic Hierarchy Process
HDD	Horizontal Direction Drilling

Part A- Engineering

HDET	Hand Held Data Entry Terminal
HDPE	High Density Polyethylene
HF	Hollow Fiber membranes
HFIW	High-Frequency Induction Welded
HFL	High Flood Level
HFS	Hot Finished Seamless
HGL	Hydraulic Grade Line
HGM	Hydro-Geomorphological Map
HMDA	Hyderabad Metro Development Authority
HMI	Human Machine Interface
HOT	Hand operated Traveling Crane
HSC	House Service Connection
HT	High-Tension
HTH	High Test Hypochlorite
HUG	Hydrometric Uncertainty Guidance
HW	Hazen-Williams
HWL	High Water Level
Hz	Hertz
ID	Industrial Demand
IDEMI	Institute for Design of Electrical Measuring Instruments
IDW	Inverse Distance Weighted
IEC	Information, Education & Communication
ILI	Infrastructure Leakage Index
IoT	Internet of Things
IPS	Inclined Plate Settler
IRP	Iron Removal Plant
IS	Indian Standards
ISO	International Standard Organization
ISRO	Indian Space Research Organization
IT	Information Technology
ITES	IT Enabled Services
IUWM	Integrated Urban Water Management
IUWRM	Integrated Urban Water Resources Management
IV	Isolation Valve
IWRM	Integrated Water Resource Management

Part A- Engineering

IX	Ion Exchange
JICA	Japan International Cooperation Agency
KFW	Kreditanstalt für Wiederaufbau
KMC	Kolkata Municipal Corporation
KMZ	Keyhole Markup Language Zipped
KPI	Key Performance Indicators
KT	Kolhapur Type
LBF	Lake Bank Filtration
LGW	Local Ground Water
LIDAR	Light Detection and Ranging
LNf	Legitimate Night Flow
LoRa WAN	Long Range Wide Area Network
LP	Linear Programming
LPCD	Litres per Capita per Day
LPG	Linear Programming Gradient
LSL	Lowest Supply Level
LWL	Low Water Level
M&R	Maintenance and Repair
MS	Mild Steel
MAOP	Maximum Allowable Operating Pressure
MAR	Managed Aquifer Recharge
MBR	Master Balancing Reservoir
MCC	Motor Control Centre
MCL	Maximum Concentration Level
MDDL	Maximum Drawdown Level
MDG	Millennium Development Goal
MDM	Meter Data Management
MDPE	Medium Density Polyethylene
MED	Multi-Effect Distillation
MEUF	Micellar-Enhanced Ultrafiltration
MF	Microfiltration
MGD	Million Gallons per Day
MHa	Million Hectares
MIDC	Maharashtra Industrial Development Corporation
MIHAN	Multi-modal International Hub and Airport in Nagpur
MINAR	Monitoring of Indian National Aquatic Resource

Part A- Engineering

MIS	Management Information System
MIU	Meter Interface Units
MJP	Maharashtra Jeevan Pradhikaran
MLD	Million Litres per Day
MLDB	Main Lighting Distribution Board
MMDB	Mono Media Deep Bed Gravity
MNF	Minimum Night Flow
MOCZ	Manganese Oxide-Coated Zeolite
MoHUA	Ministry of Housing and Urban Affairs
MoWR	Ministry of Water Resources
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSF	Multi-Stage Flash Distillation
MSL	Mean Sea Level
mWC	Meters of Water Column
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAQUIM	National Aquifer Mapping and Management
NASA	National Aeronautics and Space Administration
NBC	National Building Code
NB-IOT	Narrowband Internet of Things
NDD	Non- Domestic Demand
NDT	Non-Destructive Test
NF	Nanofiltration
NFA	Node Flow Analysis
NGT	National Green Tribunal
NHA	Node Head Analysis
NHFR	Node-Head-Flow Relationship
NIRA	National Interlinking of Rivers Authority
NIT	Nagpur Improvement Trust
NLP	Non-Linear Programming
NMC	Nagpur Municipal Corporation
NMs	Nano-Materials
NNF	Net Night Flow
NOM	Natural Organic Matter
NPSH	Net Positive Suction Head
NRLP	National River Linking Project
NRSA	National Remote Sensing Agency

Part A- Engineering

NRV	Non-Return Valve
NRW	Non-revenue Water
NWDA	National Water Development Agency
NWP	National Water Policy
O&M	Operation and Maintenance
OD	Outside Diameters
ODA	Official Development Assistance
ODP	Open Drip Proof
OPVC	Oriented Polyvinyl Chloride
OT	Orthotoulidine Test
OTA	Orthotolidine Arsenite Test
OZ	Operational Zone
P	Power
P&IDs	Process/Piping and Instrumentation Diagrams
PE	Polyethylene
PN	Proctor Normal
PAC	Powdered Activated Carbon
PAP	Project Affected Person
PCR	Polymerase Chain Reaction
PDA	Pressure-Dependent Analysis
PDS	Plain Deep Well Screen
PE-AL-PE	Polyethylene-Aluminium-Polyethylene
PFAS	Poly-Fluorinated Alkyl Substances
PFC	Power Factor Controller
PFRV	Pressure and Flow Rate Reducing Valve
PLC	Programmable Logic Controller
PMC	Project Management Consultant
PMCC	Power cum Motor Control Centre
PMS	Plain Medium Well Screen
PN	Nominal Pressure
PP	Polypropylene
PPCP	Pharmaceuticals and Personal Care Product
PPP	Public Private Partnership
PPP	Pharmaceutical and Personal Care Product
PP-R	Polypropylene Random Copolymer

Part A- Engineering

PRBs	Permeable Reactive Barriers
PRV	Pressure Reducing Valve
PSC	Prestressed Concrete, Cylinder or non-cylinder
PTZ	Pan Tilt Zoom
PU	Polyurethane
PVC	Poly-Vinyl Chloride
PVDF	Poly-Vinylidene Fluoride
PVRV	Pressure Vacuum Relief Valve
PW	Present Worth
RC	Reinforced Concrete
RBF	River Bank Filtration
RCC	Reinforced Cement Concrete
RCW	Recycled Water
RC-Wells	Radial Collector Wells
RDS	Ribbed Deep Well Screen
RF	Radio Frequency
RFP	Request for Proposal
RM	Consumer Relations Management
RMS	Ribbed Medium Well Screen
RO	Reverse Osmosis
ROI	Return on Investment
ROVs	Remotely Operated Vehicles
RPMs	Revolutions per Minute
RRWSS	Rural Regional Water Supply Scheme
RTUs	Remote Terminal Units
RWH	Rain Water Harvesting
RWSS	Rural Water Supply Scheme
SCADA	Supervisory Control and Data Acquisition
SDB	Sludge Drying Bed
SDG	Sustainable Development Goal
SDI	Silting Density Index
SDR	Standard Dimension Ratio
SEC	Specific Energy Consumption
SEZ	Special Economic Zone
SIV	System Input Volume

