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Jawaharlal Nehru National Urban Renewal Mission
Ministry of Urban Development, Government of India

NON REVENUE WATER (NRW) REDUCTION TOOL KIT

June 2012

MY CITY MY PRIDE | JnNURM

Creating sustainable, equitable and economically vibrant cities

Jawaharlal Nehru
National Urban Renewal Mission

Government of India

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JnNURM

Preface

Jawaharlal Nehru National Urban Renewal Mission (JnNURM) is a reform driven infrastructure improvement programme that aims to create economically productive, efficient, equitable and responsive cities. The Government of India launched the JnNURM in 2005 with an overarching objective to strengthen and empower urban local bodies/municipalities and to catalyze investment, both public and private, for urban infrastructure and amenities. The Mission has been instrumental in driving ULBs across the country to advance their systems and procedures in order to create a visible improvement in quality and capacity of providing basic civic services to their citizens.

This tool kit highlights the prominent components of the Non Revenue Water (NRW) reduction processes in management of the efficient water supply projects. The tool kit also provides the idea of auditing water supply and calculating losses at various stages from the water treatment plant to the consumer's premise level. A comprehensive water audit enables the utility to identify problem areas and target the overall reduction of NRW. The combination of the increasing demand for water and its diminishing sources means that the reduction of water loss through leakage control is vital in urban India. The distribution network in the municipalities suffers from water loss, and it is only the amount of loss that varies. The volume of water loss depends on the condition of the mains and service connections that make up the network, factors such as the type of soil, operational practice, the type of material used, and the level of trained manpower. Many water supply pilot projects have already initiated the process of NRW reduction and many of them have achieved required level of reduction in NRW, while others are in process of targeting NRW reduction.

I hope the tool kit will provide an initial guidance to the officials engaged in providing water supply, and sector utilities' policy makers. This effort may be considered as a basic guideline for achieving the service level benchmark of NRW i.e. 20% in all the JNNURM cities. It is recommended that the tool kit be circulated to all officials and staff involved at each of the stages in the implementation and management of the water supply.

Nisha Singh
Joint Secretary & Mission Director
JNNURM

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1 Introduction:

1.1 What is NRW?

The difference between the amount of water put into the distribution system and the amount of water billed to customers is known as Non-Revenue Water (NRW).NRW is made up of real losses and apparent losses. Real losses occur in distribution systems, service connections, bursts and storage tanks (including overflow). Apparent loss includes meter and record inaccuracies and unauthorized water uses such as theft and unauthorized connections. Authorized unmetered uses can also be considered as one of the components of NRW.

1.2 NRW Bench Mark:

The service level benchmark for NRW is 20% whereas the actual extent of NRW in some cities as per a 2008-09 pilot project in service level benchmarking carried out by MoUD are as follows:

S.No.	Name of City	NRW (%)
1	Amritsar	57
2	Bangalore	50.9
3	Chandigarh	31.3
4	Ahmedabad	31
5	Berhampur	34
6	Bhopal	30
7	Bhubaneswar	69.5
8	Bokaro	63.6
9	Chandigarh	31.3
10	Delhi	55.3
11	Nashik	57.8
12	Dharamshala	6
13	Shimla	23.7
14	Trivandrum	18.2
15	Surat	20.4
16	Pimpri Chinchwad	24
17	Bhopal	30
18	Bokaro	63.6
19	Chas	42.6
20	Guntur	52.7
21	Hyderabad	37.5

It is thus obvious that the there is considerable scope for reduction of NRW. Though reduction of NRW is a very big challenge, there have been examples of successful reduction of NRW as observed from the cases of Singapore where the NRW is 5% and in Phnom Penh where NRW is 5.9%. In our country, though there are no major examples of successful NRW reduction at a city level, there are a few examples where an attempt has been made to reduce NRW with a fair degree of success.

These are as follows:

Hubli Dharwar, Karnataka	Hubli-Dharawar a demonstration project taken up for providing continuous pressurised water supply which resulted increase in hours of water supply from two hours every few days to 24 hours water supply with provision of individual accurate flow meters to all customers in the zone. Use of step test, and active leak detection resulted in NRW reduction from 50% to 7 % in pilot area.
Nagpur, Maharashtra	Dharampeth pilot zone was taken up for providing 24X7 water supply in March 2006, and 8349 consumer meters had been replaced. 24X7 water supply is ensured for 16019 connections. As a result, NRW reduced 32% from 50% (assessed before the commencement of the project). Costumer's complaints have been reduced and satisfaction level is increased.
Malkapur, Maharashtra	Use of high quality polyethylene material pipes to lay the 53.55 km of water mains ranging in diameter from 75 mm to 140 mm to supply the water to 3,000 houses in the Malkapur. It was an appropriate decision to use pipes of the highest quality and durability to ensure the long service life without interruption and minimize leakage. Consequently, Malkapur has reduced NRW from 40% to 12%.
Navi-Mumbai Maharashtra	The Navi-Mumbai Municipal Corporation is able to provide 24X7 water supply to around 50% corporation area including slums. The corporation introduced metering systems whereby 100% commercial/institutional connections and 50% of residential connections are metered. Its other achievements include reduction in non-revenue water from 51% to 21%.
Shastrinagar, Jamshedpur	District Metering Area (DMA) approach helped in analyzing the leaks in pilot zone. By adopting best practices to reduce leak repair time, close controlling on commercial losses by schedule accuracy testing of customer meters. Public awareness on metering policy, weekly illegal connection assessment and regularization has increased the public confidence. Better operational efficiency led to reduced water loss, and JUSCO has achieved reduction in NRW in pilot DMA from 31% to 8 % within 12 month.
Amravati, Maharashtra	Amrawati has been divided into three DMA zones and each zone taken up for providing 24x7 water supply. GIS based hydraulic models have been developed for each DMA and illigal connections tracked using GIS. Old pipe lines of 55 KM had been replaced, and an affordable conversation cost is kept for water connections which resulted NRW reduction from 50 % to 15 %.

The need to reduce NRW is well acknowledged in view of its potential to increase availability of water and also improve the financial viability of the utility. However, it has generally been observed that reduction of NRW has not been adequately prioritized in our country for various reasons including inadequate understanding of the problem (magnitude, sources, costs); lack of capacity (insufficient trained staff); Inadequate funding to replace infrastructure (pipes; meters); lack of management commitment; and weak enabling environment and performance incentives.

2 Purpose of the toolkit:

The purpose of this toolkit is to assist the ULBs in preparing an effective Non Revenue Water Reduction (NRW) reduction strategy while proposing water supply projects under JNNURM. The expected outcomes of the implementation of an NRW reduction strategy include the following:

1. Reducing water loss and minimizing inefficient use of water can defer major investments required for the development of new water sources as also the associated environmental impacts;
2. NRW reduction could be one of the major solutions to overcome inequitable supply and increasing supply/demand gap;
3. More coverage, reliability and quality of services can be achieved by increased water availability which can result in greater customer satisfaction.
4. Utilities can improve their financial viability;
5. Reducing leakages and improving the quality of networks would help reduce the risk of contamination of water supplied to consumers; and
6. More efficient and sustainable utilities improve the customer service.

3 Elements of NRW reduction strategy:

3.1 Water Audit & Water Balance:

Determining the exact volume of NRW is the first challenge. One of the foremost steps to be taken for the reduction of NRW is the establishment of a standard water balance through an annual water audit. A Water Balance is based on measurement or estimation of system input, water produced, imported, exported, used and lost etc to quantify the revenue and non revenue water in the water network. Water audit for water supply is done by calculating the difference between the amount of water produced and the amount sold i.e. metered sales, and then calculating the difference. Elements of the audit include;

- Record of the amount of water produced;
- Record of the amount delivered to metered users;
- Record of the amount delivered to unmetered users;
- Record of amount of water loss; and
- Measures to address water loss.

