Views of the Elluru Canal Bridge from the banks of river Krishna

7

TRANSPORT AND INFRASTRUCTURE STRATEGIES

This chapter presents the transportation and infrastructure strategies proposed for the Amaravati Capital city.

The chapter covers the following topics:
1. Transportation Strategy
2. Flood Management
3. Water Supply
4. Waste Water
5. Solid Waste, and
6. Power Supply


Well planned Road network


MRT network

BRT network


Pedestrian Friendly Environment


Water Treatment Plants


Composing Plants


Recycling Centres


Electrical Substations

7.1 INTRODUCTION

The new Capital city, Amaravati is an almost Greenfield site and is therefore lacking in infrastructure. Major investment in transportation and infrastructure is required in the coming years to prepare the site as the new Capital of Andhra Pradesh.

The transportation and infrastructural requirements, planning intention and objectives have been identified in this master plan. This is to guide the future detailed studies that will be conducted to develop detailed transportation and infrastructure plans for the Capital City.

These recommendations have been included in the land use master plan in order to reserve appropriate land space for infrastructure development.

7.1.1 Transportation

Existing Requirements:

Below are the key requirements that have been identified for the transportation sector:

- Developing a conceptual integrated land-use transport planning model with emphasis on public transport.
- Reducing reliance on private transport and increase the public transport share.
- Creation of traffic discipline for the city.
- Multi agencies involvement in planning, implementing, regulating, operating and maintaining the city's transportation systems.
- Exploring the financial resources for implementing the planned projects.

Concept/Planning Intention:

Integrated land-use transportation system will demonstrate the global standards to offer high levels of convenience to people of all ages. The sustainable urban transport system will form a unique identity for the new capital.

Planning Objectives:

The planning objectives for the transportation infrastructure in the Amaravati Capital city include:

- To develop world class integrated transport infrastructure systems with facilities for seamless travel in line with rapid urbanization.
- To develop the concept of multi-modal transport network connectivity which could be adopted for all parts of India.
- To plan, coordinate and implement Travel Demand Management (TDM), Traffic System Management (TSM) techniques.
- To create institutional framework and resources mobilization mechanism for implementation, operation and maintenance of planned transportation projects.
- To develop and encourage Transit Oriented Development (TOD) areas, Non-Motorized Transport (NMT) friendly road networks with commuter affordable, safe systems.

7.1.2 Infrastructure

Existing key issues/challenges:

Below are the key issues that have been identified for the infrastructure sector:

- Flooding issues in the Kondaveeti Vagu catchment in the monsoon season due to heavy rainfall.
- Unreliable water supply system, especially in the dry seasons.
- Lack of modern sanitation and formal sewerage system.
- Lack of comprehensive waste collection system and solid waste treatment facilities.
- Unreliable power supply system and outdated overhead power transmission lines.

Concept/Planning Intention:

The Amaravati Capital city aims to develop an economically sustainable and smart liveable city, which is supported with world class infrastructure facilities and services.

Planning Objectives:

The planning objectives for the infrastructure in the Amaravati Capital city include:

- To prevent flooding in the Amaravathi Capital city.
- To provide reliable, sufficient, and clean potable water with 24X7 water supply for all households.
- To develop a separate and comprehensive sewerage network with high quality treatment disposal System.
- To promote Zero Waste concept, and to achieve Waste as a Resource to recover energy from Waste.
- To accomplish reliable, adequate, efficient and quality power supply.

7.2 TRANSPORTATION STRATEGY

One of the primary goals for the new Amaravati Capital city is to provide world class infrastructure for its residents. The following section proposes road and public transportation strategies that will help in achieving this goal.

7.2.1 Road Network - Efficient Grid

A grid network is proposed for the new Amaravati Capital city. The grid network comprises roads designed and classified based on functions and capabilities. Fig.7.1 shows the proposed road hierarchy matrix.

For classification of roads (As prescribed by the Urban and Regional Development Plan Formulation and Implementation Guidelines URDPFI 2014) were identified and used as the major classes of roads in the Master Plan. They are:-

- Urban Expressway
- Arterial
- Sub-arterial, and
- Collector

Unclassified roads such as local and access roads are not identified at Master Plan level, however detailed guidelines for local roads should be prepared to guide developers during development control. The proposed grid network will also be sub-categorised based on the level of social interaction, in line with international practice to create streets for people in urban settings.