Part A- Engineering

SLB	Service Level Benchmark
SOM	Synthetic Organic Matter
SOP	Standard Operating Procedure
SOR	Surface Overflow Rate
SPDP	Screen Protected Drip Proof
SPV	Solar Photo Voltaic
SPV	Special Purpose Vehicle
STP	Sewage Treatment Plant
SV	Sluice Valve
SWD	Side Water Depth
SWM	Solid Waste Management
SWOT	Strengths Weaknesses Opportunities Threats
SWRO	Seawater Reverse Osmosis
TBL	Triple Bottom Line
TCLP	Toxicity Characteristics Leaching Procedure
TDS	Total Dissolved Solids
TEFC	Totally Enclosed Fan Cooled
TESWC	Totally Enclosed Self Water Cooled
TETV	Totally Enclosed Tube Ventilated
TFC	Thin Film Composite
TGW	Treated Ground Water
THMs	Trihalomethanes
TMP	Transmembrane Pressure
TOF	Time of Flight
TSS	Total Suspended Solids
TSW	Treated Surface Water
TTRO	Tertiary Treatment RO
UC	Uniformity Coefficient
UN SDG	United Nations' Sustainable Development Goal
UF	Ultrafiltration
UFW	Unaccounted for Water
ULBs	Urban Local Bodies
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
UPV	Ultrasonic Pulse Velocity
UPVC	Unplasticized Polyvinyl Chloride

Part A- Engineering

UV	Ultraviolet
UWTP	Used Water Treatment Plants
VC	Vapour Compression
VCB	Vacuum Circuit Breaker
VFD	Variable Frequency Drive
VOC	Volatile Organic Compounds
VSD	Variable Speed Drive
VT	Vertical Turbine
WBE	Wastewater-Based Epidemiology
WDN	Water Distribution Networks
WDS	Water Distribution System
WHO	World Health Organization
WL	Water Level
WQI	Water Quality Index
WRC	Water Research Council
WRD	Water-Resources Division
WRIS	Water Resource Information System
WRM	Water Resources Management
WSP	Water Safety Plan
WTM	Water Transmission Mains
WTN	Water Transmission Network
WTP	Water Treatment Plant
WWAP	World Water Assessment Programme
ZBR	Zonal Balancing Reservoir
ZVV	Zero Velocity Valve

PART A

Glossary

GLOSSARY

24x7 Pressurised Water Supply System is a system having continuous pressurised water supply with Drink from Tap facility.

A

Adsorption, physical process in which dissolved molecules or small particles in water (the adsorbate) are attracted and become attached to the surface of something larger (the adsorbent)

Aeration, process of treatment that consists of passing large amounts of air through water and then venting the air outside. The air causes the dissolved gases or volatile compounds to release from the water. The air and the contaminants released from the water are vented

Air Valves, hydromechanical devices with an internal float mechanism designed to release trapped air during filling and operation of a piping system

Air Vessel, used to compensate for pressure fluctuations and as safety device to avoid surge pressure

Algae, the plural form of the word alga, which in Latin means "seaweed." and are defined as a group of predominantly aquatic, photosynthetic, and nucleus-bearing organisms that lack the true roots, stems, leaves, and specialized multicellular reproductive structures of plants

Algicides, chemical compounds whose active ingredients kill algae and/or prevent it from growing in water

Alkalinity, capacity of a Water to neutralise acids. It is usually expressed in milligrams per litre of equivalent calcium carbonates

Automatic Meter Reading, technology used to automatically collect consumption, diagnostic and status data through water metering devices. The AMR then transfers this data to a central database for billing, troubleshooting and analysis

Anti-Vacuum Valve, special type of air valve to prevent the formation of vacuum in large diameter water mains, which might cause line collapse under such conditions of flow as may result from too rapid a closure of an upstream head gate or shut down valve, or ordinary emptying of a pipeline

Aquifer, geological formation that is permeable enough to transmit sufficient quantities of water to support the development of water wells.

Aquifer Vulnerability Index, the aquifer is vulnerable to surface contaminants and the Aquifer Vulnerability Index is a method of assessing the vulnerability of aquifers to surface contaminants. It is assessment of risk accumulated with groundwater resources

Part A- Engineering

Automation, use of technology to control a system or process without human intervention. In the context of water supply, automation can be used to control a variety of aspects of the water distribution system, including Pumping, Valves etc.

B

Benchmark, the level of supply and the quality of water that a consumer is entitled to get.

Borewell, a deep narrow well for water drilled into ground & has pipe fitted as a casing in the upper part of the borehole and a pump to draw water to the surface

Branched Transmission Main, branch main that is off taking from the transmission main for coverage of enroute habitations.

Bulk-Meter, a large meter that is usually fitted to pipes to measure bulk water quantity delivered to elevated service reservoirs and is also used in water auditing and leak detection purposes

Break Pressure Tank, to break the hydrostatic pressure, a tank is specially built which is known as a break pressure tank. It will be located at the highest elevation of the transmission pipeline and is required to manage the water pressures that will be generated in the operation of the transmission pipeline.

Brine, water saturated or strongly impregnated with common salt

Butterfly Valve, valve consisting of a rotating circular plate or a pair of hinged semicircular plates, attached to a transverse spindle and mounted inside a pipe in order to regulate or prevent flow. These valves are used where space is limited and can be used for throttling or regulating flow as well as in the full open and fully closed position. The pressure loss through a butterfly valve is small in comparison with the gate valve

C

Carcinogenic, having the potential to cause cancer

Check Dam, a small, sometimes temporary, dam constructed across a swale, drainage ditch, or waterway to counteract erosion by reducing water flow velocity

Chloramines, (also known as secondary disinfection) are disinfectants used to treat drinking water and they are most commonly formed when ammonia is added to chlorine to treat drinking water, provide longer-lasting disinfection as the water moves through pipes to consumers

Chlorination, the process of adding chlorines or chlorine compounds such as sodium hypochlorite to water. Chlorination is used to prevent the spread of water borne diseases

Chlorine Residual, the low-level amount of chlorine remaining in the water after a certain period or contact time after its initial application. It constitutes an important safeguard against the risk of subsequent microbial contamination after treatment—a unique and significant benefit for public health

Chlorinator, a device to apply or to deliver a chlorine disinfectant to water at a controlled rate

Part A- Engineering

Canadian Investment Regulatory Organization, regulates the mutual fund dealers that invest in water funds. These funds invest in water infrastructure companies and other water-related businesses. This can help to make water investment more accessible to individual investors.

Coagulant, a chemical that is used to remove suspended solids from drinking water. They are made up of positively charged molecules, which help to provide effective neutralization of water

Coagulation, the chemical water treatment process used to remove solids from water, by manipulating electrostatic charges of particles suspended in water. This process introduces small, highly charged molecules into water to destabilize the charges on particles, colloids, or oily materials in suspension

Cold Desert, an arid habitat with an annual rainfall of less than 25 cm. They have a temperate climate with scorching summers and chilly winters because they are situated at a high latitude.