Annexure-I gives the details. Water audit has been implemented in India in the following cases:

- **Bangalore –** Water audit was conducted using ultrasonic bulk flow meters and areas with high volume of water supply were identified and water was diverted to water scarce areas.
- Under the **Maharashtra Sujal and Nirmal Abhiyan** which is a reforms linked programme for the water and sanitation sector in Maharashtra, 11 ULBs **(Sillod, Degloor, Majalgaon, Kinwat, Nilanga, Panchagani, Panhala, Ramtek, Kalmeshwer, Sailu, Sonpeth)** have done their water audit and it was found that the losses range from 87% to 76%.

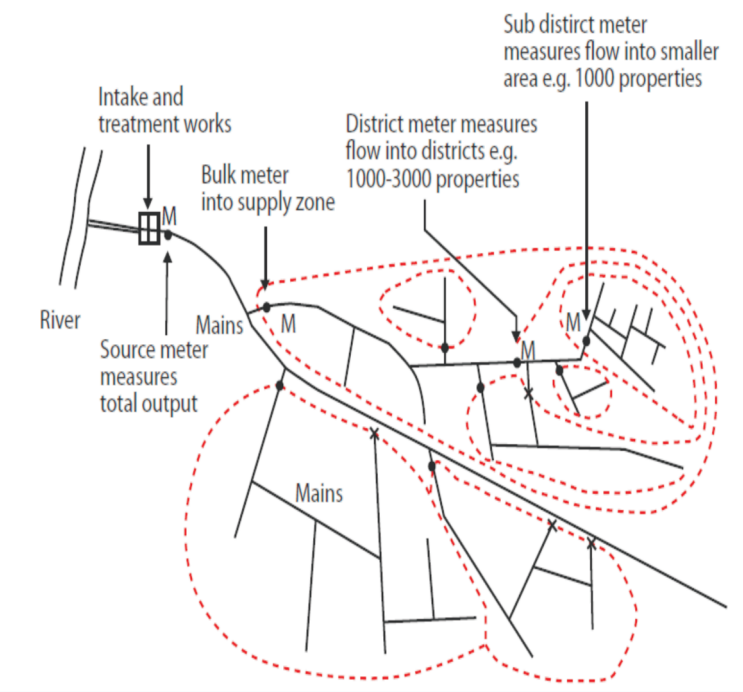
3.2 24X7 water supply:

Other spin off is 24x7 water supplies is achieved when water is delivered continuously to every customers of the service 24 hours a day, every day of year , through a transmission and distribution system that is continuously full and under positive pressure throughout all of its pipelines and networks. One things is a common to all water distribution systems-intermittent water supplies are a considerable danger to health and preclude any possibility of practicing service efficiency and cost-effectiveness. The negative aspect of this can be avoided by converting to 24X7 water supply. 24X7 is stated to ensure the hygienic quality of treated water by eliminating the incidence of empty pipelines. On the other hand, it also enables the identification and elimination of all visible leaks.

Improvement in the quality, coverage and operational efficiencies and effectiveness is an important target sector of the JNNURM. There are many references to water supply in the sector, conversion to 24X7 supply and reduction in Non Revenue Water (NRW). Conversion from intermittent to 24X7 supply is fundamental to the achievements of the objectives of the JNNURM relating to water supply. Increased supply leads in a large way to availability of increase services & public satisfaction.

3.3 District Metered Area (DMA):

The distribution network should incorporate a District Metered Area (DMA) approach typically with 2000-5000 connections in each DMA. Each DMA is a hydraulically separate portion of the network isolated from neighboring DMAs by a system of boundary valves and preferably fed with water from a single point on its boundary. A meter chamber is built in the inlet to the DMA and flow into the area is continuously metered. A pressure control valve is installed at more



than one point as per the site requirements. Analysis of water flow and pressure, particularly in the night when most users are not drawing water enables leakage specialists to identify leakages and calculate the level of leaks in the DMA. This can be used to determine not only whether work should be undertaken to reduce leakage, also to compare levels of leakage in the different DMAs and thereby take up the required maintenance.

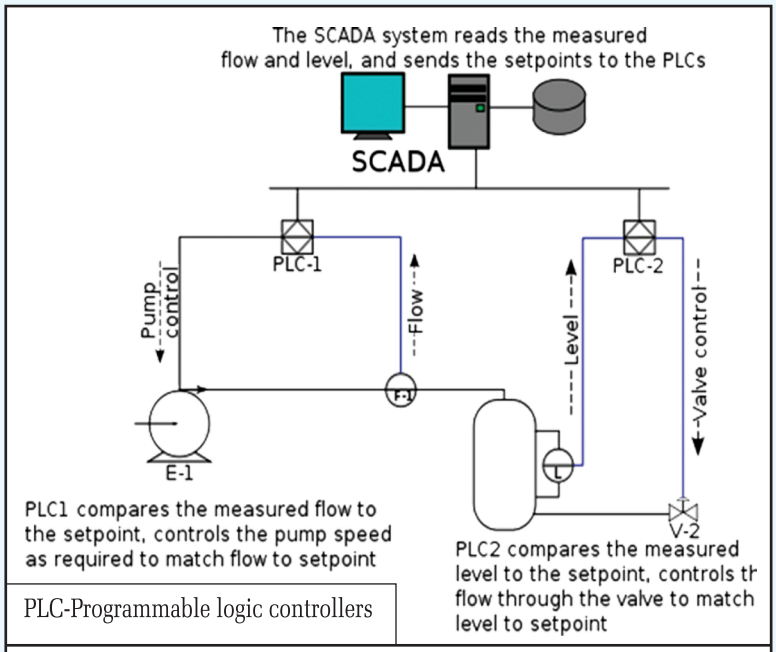
Criteria for initial DMA design;

- Size of DMA - number of connections;
- Number of valves- must be closed to isolate the DMA;
- Number of flow meters- to measure inflows and outflows;
- Ground-level variations and thus pressures within the DMA; and
- Easily visible topographic features that can serve as boundaries for the DMA.

The DMA approach not only facilitates NRW reduction also helps maintain assets for a longer duration and enables better service delivery through better pressure management, better water quality and continuous water supply. Designation of the licensed plumbers in a particular DMA for installation of fresh connections and repairs must be established for smooth management of water supply, and they may be responsible for any illegal water connections in the area. DMA approach has been adopted in **Surat, Pune, and Navi Mumbai** successfully.

3.4 Supervisory Control and Data Acquisition (SCADA):

Supervisory Control and Data Acquisition (SCADA) is a monitoring system that allows an operator to monitor and control processes that are distributed among various remote sites. It enables better data collection related to the water flow in the system which in turn enables better assessment of NRW. Such operational NRW can then be reduced by implementing measures such as installation of more flow meters, better operations and preventive maintenance. There are quite a few examples of installation of SCADA in the country. The SCADA system consists of servers having SCADA software and the three following elements:



SCADA schematic overview

a) **The master terminal unit (MTU);** The master terminal unit which is responsible for communication gathers data, stores information, sends information to other systems, and interfaces with operators.

b) **The remote terminal unit (RTU);** The function of remote terminal units is to gather information from remote sites from various input devices like valves, pumps, alarms, meters, etc.

c) **The communications equipment;** Communication equipment is required for two way communications between an RTU and the MTU.