Confined Aquifer, an aquifer below the land surface that is saturated with water. Layers of impermeable material are both above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer

Contamination, any substance added to water that degrades its quality. Water bodies include lakes, rivers, oceans, aquifers, reservoirs and groundwater

Consumer Survey, a source to obtain information about consumer satisfaction levels with existing water quality and services and their opinions and expectations regarding new water quality and services

Control Valve, a valve used to control fluid flow by varying the size of the flow passage as directed by a signal from a controller. This enables the direct control of flow rate and the consequential control of process quantities such as pressure, temperature, and liquid level

Cryptosporidium, cryptosporidium parvum is a waterborne parasite encased in a leathery shell, (or oocyst), and causes severe flu-like symptoms when ingested.

City Water Balance Plan, a document that describes the water resources of a city, including the sources of water, the demand for water, and the ways in which water is used and managed. The CWBP is used to identify the water supply and demand gaps in a city and to develop strategies to close these gaps.

City Development Plan, sets out how best the city can enable growth and investment over the years.

Communication Technologies, technologies used in water supply for a variety of purposes, including monitoring and control of water infrastructure, asset management, customer service, emergency response and research and development.

D

Dual Water Distribution System, for coastal cities and new layouts of water scarce cities consist of two independent pipe networks with separate treatment, pumping and storage system to supply different grade of water to consumers.

Part A- Engineering

Debottlenecking, the process of identifying specific areas in plant equipment or the workflow configuration that limits the flow of product. By optimising plant operations, overall capacity and/quality can be improved

Digital Terrain Modelling, a mathematical representation (model) of the ground surface, most often in the form of a regular grid, in which a unique elevation value is assigned

Digitalization, describes the pure analog-to-digital conversion of existing data and documents.

Digital Twin, is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision making

Disaster, an event whose timing is unexpected and whose consequences are seriously destructive

Disinfection, a process of removal, deactivation or killing of pathogenic microorganisms. Microorganisms are destroyed or deactivated, resulting in termination of growth and reproduction

Distillation, a process that relies on evaporation to purify water. Contaminated water is heated to form steam. Inorganic compounds and large non-volatile organic molecules do not evaporate with the water and are left behind. The steam then cools and condenses to form purified water

District Metered Area, a discrete part of a water distribution network. It is usually created by closing boundary valves or by permanently disconnecting pipes to neighbouring areas

Detailed Project Report, consists of detailed data, design drawings and estimate of a prospective project

Drink from Tap, continuous pressurised water supply system to ensure water quality for drinking, cooking, washing, etc. made available to consumer tap.

Drones, a flying robot that can be remotely controlled or fly autonomously using software- controlled flight plans in its embedded systems used for various purpose in water sector and other areas

Distribution System, a network of pipes, pumps, and other infrastructure that delivers water from a treatment plant to homes and businesses.

E

Electrical Conductivity, a measure of the capability of water to pass electrical flow. This ability directly depends on the concentration of conductive ions in the water. These conductive ions originated due to inorganic materials such as chlorides, alkalis, carbonate and sulphide compounds and dissolved salts. The unit of EC is milli-Siemens per meter (mS/m)

Electro-chlorination, a process of producing hypochlorite by passing electric current through salt water. This disinfects the water and makes it safe for human use, such as for drinking water or swimming pools

Electro-dialysis, a process controlled by an electric field gradient that allows the separation of minerals from feed water solution. It moves dissociated ions through ion-permselective membranes

Part A- Engineering

and forms two different flows - desalinated flow called dilute and a concentrated flow called concentrate (brine)

Electrofusion, a method of joining MDPE, HDPE and other plastic pipes using special fittings that have built-in electric heating elements which are used to weld the joint together

Emerging Contaminants, which have not previously been detected through water quality analysis, or have been found in small concentrations with uncertainty as to their effects. The risk they pose to human or environmental health is not fully understood

Energy Audit, an inspection survey and an analysis of energy flows for energy conservation and includes a process or system to reduce the amount of energy input into the system without negatively affecting the output

Elevated Service Reservoirs, are constructed, where water is to be supplied at elevated height (less than the level of ESR) or where the distance is large and topography is undulating

Estuary, a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it and with a free connection to the open sea

F

Filter Console, provides continuous and discrete controls that are necessary for a typical surface or bulk filter in a water treatment plant

Filter Sand, Quartz sand, silica sand, anthracite coal, garnet, magnetite, and other materials may be used as filtration media. Silica sand and anthracite are the most commonly used types

Filtration, a process in which solid particles in a liquid or gaseous fluid are removed by the use of a filter medium that allows the fluid to pass through while retaining the solid particles. It may mean the use of a physical barrier, chemical, and/or a biological process

Floating Reservoirs, during peak demand in the distribution system, water from the source as well as from the storage reservoir will be supplied. The storage reservoir under this condition is called Balancing Reservoir. Balancing reservoir is also called floating reservoir

Flocculation, a process where solids form larger clusters, or flocs, to be removed from water. This process can happen spontaneously, or with the help of chemical agents. It is a common method in the purification of drinking water

Flow Control Valve, designed to maintain a constant pre-set maximum flow regardless of fluctuating demand or varying system pressure. Flow limiting is required at the outlets from main systems to consumers like secondary systems (main line to hydrant line; hydrant line to distribution line), reservoirs, etc.

Flow-meters, critical instruments in water treatment plants, providing accurate measurement and control of water flow to achieve efficient treatment processes, meet regulatory requirements, conserve water, and maintain optimal plant performance

Part A- Engineering

Flumes, device used to measure the flow in an open channel. The flume narrows to a throat of fixed dimensions and then expands again. The rate of flow can be calculated by measuring the difference in head (pressure) before and at the throat of the flume

Foot Valve, type of check valve that is typically installed at a pump or at the bottom of a pipe line (hence the name). Foot valves act like ball check valves, but have an open end with a shield or screen over it to block debris from entering the line.

G

Geographic Information System, an effective tool for storing, managing, and displaying spatial data often encountered in water resources management. The application of GIS in water resources is constantly on the rise

Globe Valve, an instrument used to stop and/or control the flow of fluids in a pipeline. It works by halting the flow of a fluid through a pipe. The name globe comes about due to the valve's cylindrical shape. There are usually two halves of the body within the globe valve that are separated by an internal baffle

Ground Penetrating Radar, a geophysical locating method that uses radio waves to capture images below the surface of the ground in a minimally invasive way

Gravity Transmission Main, gravity water systems use gravity to transport water from the source to the user through a pipe network.

Groundwater, water that exists underground in saturated zones beneath the land surface

Groundwater Table, the top of the subsurface ground-water body, the water table, is a surface, generally below the land surface, that fluctuates seasonally and from year to year in response to changes in recharge from precipitation and surface-water bodies

Guniting, a technique of applying mortar or concrete to a surface with a spray cannon during construction

H

Halogen, fluorine (F), chlorine (Cl), bromine (Br), iodine (I), astatine (At) and tennessine (Ts) are halogen elements. Because of their great reactivity, the free halogen elements are not found in nature. Halogen reacts to a small extent with water, forming acidic solutions with bleaching properties. They also undergo redox reactions with metal halides in solution, displacing less reactive halogens from their compounds

Hazen William Co-efficient (C), usually considered independent of pipe diameter, velocity of flow and viscosity. However, to be dimensionally consistent and to be representative of friction conditions, it must depend on relative roughness of pipe and Reynold's number

Head Works, a civil engineering term for any structure at the head or diversion point of a waterway. When dam is constructed across a river to form a storage reservoir, it is known as storage head work. It stores water during the period of excess supplies in the river and releases it when demand overtakes the available supplies

Part A- Engineering

Hydrogeology, study of the occurrence distribution, and movement of underground water

Hydrogeomorphic Map, hydro-geomorphological maps incorporate relationship of geomorphic units with their groundwater potential as interpreted from landform characteristics as well as sub-surface geology

Hydraulic Modelling, a collection of mathematical equations that give a simple representation of reality. They estimate flow, water level and velocity in river channels and pipe networks. A hydraulic model can make these calculations and simulate infrastructure performance. Visibility into deviations from forecast, Demand forecasting and other forecast models are critical tools that can help water utilities plan for the future

I

Intermittent Water Supply, piped water supply service that is available to consumers less than 24 hours per day. In an IWS situation, the consumers usually secure their water supply through the use of ground or roof tanks, where water is stored during the length of time that the supply is provided

Internet of Things, describes the network of physical objects— “things”— that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet

Ion Exchange, system used for efficient removal of dissolved ions from water. It exchanges one ion for another, hold it temporarily and then release it to a regenerant solution. In an ion exchange system, undesirable ions in the water supply are replaced with more acceptable ions

Isohytal Map, map depicting characteristics of equal precipitation amounts recorded during a specific time period

Isotopes, atoms with same number of protons but different number of neutrons.

Integrated Water Resources Management, a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems

Integrated Urban Water Resources Management, a process that promotes the coordinated development and management of urban water, urban land and related urban resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

K

K value in pipe, a proportional coefficient between pressure drop (head loss) and square velocity of fluid flowing through valves and fittings like an elbow, bend, reducer, tee, pipe entrance, and pipe exit

Part A- Engineering

Kinetics of Disinfection, the rate of destruction of micro-organisms has been expressed by a first order reaction referred to as "Chick's law." Chick's law states that the rate of bacterial destruction is directly proportional to the number of organisms remaining at any time

L

Litres per Capita per Day, actual quantity of water in litres per capita per day (lpcd) supplied to the population

Long Range Wide Area Network, a low-power wide-area networking (LPWAN) technology that is designed to connect battery-powered devices over long distances with same uses as NB IOT.

M

Manholes, the commonly used maintenance utility underground structures to provide access to installed pipelines for inspection and cleanout. It is a vital component of the water supply and sanitary system, the basic underground utilities

Manometers, instruments for measuring the pressure acting on a column of fluid, consisting of a U-Shaped tube of a liquid in which a difference in the pressures acting in the two arms of tube causes the liquid to reach different heights in the two areas

Main Balancing Reservoir, used to regulate water distribution and pressure for the entire system. It is larger than zonal balancing reservoirs and are located at the headwaters of a water distribution system.

Membrane Desalination, the process by which salt and minerals are removed from water solution when it passes through a semipermeable membrane

Managed Aquifer Recharge, a water management approach that can be used to maximize natural storage and increase water supply system resilience during periods of low flows and high seasonal variability

N

NAQIUM, represents National Project on Aquifer Management implemented by Central Ground Water Board (CGWB) for the Mapping of Aquifers in India

Narrowband IoT, a low-power wide-area network (LPWAN) radio technology standard developed by 3GPP for cellular network devices and services. NB-IoT is used in a variety of IoT applications, including Asset Tracking, Smart Metering, Environmental Monitoring, Industrial automation and Smart city applications.

Non-Revenue Water, the water that has been produced and is "lost" before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies)

O

Over-exploited Unit, units where groundwater abstraction substantially exceeds (more than 100%) the annually replenishable ground water

Ozone, used to disinfect water and wastewater. It is produced when oxygen (O_2) molecules are dissociated by an energy source into oxygen atoms and subsequently collide with an oxygen molecule to form an unstable gas, ozone (O_3)

Ozonation, a type of advanced oxidation process, involving the production of very reactive oxygen species able to attack a wide range of organic compounds and all microorganisms

P

Parastatals, refers to a government entity or agency that operates independently of the formal government structure, but is ultimately accountable to the government such as semi- autonomous, state-owned, quasi-governmental, public enterprise, government-owned corporation, and statutory corporation

Pathogenic Organism, includes bacteria, viruses or cysts, capable of causing diseases (typhoid, cholera, dysentery) in a host (such as a person). There are many types of organisms which do not cause disease

Peak Factor, used to calculate maximum month, maximum day and peak hour water use conditions. It is typically expressed as a ratio, or peaking factor, dividing the peak water use by the average daily water use.

PERT Diagram, stands for program evaluation and review technique diagram. It provides a visual representation of a project's timeline and breaks down individual tasks. These charts are similar to Gantt charts, but structured differently. This diagram consists of a few steps to get you from a project start date to end date

Pesticides, chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds)

pH, a measure of acidic/basic characteristic of water. The range goes from 0 to 14, with 7 being neutral pHs of less than 7 indicate acidity

pH Meter, an instrument used to measure acidity or alkalinity of a solution.

Pneumatic System, collection of interconnected components using compressed air to do work for automated equipment.

Potable Water, water that is suitable for human consumption (i.e., water that can be used for drinking or cooking). The term implies that the water is drinkable as well as safe

Part A- Engineering

Pressure Filter, a process of separating a suspended solid such as a precipitate from the liquid in which it is already suspended by straining it – under pressure – through a porous medium that can be penetrated easily by liquid

Public-Private Partnership, a partnership between the public sector and the private sector for the purpose of delivering a project or a service traditionally provided by the public sector.

Pump House, building containing pumping equipment, thus, a building containing pumping equipment to provide the water supply from a well, spring, creek, or pond, water treatment plant, clear water reservoir, service reservoirs, etc.

R

RADAR, a device that sends out radio waves for detecting and locating an object by the reflection of the radio waves and that may use this reflection to find out the position and speed of the object

Radiography, X-ray, also referred to as radiography, enables NDT technicians to analyse the interior and exterior structure of pipes without having to alter or damage any components. X- ray inspections require having access to two sides of the pipe – one side to transmit radiation, and one side to record it

Recycled Water, water reuse (also commonly known as water recycling or water reclamation) reclaims water from a variety of sources then treats and reuses it for beneficial purposes such as agriculture and irrigation, potable water supplies, groundwater replenishment, industrial processes, and environmental restoration

Resilient, resilience is the ability of social-ecological systems to weather and recover from shocks while remaining adaptable to an uncertain future, and “water resilience” refers to those characteristics in a water system

Rejuvenation, restoration to its original or near original like structure

Remote Sensing, the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth

River Basin, the portion of land drained by a river and its tributaries. It encompasses all of the land surface dissected and drained by many streams and creeks that flow downhill into one another

Robotic, systems that provide intelligent services and information by interacting with their environment, including human beings, via the use of various sensors, actuators and human interfaces.