The potential benefits of use of SCADA include;

- It allows the utility or operator to monitor and control processes that are distributed among various remote sites;
- Better grievance redressal since the condition of the water system and the water quality is known to the operators well before customers;
- Reduced number of man-hours to troubleshoot a pump or other electrical device that do not operate as designed;
- Automated report generation. ;
- Reduced operating costs which can translate into an increased return on investment for utilities; and
- A single data server can support multiple communications protocols and supervise many DMAs at a time which helps the leakage management team to prioritize repairs.

In Vijayawada, installation of SCADA led to elimination of overflows and inflow and outflow leakage at reservoirs and scheduling of cleanup of reservoirs. SCADA has been used successfully in other cities such as **Pimpri-Chinchwad, Hyderabad, Pune, Jamshedpur, Ahmadabad, Surat, Lucknow, Kanpur, and Nagpur**.

3.5 Network mapping:

Adoption of network mapping by preparing "as built" drawings and carrying out hydraulic modeling from time to time can facilitate NRW reduction. There must also be a Unique Id/ common Id that links all utilities in the vicinity. For example pipes, valves, valve chambers should have road Id. Sewerage pipe lines, electricity lines, telephone cables on the same road should also have the same road id. This will come in handy during regular O&M operations and during emergency breakdowns. Net work drawings also enable the maintenance staff to get accurate information about the location of valves, joints, flow meters and alignment of the water lines even after a long time, which will in turn save time and money in repairs etc. It involves a combination of finding out old drawings, getting information from valve operators etc. The GIS map should also be linked to other data base such as property map data by linking the house service connection numbers to the property numbers. By achieving this data connectivity billing, consumption analysis, payment potential could be easily ascertained. This will also yield valuable information when it comes to tariff revision.

Amravati city has prepared a water supply net work using satellite image and Malkapur has also adopted GIS based mapping successfully.

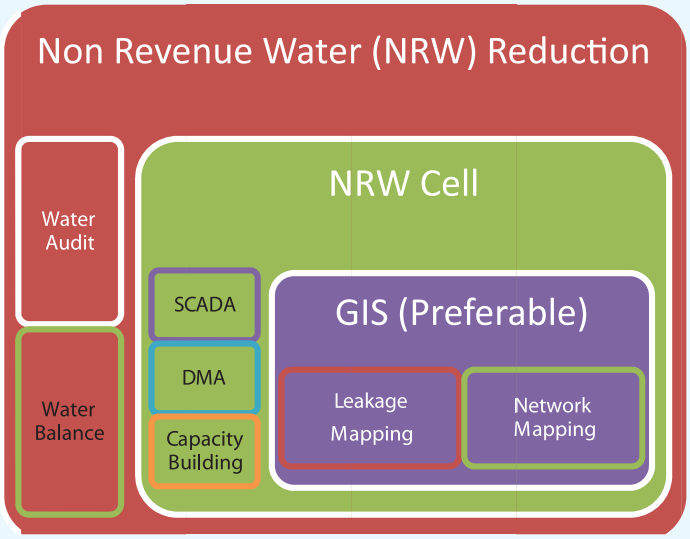
3.6 Leakage mapping:

In Surat city, leakage mapping has been attempted based on the actual number of complaints received. Locations of leakages are identified and maps are prepared showing such locations. It was found that the central zone was more prone to leakage due to older pipelines. Accordingly, replacement of pipelines was carried out and there is a significant reduction in the number of complaints due to this effort. For the city as a whole, the number of leakages has come down by almost 32% per year.

3.7 Regularization of Public Stand Posts (PSP):

Amravati, Maharashtra has successfully replaced PSPs with individual connections. This has also been done in **Malkapur, Vijayawada, Bhilai, Raipur,** etc. By taking this step, the cities are in a better position to account for the number of consumers as well as the consumption. Further, it is well acknowledged that higher number of PSPs invariably leads to greater wastage of water. Some of the cities have simplified legal procedures and reduced connection charges to enable a wider cross-section of consumers to obtain household connections, and thereby reduce illegal connections in the regular network. Promoting indivisible embossed high quality taps for slums, and EWS families, instead of public stand posts. This has resulted in improvement of revenue collections and reduction of technical losses.

3.8 NRW Cell:



Establish separate NRW monitoring & training cell at ULB level for imparting training to all water supply system staff and for monitoring reduction of NRW in each zone /DMA/system/ plant / unit / facility etc. **Surat** Municipal Corporation has established a NRW cell. The main objective of this cell is to enhance the efficiency of the transmission and distribution network, ensure equitable distribution of water and conduct water audit every 3 years. Every ULB must work out an annual NRW reduction plan which will document the actual steps that will be taken to reduce NRW. This plan should be reflected in the performance targets assigned to each zone or any other unit and taken into account for performance appraisal of staff.

A state level NRW cell can be set up with the following responsibilities:

- Procurement of services;
- Procurement of hardware;
- Conducting training programs;
- Preparation of model NRW reduction strategy;
- Incentivizing reduction of NRW by the ULB as has been attempted in the case of the

Maharashtra Sujal and Nirmal Abhiyan where capital grants from the state government are linked to efforts to reduce NRW;

- Intention to pursue a 24X7 water supply conversion programme;
- Establishment of operation & management plan and emergency repair teams;
- Developing a protocol for fresh connections;
- Setting of volumetric tariff structure;
- Ensuring universal access to water supply, and 100% metering of connections.
- Ensure the protection of the valves, taps, covers, pipes etc and valuable materials such as water meters by theft.
- Ensuring peoples participation, and providing free guidance & technical assistance to costumers to reduce NRW/ leakage within customer's premises; and
- Promote use of non-corrosive material suiting to specific service requirements.

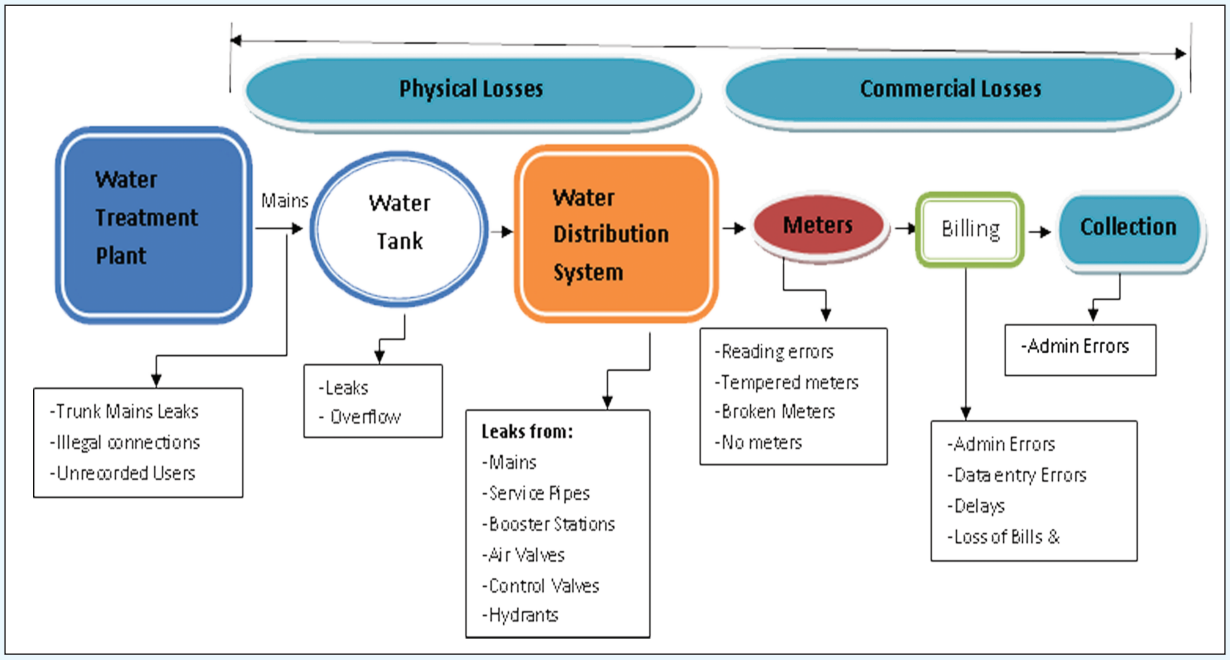
3.9 Capacity building:

Focus on public awareness generation and capacity building at all levels. The NRW cell mentioned above can initiate **"Certified plumber training programs"** to make available skilled plumbers for providing leakage proof water connections and quick repairs of leakages to reduce NRW as per engineering norms. **Annexure-II** gives the details list of institution conducting courses water supply in India.