S

Safe Yield, the maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head or deterioration in water quality in the aquifer

Part A- Engineering

Sedimentation, a process of separating small particles and sediments in water. This process happens naturally when water is still because gravity will pull the heavier sediments down to form a sludge layer. However, this action can be artificially stimulated in the water treatment process

Simulation, the imitation of the operation of a real-world process or system over time

Specific Capacity of a Well, the pumping rate divided by drawdown at some time after pumping was started

Satellite Images, images of Earth collected by imaging satellites operated by governments and businesses around the world

Sanitation, system which includes the collection, storage, transportation, treatment and disposal or reuse of human excreta and wastewater

Supervisory Control and Data Acquisition, a system of software and hardware elements that allows organisations to control processes locally or at remote locations, monitor, gather, and process real-time data

Service Hazards, the potential risks to human health and the environment that can occur during the delivery of water to homes and businesses. These hazards can be caused by a variety of factors, including Contamination, Physical hazards, biological hazards and Chemical hazards.

Seepage, the flow of water or any fluid through the soil or ground

Sluice Valves, use a gate or a wedge-shaped disc to control and regulate the flow. This gate runs perpendicular to the flow of fluids into or out of the pipeline. The valve opens by lifting the gate out of the path of the fluids and enabling it to flow

Soil Resistivity, the measure of soil's capability to oppose, resist, and reduce the flow of electric current through it. Soil Resistivity is determined by its content of electrolytes which consist of moisture, minerals, and dissolved salts

Solar Stills, a device to desalinate impure water like brackish or saline water. It a simple device to get potable/fresh distilled water from impure water, using solar energy as fuel, for its various applications in domestic, industrial and academic sectors

Solar Pump, an application of photovoltaic technology which converts solar energy into electricity to run the pumping system thereby replacing erratic grid supply and pollution- causing diesel-powered versions

Solar Panels, a device which is used to absorb the sun's rays and convert them into electricity or heat

Spring, a natural opening in the ground where water emerges & flows directly from the aquifers to earth surface

Stakeholders, anyone who can affect or be affected by the urban water service delivery

Part A- Engineering

Static Head, sometimes referred to as the pressure head, is a term primarily used in Hydraulics to denote the static pressure in a pipe, channel, or duct flow

Storage Sumps, an underground (or partially underground) tank that is usually used for large water tank storage and can be built using cement-like materials.

Submersible Pump, a pump that can be fully submerged in water. The motor is hermetically sealed and close-coupled to the body of the pump. A submersible pump pushes water to the surface by converting rotary energy into kinetic energy into pressure energy

Surge Tank, a standpipe or storage reservoir at the downstream end of a closed aqueduct, feeder, dam, barrage pipe to absorb sudden rises of pressure, as well as to quickly provide extra water during a brief drop in pressure

Surge-Shaft, a structure provided at the end of headrace tunnel or pipe to account for water hammering effect in the pipe at its downstream

T

Tariff, price assigned to water supplied by a public utility through a piped network to its customers

Total Dissolved Solids, a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. TDS are often measured in parts per million (ppm). TDS in water can be measured using a digital meter

Telemetry, the automatic measurement and wireless transmission of data from remote sources. In general, telemetry works in the following way, Sensors at the source measure either electrical data, such as voltage and current, or physical data, such as temperature and pressure

Total Organic Carbon, total amount of organic carbon present in water

Transformer, a device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing (stepping up) or reducing (stepping down) the voltage

Turbidity Meter, technically known as nephelometers – emit light and measure the amount scattered by particles in the sample. The units depend on the wavelength of the light and the angle of the detector(s); the most common units are Nephelometric Turbidity Units (NTU) or Formazin Nephelometric Units (FNU)

Turbine Pump, a class of centrifugal pump which uses turbine-like impellers with radially oriented teeth to move liquids. Turbine pumps are commonly used in installations which require high head, low flow, and compact design. A vertical turbine pump commonly removes water from an underground well or reservoir.

U

Underground Tank, used to store treated disinfected water supplied from the ULBs for use by the residents of the building

Part A- Engineering

Urban Local Bodies, Municipal Corporation, Municipality or Town that administers or governs a city or a town of specified population Panchayat

Ultrafiltration, a variety of membrane filtration in which hydrostatic pressure forces a liquid against a semi permeable membrane. Suspended solids and solutes of high molecular weight are retained, while water and low molecular weight solutes pass through the membrane

Ultrasonic, vibrations of frequencies greater than the upper limit of the audible range for humans that is, greater than about 20 kilohertz. The term sonic is applied to ultrasound waves of very high amplitudes

Ultrasonic Pulse Velocity, an in-situ, non-destructive test to check the quality of concrete & natural rocks

Ultrasonic Water-meters, comes with two transducers which trigger sound waves. Sound waves determine the velocity of a water flowing in a pipe. Under no flow conditions, the frequencies of an ultrasonic wave transmitted into a pipe and its reflections from the fluid are the same

Unconfined Aquifers, aquifer where rock is directly open at the surface of the ground and groundwater is directly recharged, for example by rainfall or snow-melt. The upper water surface of unconfined aquifer is at atmospheric pressure

Up-Flow Filter, upflow units contain a single filter medium—usually graded sand. The finest sand is at the top of the bed with the coarsest sand below. Gravel is retained by grids in a fixed position at the bottom of the unit. The function of the gravel is to ensure proper water distribution during the service cycle.

V

Vertical Turbine Pumps, type of centrifugal pumps, also known as the vertical pump, deep well, or line shaft pump. They are designed to move water from underground wells or reservoirs

Variable Frequency Drive Pump, a type of drive that controls the speed, of a non-servo, AC motor by varying the frequency of the electricity going to that motor. VFDs are typically used for applications where speed and power are important.

W

Wastewater, water that has been adversely affected in quality by anthropogenic influence and comprises liquid waste discharged by domestic residences, commercial properties, industry and/or agriculture and can encompass a wide range of potential contaminants and concentrations

Water Audit, a systematic process of objectively obtaining a water balance by measuring flow of water from the site of water withdrawal or treatment, through the distribution system, and into areas where it is used and finally discharged

Part A- Engineering

Water Treatment, a process, device, or structure used to improve the physical, chemical, or biological quality of the water in a public water system

Water Distribution Networks, a part of water supply network with components that carry potable water from a centralized treatment plant or wells to consumers to satisfy residential, commercial, industrial and firefighting requirements

Water Quality Index, provides a single number that expresses the overall water quality, at a certain location and time, based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public

Z

Zonal Balancing Reservoir, used to regulate water pressure and distribution within that zone. It is typically smaller than main balancing reservoirs and are located within a specific zone of a water distribution system.

Zero Velocity Valve, consists of a spring-loaded closing disc for stopping reverse flow in case of failure of pumps. It is enclosed in an outer shell. As the forward velocity of water reduces to near zero, the springs close the disc on the seat and breaks the returning water column to prevent positive pressure surge

Zeolite, a mineral that can form into a variety of structures made of arrays of aluminium

PART A

Executive Summary

EXECUTIVE SUMMARY

1. INTRODUCTION

Safe drinking water is most essential for the human health and well-being of people in India. Contamination of drinking water gives rise to many water borne diseases like cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio. Adequate or appropriately managed water and sanitation services help to avoid preventable water borne diseases and health risks.

India's urban water sector is under immense pressure due to the increasing population, rapid urbanization and water scarcity. Inefficient management, aging infrastructure, contamination, and climate change further exacerbate the situation. ULBs are focusing on creation of infrastructure rather than improving service levels to ensure a sustainable and resilient urban water sector, transformative changes are required.

The objective of this revised manual is to provide comprehensive guidelines for effective planning, design, implementation, O&M and management of 24x7 Pressurised Water Supply System (24x7 PWSS) with drink from tap meeting drinking water quality standards, IS 10500:2012. This revised Manual aims at presenting a detailed analysis of the challenges faced by the Indian urban water sector and outlines strategies to achieve a successful transformation. It intends to serve as a guide to the field engineers, practitioners, administrators, managers engaged in the water supply sector. The Manual comprises of three parts Part A (Engineering), B (O&M) and C (Management).

The Part A of the Manual provides comprehensive guidelines for planning, investigation, design and implementation of water supply schemes to achieve 24x7 PWSS with *drink from tap* by converting existing intermittent water supply systems as well as planning, design and implementation of new water supply systems in urban areas. It also provides guidelines for planning, design and implementation of Regional Water Supply Schemes (RWSS) for both Urban and Rural areas.

The Executive Summaries of Part B and Part C Manuals are provided in the respective Parts of the manual.

2. PRESENT SCENARIO OF WATER RESOURCE AVAILABILITY

Table 1: Sector wise water demand (BCM)

Sector	2010	2025	2050
Irrigation	688	910	1072
Drinking water	56	73	102
Industry	12	23	63
Energy	5	15	130
Others	52	72	80
	813	1093	1447

Source:

<https://www.statista.com/statistics/report-content/statistic/1111839>

India is a home for 17% of the world's population but has only 4% of the world's freshwater resources. Every year India receives about 4,080 billion cubic meters (BCM) of water as annual renewable water resources. From the surface water and replenishable groundwater, 1,999 BCM water is available annually but only 60% of it can be beneficially used. Thus, India's total available water resource is 1,128 BCM out of which 690 BCM is surface water and 438 BCM is in the form of groundwater. The surface and groundwater approximately contribute 61% and 39% of total availability. In India, 90% of flow in the rivers occurs in 4 months of monsoon and 50% of this occurs in just 15 rainy days. As per the estimate the water resources availability will be 1191 BCM, whereas demand

for the water will be 1447 BCM by the turn of the year 2050 for all users like irrigation, drinking water, industry, energy and others. The sector wise water demand for different years is shown in Table 1. There is a gap of about 256 BCM. Hence, it is essential to bring reforms in the water sector with focus

on conservation of water through recycling of wastewater, rain water harvesting and control of NRW etc.

As per 2011 census the coverage of pipe water supply in urban areas was 71% NITI Aayog (2019) stated that 93% of India's urban population had access to basic water supply. The AMRUT Mission was launched by the Ministry of Housing and Urban Affairs (MoHUA) in 2015. Universal piped water supply coverage was the objective under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 500 cities of India. As of November 2023, 1.73 Crore new tap connections have been provided under AMRUT. AMRUT 2.0 was launched by MoHUA in October 2021 with an objective to provide water security and 100% functional tap connections in all cities and towns in the country with the target of 2.68 Crore connections till 2026.

One of the objectives of the AMRUT 2.0 is to provide 24x7 pressurized water supply system (24x7 PWSS) with the drink from tap facility in at least 1 zone or 2000 connections in 500 AMRUT cities. There lies a great challenge ahead to supply continuous water supply to every household with functional water tap.

Many cities in India are moving towards 24x7 PWSS with drink from tap facilities. While cities such as Puri, Malkapur, Alnawar, Kundagol, Thirthahalli, Indi etc. have successfully 100% converted their intermittent water supply system to 24x7 PWSS, some major cities are in the process of upscaling 24x7 PWSS. City of Vishakhapatnam has been implementing 24x7 PWSS for 3 Lakh population. Coimbatore and Nagpur also partly commissioned their supply to 24x7 PWSS partly. In Puri, Drink from Tap (DFT) is practiced and the Government of Odisha has embarked on its journey of Drink from Tap in 23 towns.

3. MAJOR TECHNICAL CHALLENGES IN URBAN WATER SUPPLY SYSTEMS

The Urban water supply systems are essential for sustaining urban growth and economic development. However, Indian cities are grappling with a range of challenges that impede the effective service delivery of clean and adequate water to their residents, which are as follows:

- a) Water security including Quantity and Quality
- b) Conversion of Intermittent water supply to 24x7 PWSS with Operational Zones (OZs) and District Metered Areas (DMAs)
- c) Strategy for Improvement of Drinking Water Quality
- d) Monitoring and Control of Non-Revenue Water (NRW)
- e) Effective Drinking Water Quality Monitoring and Surveillance
- f) Creation of database including Maps
- g) Achieving Service Level Benchmarks (SLBs)

4. ADDRESSING THE MAJOR TECHNICAL CHALLENGES

To ensure a sustainable and resilient urban water supply sector, transformative changes are required to address the above challenges. This Manual presents a detailed analysis of the major challenges faced by the Indian urban water supply sector and outlines strategies to achieve a successful transformation.

a) Water security including Quantity and Quality

Urban Water Security is defined as the dynamic capacity of the water system and water stakeholders to safeguard sustainable and equitable access to adequate quantities and acceptable quality of water, that is continuously, physically, and legally available at an affordable cost for sustaining livelihoods, human well-being, and socio-economic development. Water Security also ensures

protection against water-borne contamination, water-related disasters, and for preserving ecosystems. The Manual covers all the aspects of planning and design to make the system water secure from the source to distribution.

Success of the water supply scheme directly depends upon the potential and perennial water source, which must be 95% reliable and dependable. Selecting sustainable sources and developing the same is very crucial for any water supply system. The surface and ground water sources are to be identified, studied with respect to quantity and quality, and analysed for suitability. Once the suitability is established, various alternative ways to identify the location of source shall be studied and final selection is made. Further various alternatives/methods of treatment for different qualities of raw water are explained.