3.10 Tariff Structure:

A tariff structure is a set of procedural rules that determine the services and charges for various categories of users. Tariff should reflect the true cost of consuming water so as to avoid wastage. An efficient tariff should be affordable but should also be efficiently designed to cover the cost of production incurred by the utilities. Tariff structures should be volumetric and should incorporate the principle of "Increasing block tariff" in order to incentivize conservation.

3.11 Flow Chart to help Staff understanding the NRW Components



4 Elements to be included in the DPR:

As a first step to operationalize NRW reduction, it would therefore be necessary for DPRs to incorporate the following:

4.1 NRW baseline assessment:

1. Whether water audit has been carried out and a water balance has been prepared?
2. Whether NRW has been quantified in flow and financial terms?
3. Whether a household survey has been undertaken in the last three years to update the customer database, and identify billing errors, connections status etc?
4. Whether the city has functional bulk flow meters to ascertain quantity of water supplied to the network (ex-treatment), and also for intermediate flow monitoring?
5. Whether the city has introduced metering at the consumer level, and also adequate systems for maintenance of meters?

4.2 NRW reduction strategies:

6. Whether the distribution network envisages a DMA approach and if so whether extant principles for formation of DMA have been followed?
7. Whether the need for a computerized network management system (e.g. SCADA) was examined and if not incorporated in the DPR, whether reasons for not doing so have been indicated?
8. Whether network mapping has been included in the DPR?
9. Whether a system for Leakage mapping based on complaints has been instituted /envisaged in the utility?
10. Whether the DPR envisages a program for identification and reduction of illegal connections and replacement of public stand posts with individual household level piped connections? This would include an assessment of institutional, procedural and financial barriers to provision of household connections and strategies to overcome the same.
11. Whether capacity building measures for NRW reduction have been identified and incorporated in the DPR (e.g. creation of a well resourced NRW Cell with requisite leak detection systems)?
12. Whether annual target for NRW reduction is declared and whether this has been analyzed further zone-wise or DMA-wise?
13. Whether use of leakage detection equipment has been envisaged to determine the exact location of the leakage in order to initiate corrective action. If yes, details are provided.

4.3 Work Plan for NRW reduction:

5 Case Studies in NRW reduction:

5.1 Case 1- Jamshedpur, Jharkhand:

Jamshedpur Utilities & Services Company Ltd. India (JUSCO) is an integrated civic service provider. JUSCO implemented a pilot project in NRW reduction in Shastrinagar using the DMA approach. The details of the DMA are as follows:

- No of connections: 1040
- Population: 7322
- Average daily consumption: 115 lpcd
- Supply time: 24*7
- Total length of water network: 8 km
- DMA input meter: K 25

The **actions taken included** identification, measurement, recording and analyzing leaks, pressure monitoring at pilot zone, public awareness on metering and metering policy, weekly illegal connection, assessment, and regularization, automatic meter reading for bulk connections, setting up of test bench for assessing meters, development of DMA manual etc.

JUSCO has achieved reduction in NRW from thirty one percent to eight percent within twelve months in pilot DMA. The current eight percent loss of Pilot DMA can be reduced

further by adopting best practices to reduce the leak repair time, and close controlling of commercial losses by accurate testing of customer meters. Initiatives learned from the pilot DMA will be rolled out to other DMAs.

Difficulties faced during the implementation of the pilot project:

- Metering: opposition from public due to political reasons;
- Illegal connection drive: political interference;
- Delay in payment from consumers for new water connections; and
- Opposition from very high water consumption cases (five percent); and
- No support from Government for new area connections.

Lessons learnet:

- There is a need for discussion with public, politicians and more intense community engagement;
- Penalties can be waived for un-authorized connections found during metering;
- Billing based on meters can be taken up after the first 3 months, so that consumers can assess meters / consumption pattern;
- Meter rental cost can be reduced;
- DMA Managers to be trained in identification and measuring leaks, overflows, illegal connections.

5.2 Case- 2: Malkapur, Maharashtra

The Malkapur Nagar Panchayat is located in Buldhana district of Maharashtra state. The Malkapur water supply system is the first public sector initiative in India that operates to provide water on round the clock basis. Malkapur is known for its enterprising farmers and an efficient cooperative sector for managing sugar mills, lift irrigation systems, milk production, and collection and selling. In 2010, a project was undertaken by the Malkapur Nagar Panchayat (MNP) and Maharashtra Jeevan Pradhikaran (MJP). Important outcomes of the project are as follows:

- Malkapur twenty four by seven water supply system is successfully supplying water round the clock to the entire town with one hundred ten liters per capita per day (lpcd) supply;
- Consumption of water has reduced the consumption by nearly thirty percent;
- The operational cost of the system has decreased by INR seventy five thousand per month;
- Revenue generation has drastically increased to show a surplus of INR four lakh per annum instead of existing deficit of INR thirty lakh;
- PSP has been totally eliminated;
- NRW reduced from 40 percent to 12 percent; and
- Citizens do not have to pump water, and water quality has improved.

Steps taken:

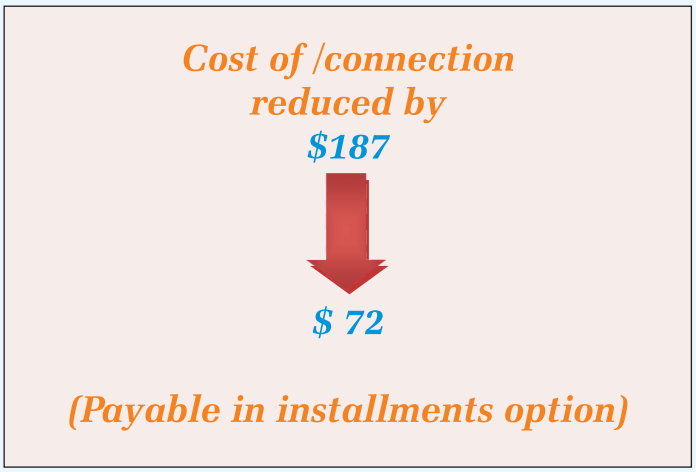
- WaterGEMS hydraulic model software was used to design a new distribution net work from source to consumer's door step; this software model gives the pattern of uses of water in different times of the day.

- All customers were identified through a consumer survey in the initial stages of the project as a result of which illegal connections were identified and regularized.
- A volumetric tariff structure and well targeted subsidies were introduced. To complement this, Automatic Meter Reading (AMR) system was introduced.
- Annual billing cycle has been replaced by monthly billing cycle.
- Skill development programmes for employees have been conducted at different levels.
- Systematic leakage control methods were deployed to reduce commercial and non-commercial losses. These measures have resulted in reducing the Non revenue water (NRW) level from forty percent to twelve present.
- Use of HDPE pipes resulted in reduction of water losses and increases the durability of the net work.
- SMS alerts for details of water charges, water consumption and payment dues have improved revenues.

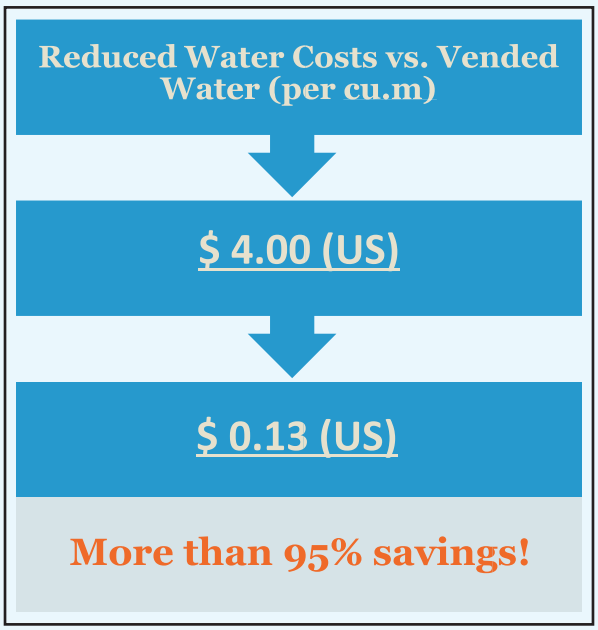
The project has received the Prime Minister's Award for Excellence in Public Administration in 2009-2010 and the Urban Water Awards for Technical Innovations awarded by the Ministry of Urban Development (MoUD), Government of India in December 2011.

5.3 Case-3: The world largest NRW management programme - Manila water supply:

Manila, one of the most heavily populated capital cities in the world, suffers from high levels of NRW. Before 1997, the system loss was 66% i.e. 1000 MLD. Only 26% of population was getting 24x7 water supply. There was a vicious cycle of low coverage, low water tariffs, unwillingness of customers to pay, poor collection, very low cash flows, and under investment. A severe drought hit the country in year 1998, and left the majority of Manila residents without water for several days. This prompted the government to pass the National Water Crisis Act. Under the Act, the state-owned Metropolitan Waterworks and Sewerage System (MWSS) was open for bidding. The government entered into concession agreements for the East Zone and West Zone of Manila. The focus of the agreement was to improve service delivery, expand coverage, increase operating efficiencies and tariff mechanism to address the issue of investment risk, inflation risk, foreign currency differential adjustment, and unforeseen risks like extraordinary price adjustment efficiency indicators were set to evaluate the performance of distribution network, water quality, and service quality.



Currently Manila Water is serving about 6.1 million customers, and 99% of customers connected to the distribution network are able to access 24X7 water supply. Non-Revenue Water (NRW) has reduced from 66% in 1997, to 11.2 % in 2011, saving over 700 million liters of water per day.



Key to success:

- Strong support from top management;
- Sufficient funding and manpower;
- World class advisors - and a young and motivated local team;
- Holistic strategy - not only relying on pipe replacement;
- Significant transfer of know-how and technology; and best equipment and software systems

Annexure I

Water Balance matrix:

A Water Balance is based on measurements or estimations of water produced, imported, exported, used and lost. The water balance chart is the tool used to enhance a meaningful water audit report.

International Water Association (IWA) Operation and Maintenance Specialist Group has set performance indicators to assess the water loss and to quantify the components of NRW. The IWA task force has produced an international standard for water balance calculations;

<table>
<tr><td rowspan="8">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="4">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td><td rowspan="6">Non-Revenue Water</td></tr>
<tr><td>Metering Inaccuracies and Data</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

The various steps in conducting a water audit would be as follows:

Step 1 – Determining System Input Volume-the annual volume input to the water supply system.

Step 2 – Determining Authorized Consumption-the annual volume of metered and unmetered water taken by the customers;

i. Billed Metered Consumption
ii. Billed Unmetered Consumption
iii. Unbilled Metered Consumption
iv. Unbilled Unmetered Consumption

Step 3 – Estimating Apparent Losses- unauthorized Consumption, all types of metering inaccuracies and systematic data handling errors;

i. Unauthorized Consumption
ii. Customer Metering Inaccuracies and Data Handling Errors

Step 4 – Calculating Real Losses- the annual volumes lost through all types of leaks, breaks and overflows on mains, service reservoirs and service connections, up to the point of customer metering;

Step 5 – Estimating Real Loss Components

i. Leakage on Transmission and/or Distribution Mains successfully implemented in Surat, Malkapur, Nagpur

ii. Leakage and Overflows at Utility's Storage Tanks

iii. Leakage on Service Connections up to Point of Customer Metering.

Water Balance Definitions:

In the following, all terms used in the water balance are listed in hierarchical order—as one would read the water balance form from left to right. Some of the terms are self-explanatory, but are still listed and briefly explained.

- **System Input Volume:** The volume of treated water input to that part of the water supply system to which the water balance calculation relates. It may come from a utility's own sources and treatment facilities or from external bulk suppliers. It is important to note that water losses at raw water transmission schemes and losses during the treatment process are not part of the annual water balance calculations. In case the utility has no distribution input meters, or they are not used and the key meters are the raw water input meters, the system input has to be based on the raw water meters but must be adjusted by treatment plant water use. In either case, the measured volume has to be corrected for known systematic bulk meter errors.
- **Authorized Consumption:** The volume of metered and/or unmetered water taken by registered customers, the water utility, and others who are implicitly or explicitly authorized to do so for residential, commercial, and industrial purposes. This also includes water exported across operational boundaries. Authorized consumption may include items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered, or unmetered.
- **Water Losses:** The difference between system input and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones. Water losses consist of physical losses and commercial losses.
- **Billed Authorized Consumption:** Those components of authorized consumption that are billed and produce revenue (also known as revenue water or billed volume). This is equal to billed metered consumption plus billed unmetered consumption.
- **Unbilled Authorized Consumption:** Those components of authorized consumption that is legitimate but not billed and therefore do not produce revenue. This is equal to unbilled metered consumption plus unbilled unmetered consumption.
- **Commercial Losses:** Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus

unauthorized consumption (theft or illegal use).

- **Physical Losses:** Leakage and other physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer use. In metered systems, this is the customer meter. In unmetered situations, this is the first point of use (stop tap/tap) within the property.
- **Billed Metered Consumption:** All metered consumption that is billed. This includes all groups of customers, such as domestic, commercial, industrial and institutional, and also includes water transferred across operational boundaries (water exported) that is metered and billed.
- **Billed Unmetered Consumption:** All billed consumption that is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example, billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water transferred across operational boundaries (water exported) that is unmetered but billed.
- **Unbilled Metered Consumption:** Metered consumption that is for any reason unbilled. For example, this might include metered consumption by the utility itself or water provided to institutions free of charge, including water transferred across operational boundaries (water exported) that is metered but unbilled.
- **Unbilled Unmetered Consumption:** Any kind of authorized consumption that is neither billed nor metered. This component typically includes items such as firefighting, flushing of mains and sewers, street cleaning, frost protection, etc. In a well-run utility, it is a small component that is very often substantially overestimated. Theoretically, this might also include water transferred across operational boundaries (water exported) that is unmetered and unbilled (although this is an unlikely case).
- **Unauthorized Consumption:** Any unauthorized use of water. This may include illegal water withdrawal from hydrants (for example for construction purposes), illegal connections, bypasses to consumption meters, or meter tampering and under-reading of customer meters because of meter reader corruption.
- **Customer Metering Inaccuracies and Data Handling Errors:** Apparent water losses (water that is only "apparently" lost but causes a loss in revenues) caused by customer meter inaccuracies and data handling errors in the meter reading and billing system.
- **Leakage on Transmission and/or Distribution Mains:** Water lost from leaks and breaks on transmission and distribution pipelines. These might either be small leaks that are not visible at the surface (e.g., leaking joints) or large breaks that were reported and repaired but did leak for a certain period before that and contribute therefore to the annual volume of physical losses in a particular year.
- **Leakage and Overflows at Utility's Storage Tanks:** Water lost from leaking storage

tank structures or overflows of such tanks caused, for example, by operational or technical problems.