The planning in the water supply sector aims at creating schemes with a holistic/ comprehensive approach that helps in effective water resource planning through Integrated Urban Water Resource Management (IUWRM) which is a subset of Integrated Water Resource Management (IWRM). IUWRM emphasizes the need for city water balance and water conservation through rainwater harvesting, use of recycled water along with conjunctive use of surface and ground water sources. Effective IUWRM helps to achieve the goal of converting existing intermittent water supply to continuous 24x7 PWSS and covering uncovered areas to ensure adequate water source to every household.

b) Conversion of Intermittent water supply to 24x7 PWSS with Operational Zones (OZs) and District Metered Areas (DMAs)

In many urban areas, including cities and towns, the water supply is characterized by interruptions, where water is available for only a limited duration each day, typically ranging from 2 to 6 hours. This intermittent water supply system poses significant challenges. During the periods when water is not flowing through the pipelines, there is a risk of contamination of the drinking water within the distribution network. Additionally, this intermittent supply contributes to high levels of Non-Revenue Water (NRW), which essentially means water that is lost or unaccounted for, leading to an uneven and inequitable distribution of water resources among residents. To address these issues, a shift from traditional centralized planning to a decentralized approach is necessary, incorporating the concepts of OZ (Operational Zone) and DMAs (District Metered Areas). The Bureau of Indian Standards (BIS) code IS 17482:2020 provides the guidelines and standards for planning and designing OZs and DMAs, offering a structured framework for improving water supply management in urban areas. This transition is critical for ensuring reliable and equitable access to clean drinking water for all residents.

The Chapter 2 of Part A of this manual provides the detailed procedure for gradual conversion of intermittent system to 24x7 PWSS with drink from tap. This includes a procedure for determining optimum boundary of operational zone, establishing DMAs which are hydraulically discrete. The OZ and DMAs can be suitably planned using Geographic Information System (GIS) based hydraulic modelling. The Ministry (MoHUA) has published advisory on "GIS mapping of water supply and sewerage infrastructures," which may be followed by referring the Ministry's web site.

The size of OZ should not be more than 50,000 population (ultimate) or 10,000 connections for plain areas and for hilly areas, maximum ultimate population per OZ should be 30,000 or 6,000 connections. OZs are further divided into sub zones called as *District Metered Areas* (DMAs). The range of connections in DMA shall be 500-3000 connections in plain areas and 300-1500 in hilly areas. However, in saturated/ high density population areas where land is a constraint, the norm of 50,000 population per operational zone may be relaxed in plain areas and ultimate population up to

75,000 to 100,000 shall be considered in operational zone with proper justification. However, the number of DMAs may be suitably increased by restricting a maximum of 3000 household connections per DMA.

DMAs are progressively chosen for providing 100% consumer metering and with bulk meter at entry of each DMA. Leakages in chosen DMAs are identified, quantified, repaired and arrested. The leakages in all the DMAs should be stopped to enhance adequate water supply in 24x7 pressurised water supply systems.

As most of the ULBs have designed their distribution system for 7 or 12m residual heads, in the past increasing the residual pressure to 17-21m has been a challenge. One should not abruptly increase the residual pressure to 17-21m, but the pressure should be gradually increased in order to avoid sudden increase of leakages in the distribution system. In most of the cities elevated service reservoirs (ESR)s have not enough staging heights, so VFD pumps at the outlet of ESRs are suggested to increase the residual head. The detailed procedure is given in the Manual. Cities are advised to constitute NRW cell for effective monitoring and control of NRW.

c) Strategy for Improvement of Drinking Water Quality

It is the responsibility of the ULB/ Water Boards/ PHED etc. to supply water with adequate quantity & required pressure and acceptable quality meeting drinking water supply standards IS 10500: 2012 at every household. Following strategy shall be adopted for improvement of drinking water quality:

- i. **Contamination of drinking water in pipeline during non-supply hours:** It occurs during non-supply hours in intermittent water supply system when the pipeline is empty which attracts outside contaminants, thus contaminating water. The strategy is to provide continuous water supply with adequate pressure so that the entry of outside contaminants is prevented.
- ii. **Contamination of drinking water in customer underground tanks:** Customers construct underground (UG) storage tanks due to interrupted supply prevalent in the distribution system. In the past, the UG tanks were constructed with brick masonry where the joints in bricks are porous. Thus, not only the water leaks but it also allows outside contaminants to enter. Therefore, consumer UG tanks should be discouraged for the buildings up to the three storeys. The strategy is to provide continuous potable water supply with residual pressures of 17-21 m in case of Class I and II cities and 12-15 m for other and then subsequently remove UG tanks gradually. However, for high rise buildings, waterproof UG RCC/HDPE tanks are recommended with annual cleaning using chlorine.
- iii. **Contamination of water in pipelines through ferrule points of HSCs:** As per various studies conducted, about 70-80% leakages occur at ferrule points, which become the point of contamination. This manual emphasises use of standard quality ferrules and pipes in addition to employing the services of licensed skilled plumbers for giving HSCs.
- iv. **Contamination of raw water sources due to discharge of untreated wastewater:** Progressively over the past, the wastewater (partially treated or untreated) has been discharged into the water bodies. As the wastewater effluent and the pesticides leached from the agricultural fields discharged into the water bodies contain various contaminants including micro-pollutants, Endocrine Disrupting Chemicals etc., it is important to adopt high degree of treatment to protect the public health. Therefore, the conventional water treatment processes are ineffective to treat such variety of contaminants. The degree of treatment for raw water sources may be required to be enhanced with a judicious combination of appropriate treatment technologies by making additional investments. The suggested line of treatment options for contaminated surface water sources have been provided in Chapter 8.

d) Monitoring and Control of Non-Revenue Water (NRW)

Inefficient distribution systems, and unauthorized connections result in high levels of NRW. NRW is defined as the water that has been produced and is "lost" (leaks, theft or metering inaccuracies) before it reaches the customer. High value of NRW means lot of water is lost because of which the water utility gets less income, and the system becomes unsustainable. City requires all out efforts to reduce NRW level less than 15% by forming NRW cell.

DMA based approach ensures that the NRW reduction is achieved by monitoring the DMA level flows, pressures and quality. Metering along with automation will make the NRW and leakage control measured effective as the data will be real-time and used by the O&M personnel.

e) Effective Drinking Water Quality Monitoring and Surveillance

Drinking water quality monitoring is achieved by periodic sampling and analysis of water constituents and conditions. It is necessary to know whether water is contaminated physically, chemically and biologically. Thus, making arrangements for water quality monitoring and surveillance is a challenge. The water quality has to be maintained to ensure that the people can drink from tap. The Indian Standards and the resources needed for establishing a state-of-the-art water testing laboratory for effective testing and monitoring has been discussed in detail in the Chapter on Water Quality Testing and Laboratory Facilities.

f) Creation of database including Maps

There is apathy of creating maps of the water infrastructure. 24x7 PWSS with DFT needs information of the existing water system in the form of maps. Unfortunately, maps of existing pipelines laid below ground are not available in most of the Urban Local Bodies (ULBs). Hence, creation of database of water infrastructure and maps both in physical and digital form is essential for effective planning, design, implementation, operation & maintenance and management.