- **Leakage on Service Connections up to Point of Customer Metering:** Water lost from leaks and breaks of service connections from (and including) the tapping point until the point of customer use. In metered systems, this is the customer meter; in unmetered situations, this is the first point of use (stop tap/tap) within the property. Leakage on service connections might sometimes be visible but will predominately be small leaks that do not surface and run for long periods (often years).
- **Revenue Water:** Often called billed volume, includes those components of authorized consumption that are billed and produce revenue (also known as billed authorized consumption). This is equal to billed metered consumption plus billed unmetered consumption.
- **Non-Revenue Water:** Those components of system input that are not billed and do not produce revenue. This is equal to unbilled authorized consumption plus physical and commercial losses.
- (Unaccounted-for Water) Because of the widely varying interpretations and definitions of the term "Unaccounted-for Water," it is strongly recommended that this term no longer be used.

Annexure II

List of Institutes providing certification courses:

1. Certification Programme in Plumbing / Water Supply, Annamalai University, Directorate of Distance Education, Annamalai Nagar, Tamilnadu-608002. http://www.annamalaiuniversity.ac.in/

2. Indian institute of Plumbing, 3, Siddhivinayak Apartments, 4, Sanewadi Aundh, Pune-411007, +91-20-25896958, http://www.iapmoindia.org

3. Indian institute of Plumbing, No. 22, 12th "B" Main, HAL 2nd Stage, Indiranagar, Bengaluru – 560008, Karnataka, India, +91-80-30714500

List of Institutes providing M.Tech Courses in Public Health Engineering (PHE)

Duration: 4 semesters/ two years

4. The Director, Veermata Jeejabai Technological Institute, Matunga, Mumbai-400019 (Prof.J. S.Main/Dr. V.M. Topkar, HoD, Civil Engg. Department) Tel. No.022-4146972-6 (5 Lines), Fax: 022-4152874

5. The Director, Centre for Environmental Studies, Anna University, Guindy, Chennai-600025 (Dr. A.N. Gopalakrishnan, Director CES), Tel. No. 044-22354296, 22203192, Fax: 04422354717 / 22201480, E-mail: angkrishna@annauniv.edu, angkrishna@hotmail.com

6. The Director, Sri G.S. Institute of Technology & Science, 23, Park Road, Indore-452003 Dr. D.J. Killedar, Prof. CE-AMD), Tel. No. 0731-2534095 Extn.153 (O), Fax: 0731-2432540, E-mail:director@sgsits.ac.in

7. The Director, Motilal Nehru National Institute of Technology, Allahabad-211004 (Sh.Suresh Kumar Tiwari, Registrar) Tel No: EPABX-0532 2545933, 2545651, 2545752, 2545653 Fax: 0532-2545341, 2545077, www.mnnit.ac.in

8. The Director, Visvesvaraya National Institute of Technology, Nagpur-440011 (Prof. D.J. Katyayan, Co-ordinator), Tel No. 0712-2801206 Fax: 0712-2222828, E-mail: director@vnit.ac.in, ssg1@vnit.ac.in, www.vnit.ac.in,

9. The Director, Malaviya National Institute of Technology, Jaipur-302017 (Prof. B.L. Swami, HoD Department of Civil Engg.) Tel. No. 0141-2529062, 2529002, Fax No.: 0141-2529029 E-mail: academic@mnit.ac.in

10. The Director, Indian Institute of Technology, Bombay Powai, Mumbai-400076 (Prof.Krishna Rao, HoD, Department of Civil Engg.) Tel.No.022-25767301 Fax: 022-25767302 E-mail: hod@civil.iitb.ac.in

11. The Registrar, Indian Institute of Technology, Kharagpur, Kharagpur-721302 (Head of Department, Deptt. of Civil Engg.) Tel.03222-282052, Fax: 03222-55239/255303 E-mail: asregpgr@adm.iitkgp.ernet.in

12. The Registrar, Indian Institute of Technology, Delhi Hauz Khas, New Delhi-110016 (Dr. Arvind K. Nema, Co-ordinator), Tel: 011-26596423, Fax:011-26581117 E-mail: aknema@civil.iitd.ac.in

13. The Principal, Sri Jayachamarajendra College of Engineering, JJS Technical Institute Campus, Mysore-570006 (Prof. Manoj Kumar, Co-ordinator) Mobile No. 09886544263, Tel No.0821-2548285, 2548289 (Extn.2399), Fax: 0821-2548290, E-mail:manoj_kumar_b@hotmail.com, www.sjce.ac.in

14. The Director, Jawaharlal Nehru Technological University, Institute of Science & Technology, Kukatpally, Hyderabad-500085 (Prof. C. Sarla, HoD, Co-ordinator), Tel./Fax: 040-23155412, E-mail:cwr_jntu@yahoo.com, www.jntuh.ac.in

15. The Director, All India Institute of Hygiene & Public Health, 110, Chittaranjan Avenue, Kolkata-700073 (Dr.R.C.Srivastava, Prof.& Head, Deptt. Of Sanitary Engg.) Tel.No: 2241-850, E-mail: rcsrivastava5@rediffmail.com

List of Institutes providing short term courses (STC) in PHE:

Duration of the course: three months:

16. The Director, Centre for Environmental Studies, Anna University, Guindy, Chennai-600025 (Dr. A.N. Gopalakrishnan, Director CES), Tel. No. 044-22354296, 22203192, Fax: 04422354717/22201480, E-mail: angkrishna@annauniv.edu, angkrishna@hotmail.com

17. The Principal, Sri Jayachamarajendra College of Engineering, JJS Technical Institute Campus, Mysore-570006 (Prof.Manoj Kumar, Co-ordinator) Mobile No. 09886544263, Tel No.0821-2548285, 2548289 (Extn.2399), Fax: 0821-2548290, E-mail:manoj_kumar_b@hotmail.com, www.sjce.ac.in

List of the 21 institutes conducting refresher courses (RC) in PHE:

1. **The Director**
Visvesvaraya National Institute of Technology (VNIT),S.A.Road, Nagpur-440011,(Maharashtra)
Dr.V.A.Mhaisalkar (Course Coordinator)
Tel:0712-2801371, 2801338
Mobile:09822291701
Fax:0712-2223230
E-mail:vasantmhaisalkar@yahoo.com

2. **The Principal**
Sri Jayachamarajendra College of Engineering (SJCE), Mysore - 570006 (Karnataka)
Dr.B.G.Sangameswara
(Course Coordinator)
Tel: 0821-2548285/2548289
(Extn.2399)
Fax:0821-2548290
Website:www.sjce.ac.in
E-mail:bg.sangam@yahoo.com

3. **The Regional Director**
All India Institute of Local Self Govt,,
Near Palika Bhawan, 4, Shivaji Nagar,
Bhopal-462016
Sh. S.K. Sharma
(Course Coordinator)
Tel: 0755-2762289/2550861
Fax: 0755-2552862
E-mail: bhopal@aiilsg.org

4. **The Director General**
All India Institute of Local Self Govt.,
Sthanikraj Bhawan, C.D. Barfiwala Marg,
Andheri (West), Mumbai – 400058
Sh. B.V.Wakhure
(Course Coordinator)
Tel: 022-26571713/26571714
Fax: 022-26572115
E-mai: aiilsg@bom3.vsnl.net.in
Web.:www.aiilsg.org

5. **The Chief Engineer, PH (Urban)**
Public Health Department
Government of Orissa
Heads of Department Building
Bhubaneshwar – 751001
Er.M.R.Nanda
Ex. Engg. PH Div.-II
(Course Coordinator)
Mob:09437007990
Tel:0674-2542821
Tel/Fax:0674-2396935

6. **The Managing Director**
Kerala Water Authority
Water Works Campus
Thiruvananthapuram - 695033
Ex. Engg. (Training)
(Course Coordinator)
Tel: 0471-2321381
Fax: 0471-2324903

7. **The Deputy Director**
Public Health & Preventive
Medicine, Institute of Public Health
Poonamallee, Chennai – 600056
Dr. G.Thamaraiselvi
(Course Coordinator)
Tel: 044-26272062
E-mail: dphpme@tn.nic.in

8. **The Chief Chemist**
P.H.E. Department
Government of Rajasthan
Gandhinagar, Jaipur - 302015
Mr. S.K. Mishra
(Course Coordinator)
Tel: 0141-2706569

9. **The Joint Chief Engineer (RDT)**
T.W.A.D. Board, TWAD House,
31, Kamarajar Salai, Chennai – 600005
Dr. P. Rajamarthandan (Dy.Chief Engg.Trg.) (Course Coordinator)
Tel: 044-28416420 Extn.405
044-28416423 Extn.405
Fax No. 044-28548623/28525501
Mob.No. 09444543657
E-mail: dcetrgho@gmail.com

10. **The Chief Engineer**
Municipal Corporation of Greater Mumbai, Civic Training Institute & Research Centre, Abhinav Nagar,
Borivali (East), Mumbai - 400066
Chief Engg.(Course Coordinator)
Tel:022-28973708 / 28974587 / 28977561, Fax:022-28963978,
E-mail:che.ctirc@mcgm.gov.in

11. **The Vice-Chancellor,**
Banaras Hindu University
(IT-BHU),Varanasi- 221005
Dr. G.Banerjee
Civil Engineering Department Institute of Technology (Course Coordinator)
Tel:0542-2307016
Telefax: 0542-2368283
E-mail:goutam_itbhu@yahoo.co.in

12. **The Director**
Motilal Nehru National Institute of Technology (MNNIT), Allahabad – 211004,Uttar Pradesh
Sh. Suresh Kumar Tiwari,
(Course Coordinator)
Tel: 05322545933, 2545752, 2545653
Fax: 0532-2545341, 2545077
www.mnnit.ac.in

13. **The Director**
Centre for Environmental Studies
Anna University, Guindy Campus
Chennai – 600025
Dr. N. Vasudevan
(Course Coordinator)
Tel. 044-22354296/22359009
Fax: 044-22354717
E-mail: cesau2008@gmail.com

14. **The Director**
Sri G.S. Institute of Technology & Science,
23, Park Road, Indore – 452003
Dr. D.J. Killedar
(Course Coordinator)
Mob.: 09893260094
Tel: 0731-2534095 Extn.153
Fax: 0731-2432540
E-mail: director@sgsits.ac.in

15. **The Secretary**
Rajasthan Institute of Local Self Govt.,
Tonk Road, Jaipur - 302015
Secretary, RILSG (Course Coordinator)
Tel:01412710806 / 2705119

16. **The Regional Director**
All India Institute of Local Self Govt.,
22-23 Institutional Area, D-Block,
Janakapuri, New Delhi – 110058
Sh. Lojy Thomas(Course Coordinator)
Tel: 011-28521783/28525465
Fax: 011-28522117
E-mail: delhi@aiilsg.org
Web: www.aiilsgdelhi.org

17. **Secretary General**
Institute of Public Health Engineers,
CK-58, Salt lake City, Kolkata – 700091
Shri S.K. Neogi
(Course Coordinator)
Tel: 033-23588068
Fax: 033-23588058
E-mail: iphe.india@gmail.com
Website: www.ipheindia.org

18. **The Director**
All India Institute of Hygiene & Public Health (AII&PH) ,
110, Chittaranjan Avenue
Kolkata - 700073
Dr. R.C. Srivastava
(Course Coordinator)
Mobile: 09433842101
Tel: 033-22412860/3831(PBX)
E-mail: rcsrivastava5@rediffmail.com

19. **The Director**
Gujarat Jalseva Training Institute,
Gujrarat Water Supply & Sewerage Board,
Sector-15, 'G' Road,
Gandhinagar-382016
Shri V.A.Patel
(Course Coordinator)
Tel: 079-23223941-7(7 lines)
Fax: 079-23223243

20. **The Superintending Engineer**
Research & Training Centre,
Maharashtra Jeevan Pradhikaran,
I.S.P. Road, Near Divisional Commissioner's Office,
Nashik Road-422101
Sup. Engg.
(Course Coordinator)
Tel. No.: 0253-2462512
Fax: 0253-2464436
E-mai: senrtc@yahoo.co.in

21. **The Deputy Director**
Resource Centre, Metro Water Training Centre, Chennai Metropolitan Water Supply & Board,
No. 56, Raji Street, Ayanavaram,
Chennai-600023.
Dy. Director (Trg.Centre)
(Course Coordinator)
Tel: 044-26473326/2644611
Fax: 044-26473326
E-mail: cmwssbrc@yahoo.co.in

List of refresher courses to be sponsored by the ministry during 2012-13

Central Public Health and Environmental Engineering Organisation (CPHEEO)
Nirman Bhawan, Ministry of Urban Development, GoI, New Delhi
http://cpheeo.nic.in/

S.No	Name of the refresher course	Place	Agency	Duration	Month	Eligibility	Remarks
1	Water Works Supervisors Course	Nasik Road	R & T.C.,	4 weeks	August	Outstation candidates	No course fee
2	-do-	Palasuni	P.H. Deptt.	4 weeks	Nov. Dec. 2012	-do-	from their
3	Water Works Management (Junior level)	Thiruvanan Thapuram	K.W.A.	3 weeks	November-2012	Not eligible	-do-
4	Water Supply System Management	Chennai	TWAD Bd.	1 week	August 2012	Not eligible	-do-
5	-do-	Nasik Road	R & T.C., MJP	10 days	September-2012	-do-	-do-
6	Pipes & Conduits	Nasik Road	do	12 days	September-2012	-do-	-do-
7	Pipes & Conduits	Mumbai	C.T.I.&R.C. M.C.G.B	9 days	December 2012	-do-	-do-
8	New Development in Water Treatment	Kolkata	AIIH&PH	10 days	January 2013	-do-	-do-
9	Structural Design on Water Treatment Plants and other Related Structure	Nagpur	V.N.I.T.	1 week	Nov., 2012	-do-	-do-
10	Water Treatment Plant Design	Nagpur	V.N.I.T.	1 Week	Jan. 2013	-do-	-do-
11	Public Health Engineering Structures	Chennai	TWAD Bd.	9 days	November 2012	-do-	-do-
12	Waste Stabilisation Pond Practices	Kolkata	AIIH&PH	1 week	October 2012	-do-	-do-
13	do	Chennai	TWAD Bd.	-do-	January 2013	-do-	-do-
14	Filter Operation	Nasik Road	R&TC, M.J.P.	10 days	February-2013	-do-	-do-
15	-do-	Chennai	C.M.W.S.S. Board	12 days	-do-	-do-	-do-
16	Care & use of Chlorinators	Mumbai	C.T.I.&R.C., M.C.G.B.	1 week	January-2013	-do-	-do-
18	Water Analysis	Kolkata	AIIH & PH	4 weeks	Nov-2012		-do-
19	Waste Water Analysis	---do--	-do-	-do-	February,2013	-do-	-do-
20	Water & Waste Water Analysis	Jaipur	P.H.E.D.	4 weeks	February,2013	-do-	-do-
21	Chemical Analysis of Water	Chennai	TWAD Bd.	7 days	February,2013	Not eligible	-do-
22	Solid Waste Management	Kolkata	AIIH&PH	10 days	February 2013	Not eligible	-do-
23	Solid Waste Management	Bhopal	AIILSG	1 week	Nov./Dec. 2012	-do-	-do-
24	Solid Waste Management	Allahabad	MNNIT	-do-	Feb, 2013	-do-	-do-