GIS based survey with consumer data will help in developing the Network Models. The conditional assessment data will help in designing the existing as well as proposed augmentation schemes to deliver 24x7 PWSS with DFT.

g) Achieving Service Level Benchmarks (SLBs)

The targeted Service Level Benchmarks (SLBs) for water supply were notified by MoHUA in the year 2008. While planning the water supply schemes, the ULBs shall carry out the survey of its city/town and find out the baseline parameters of the performance indicators. The gaps between the benchmarks and the baseline parameters shall be worked out and the DPR shall be prepared to bridge the gaps so that the benchmarks shall be attained. Some of the service level benchmarks such as 24x7 pressurised water supply, 100% metering, control of NRW, and quality of water supply shall be considered as Key Performance Indicators in the tender document. In addition to the above, residual nodal pressure shall be included in the tender document as KPI. All water supply projects should be implemented with the objective to achieve the aforesaid SLBs and monitor the same though out design period. It is to be noted that by conversion of intermittent water supply to 24x7 pressurized water supply (24x7 PWSS with DFT) most of the SLBs will be achieved.

The manual strongly recommends planning, design and implementation of water supply projects based on operational zones and DMAs. A multi-pronged, people-centric approach for conversion from existing intermittent water supply to 24x7 PWSS with DFT has been suggested in this manual.

This manual emphasises 100% household coverage with pipe water supply and metering with differential tariff based on volumetric consumptions for ensuring financial sustainability of the 24x7 pressurised water supply systems.

However, to ensure speedy implementation of 24x7 PWSS with DFT project, the city needs to prioritise the implementation of various project components in a phased manner. In this regard, it has been suggested that the cities should initially implement water distribution network in the project area or the whole city by considering OZs and DMAs with inlet and outlet arrangements (bulk flow meters, isolation valves, pressure valves, HSC up to boundary of the premises etc.) to facilitate better utilization of the capital investment available under time bound missions like AMRUT 2.0 or State Plan Funds. Immediately after the formation of OZs and DMAs, the cities shall initiate action to connect the house service connections with houses along with water meters for gradually achieving 24x7 PWSS in one after another DMA and upscale to project area or entire city in a phased manner as clubbing the laying of main distribution network and providing house service connection with meters simultaneously will delay the commissioning of the overall project.

5. COMPOSITION OF CHAPTERS

Part A of this manual comprises of 16 chapters and the brief details covered are as follows:

Chapter 1: Introduction provides the status of water supply in urban India, the issues and challenges in urban water supply sector, the demerits of intermittent water supply and the need for conversion of intermittent water supply to 24x7 PWSS with Drink from Tap facility and its merits, concept of decentralised Urban Water Supply System, Water Policies and Governance etc.

Chapter 2: Planning, Investigations, Design and Implementation provides guidelines on planning, design, implementation of 24x7 PWSS with DFT projects with Drink from Tap facility, gradual conversion of existing intermittent water supply to continuous pressurised water supply systems with retrofitting, norms for planning and design, concepts that should be adopted and the investigations that are necessary to be carried out for optimal planning and design with comprehensive management strategy. GIS based network modelling and the processes to be adopted are explained in detail. Various case studies of successful implementation of 24x7 PWSS with DFT are provided.

Chapter 3: Project Reports explains all the documentation needed at various stages of the project development, viz. from inception, pre-feasibility, feasibility and detailed engineering design stage. The templates/checklist of the information to be provided in the reports is included. This chapter also includes environmental, social and gender safeguard components which are very crucial for the implementation of projects and for availing funding assistance from multi-lateral agencies.

Chapter 4: Planning & Development of Water Sources provides guidelines for Planning and Development of Water Sources, assessment of surface and ground water, development of surface and sub-surface sources, ground water recharge methodologies. The objectives of Integrated urban water resource management and the need for city water balance plan has been explained in detail.

Chapter 5: Pumping Stations and Pumping Machinery provides guidelines on Pumping Station and Machinery. Pumping design principles along with designs, selection of best machinery/combination for efficient selection is explained in detail. Criteria for selection of pumps, variable frequency drive pump, energy efficient motors, pumps based on class, motor rating, pumping station, etc. and other design considerations are also explained.

Chapter 6: Transmission of Water, provides guidelines on the design of the transmission main system which supplies water to various service reservoirs. The transmission main should be

designed for equalization of pressure heads at the full supply level of each service tank. This ensures the equal distribution of water even in uneven terrain. The transmission system design along with sample design for economical selection of pipe diameter and material are discussed in this manual.

Chapter 7: Water Quality Testing and Laboratory Facilities provides a comprehensive guideline on Water Quality Testing and Laboratory Facilities to maintain and monitor the water quality of sources as well as drinking water surveillance in water supply distribution network. The Indian Standards and the resources needed for establishing a state-of-the-art water testing laboratory have been explained. The frequency of supply is also discussed in the chapter. The equipment, machinery, consumables, and manpower are thoroughly discussed.

Chapter 8: Conventional Water Treatment discusses various alternatives/methods of treatment process to be followed depending on the raw water quality and are explained with detailed design and examples for each component of the process chain including their advantages and disadvantages. It also presents computer aided optimal design of water aided system.

Chapter 9: Disinfection discusses disinfection methodologies and their benefits. The advantages and limitations of various disinfection methods, combinations of disinfections are also discussed.

Chapter 10: Specific Treatment Processes provides guidelines on specific treatments needed for sea water desalination, softening, removal of Arsenic, Iron, Manganese, Fluorides etc.

Chapter 11: Pipes and Pipe Appurtenances provides guidelines on various Pipes and Pipe Appurtenances. Laying, jointing, testing of pipelines, advantages and disadvantages for different pipe material have been explained. Different valves, manhole inspection and jointing have also been discussed.

Chapter 12: Service Reservoirs and Distribution System explains in detail the design of distribution system for OZs and DMAs, design and rehabilitation of existing distribution system and the service reservoirs with all concepts of network modelling, including network management and NRW reduction process by water estimating losses using water auditing process. It also describes various requirements and materials for providing HSCs and water meters.

Chapter 13: Water Meters provides guidelines on various types of water meters and flow meters with all the technical details and specifications. The installation, testing, calibration, repair and troubleshooting are also discussed.

Chapter 14: Automation of Water Supply Systems provides guidelines on various Automation instrumentation and systems used in various components of the water supply system, including Telemetry, SCADA, instrumentation, IoT, Digital Twin etc. The guidelines for controlling NRW in DMA are discussed with modern communication technologies.

Chapter 15: Water Efficient Plumbing Fixtures discusses the use of Efficient Plumbing fixtures for water conservation as per the Indian Standards 17650 (Part 1 and 2) have been explained.

Chapter 16: Planning and Design of Regional Water Supply System provides guidelines for planning, design and implementation of Regional Water Supply Schemes for Urban, Peri- Urban and Rural areas.