S.No	Name of the refresher course	Place	Agency	Duration	Month	Eligibility	Remarks
25	Preventive Maintenance in Water distribution System Leak Detection	Nashik Rd	R & T.C., M.J.P.	10 days	January	-do-	-do-
26	-do-	Mumbai	C.T.I.&R.C., M.C.G.M.	1 week	February	-do-	-do-
27	-do-	Chennai	T.W.A.D. Board	10 days	October 2012	-do-	do-
28	Corrosion Control	Chennai	C.M.W.S.S. Board	1 week	November 2012	-do-	-do-
29-A	Total Quality Management	Batch I	Thiruvanan thapuram	K.W.A.	1 week	September-2012	-do-do-
29-B	-do-Batch II	- do -	- do -	- do-	January, 2013	-do-	do-
30	Computer aided design of pipelines and pipe network for water supply and sewerage systems	Nagpur	V.N.I.T.	1 week	November	-do-	-do-
31	Computer Application in PHE Structures Design	Indore	S.G.S.I.T.& S.	10 days	February 2013	-do-	-do-
32	Sewage Works Supervisors Course	Chennai	C.M.W.S.S. Board	2 weeks	December-2012	-do-	-do-
33	Low Cost Sanitation	Chennai	I.P.H.	1 week	September-2012	-do-	-do-
34	-do-	Jaipur	R.I.L.S.G.	-do-	Dec., 2012	-do-	-do-
35	Rain Water Harvesting	Kolkata	I.P.H.E.	-do-	September-2012	-do-	-do-
36	Cathodic Protection	Mumbai	C.T.I&R.C, M.C.G.B.	1 week	October,2012	-do-	-do-
37	Sewer Cleaning and Maintenance		--do--	9 days	November-2012	-do-	-do-
38	Computer Application for Water Distribution	Mysore	S.J.C.E.	-do-	October, 2012	-do-	-do-
39	Computer Aided Design of Computer	New Delhi	AIILSG	10 days	October,2012	-do-	-do-
40	Application for Water Distribution System Management	Chennai	Anna University	10 days	February 2013	-do-	-do-
41	Computer Application for Water Distribution System Management	Mumbai	A.I.I.L.S.G.	10 days	February 2013	-do-	-do-
42	Computer Aided Design of Water and Waste Water treatment plants	Allahabad	MNNIT	1 week	November-2012	-do-	-do
43	Scientific Source Finding	Gandhinagar	G.J.T.I.	1 week	Dec.,2012	-do-	-do-
44	Maintenance & Management Related to Municipal Water Works	Chennai	TWAD Bd	1 week	December, 2012	-do-	-do-
45	Surface drainage in small and medium towns	Bhopal	A.I.I.L.S.G.	1 Week	September, 2012	-do-	-do-
46	Laying of Water Mains & Sewer Lines	Chennai	CMWSS Bd.	1 week	February	-do-	-do-

S.No	Name of the refresher course	Place	Agency	Duration	Month	Eligibility	Remarks
47	Ground Water	Kolkata	I.P.H.E.	1 Week	November, 2012	-do-	-do-
48	Treatment of Arsenic, Iron & Fluoride in drinking water	Kolkata	I.P.H.E.	1 Week	Feb. 2013	-do-	-do-
49	Operation and Maintenance of W.S. and Sanitation projects	Kolkata	AIIH & PH	10 Days	November-2012	-do-	-do-
50	Water Quality Surveillance	Mysore	S.J.C.E.	12 Days	November, 2012	-do-	-do-
51	Positive preventive Maintenance of Water Supply and Sewerage system	Bhopal	AIILSG	1 week	December-2012	not eligible	-do-
52	Pumping & Non Pumping Mains for Water Supply System-Design, Operation & Maintenance	-do-	-do-	1 week	Jan. 2013	-do-	-do-
53	Total Quality Management in Water Supply system	-do-	-do-	1 week	November-2012	-do-	-do-
54	Water Supply from Ground Water Sources - Quantity / Quality and Ground water Recharge	-do-	-do-	-do-	October,2012	-do-	-do-
55	Preparation of Water Supply Projects	-do-	-do-	-do-	September, 2012	-do-	-do-
56	Tenders & Contract	-do-	-do-	-do-	January, 2013	-do-	-do-
57	Pump and Pumping Machinery for Public Health	Kolkata	IPHE	-do-	Feb.2013	-do-	-do-
58	Engineering Jobs and Wastewater Treatment	-do-	-do-	-do-	September-2012	-do-	-do-
59	Governance of Urban Water Supply & sanitation	Allahabad	MNNIT	1 week	December, 2012	-do-	-do-
60	Recent Water Treatment Technology and Quality	-do-	-do-	-do-	January, 2013	-do-	-do-
61	Chemical Analysis of Sewage	Chennai	TWAD Board	7 days	Oct./Nov., 2012	-do-	-do-
62	Bacteriological and Biological Examination of Water	-do-	-do-	5 days	February, 2013	-do-	-do-
63	Water Quality Management	-do-	-do-	-do-	January,2013	-do-	-do-
64	Testing of Chemicals required for water treatment	-do-	-do-	4 days	November,2012	-do-	-do-
65	Recent Development in Water Treatment Technology	Varanasi	IT, BHU	10 days	December, 2012	-do-	-do-

Abbreviations		
1	R & T.C	Research & Training Center
2	M.J.P	Maharashtra Jeevan Pradhikaran
3	K.W.A.	Kerala Water Authority
4	P.H.Deptt.	Public Health Department
5	T.W.A.D. BD.	Tamil Nadu Water Supply and Drainage Board
6	A.I.I.H.&P.H.	All India Institute of Hygiene and Public Health
7	M.N.N.I.T.	Motilal Nehru National Institute of Technology
8	V.N.I.T.	Visvesvaraya National Institute of Technology
9	C.T.I.&R.C.	Civic Training Institute and Research Centre
10	M.C.G.B.	Municipal Corporation of Greater Mumbay
11	P.H.E.D.	Public Health Engineering Department
12	A.I.I.L.S.G.	All India Institute of Local Self Govt.
13	S.G.I.T.& S.	Shri G.S. Institute of Technology and Science
14	C.M.W.S.S.B	Chennai Metropolitan Water Supply and Sewerage Board
15	I.P.H.	Institute of Public Health
16	I.P.H.E.	Institution of Public Health Engineers
17	R.I.L.S.G.	Rajasthan Institute of Local Self Govt.
18	S.J.C.E.	Sri Jayachamarajendra College of Engineering
19	G.J.T.I.	Gujarat Jalseva Training Institute
20	I.T, B.H.U.	Institute of Technology, Banaras Hindu University

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5. WHAT IS SCADA? A. Daneels, CERN, Geneva, Switzerland, W. Salter, CERN, Geneva, Switzerland;
6. Non-Revenue Water reduction Contracts and illustrated examples, Paul Fanner;
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