Urban Expressways

- Two urban expressways, which connect NH5 and NH9, are proposed to serve the Capital city.
- The main urban expressway will provide circulation along the fringe of the city, therefore allowing through-traffic to bypass the Capital city Core.
- The downtown road will provide a traffic route from the main urban expressway to the CBD
- Speeds along urban expressway are generally high to minimise travel time along the expressways
- Major Industrial Zones to be located near the expressways

Arterial Road Network

- An arterial and sub-arterial network is developed to ensure mobility between the major areas within the City i.e. CBD, commercial zones, major townships and transport hubs.
- The arterial network also serves as the major transit corridors, especially for rapid transit systems
- The sub-arterial network supports the arterial network, and is the primary access to township development zones
- Infrastructure mains are to be located within or adjacent to the arterial network to ensure access to utilities
- Traffic speeds along arterial roads should be maintained at 40-60kmh.

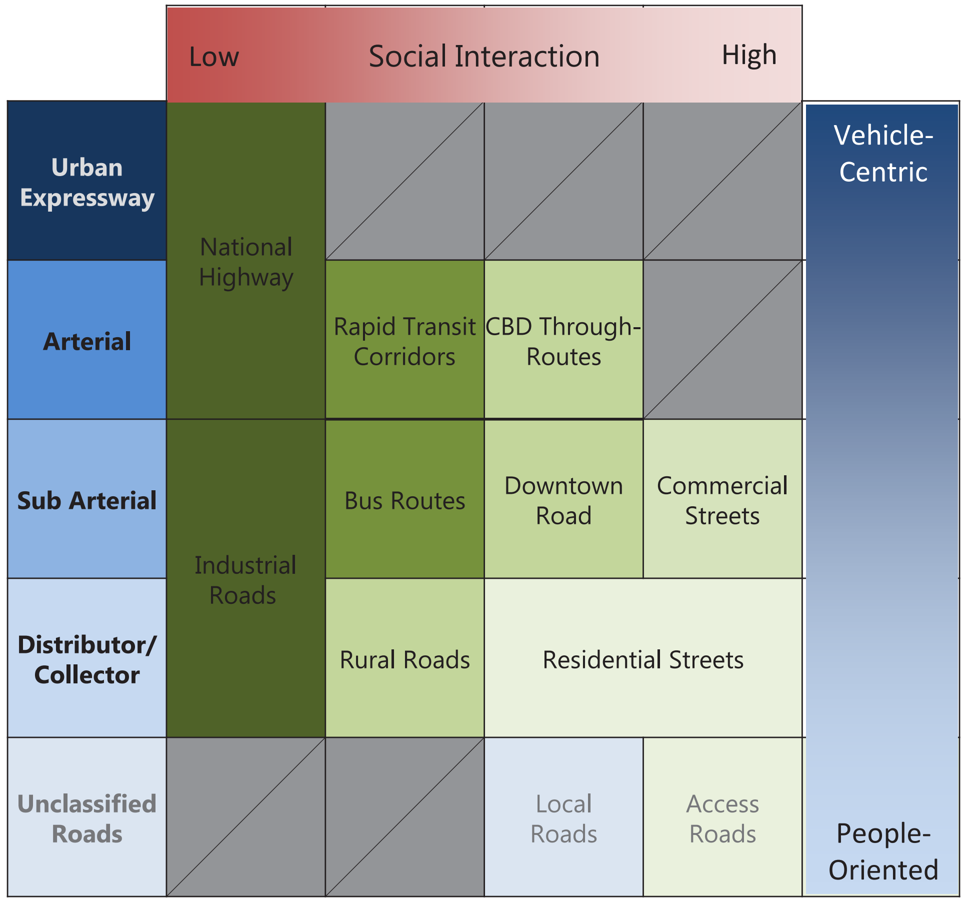


Fig.7.1 Proposed Road Hierarchy Matrix for Amaravati

Fig.7.2 Example of a Grid Road Network - Barcelona

Urban Expressway

Arterial Road

Sub-Arterial Road

Collector Road

Fig.7.3 Examples of Proposed Road Types

Collector Road Network

- The collector road network is the main distributor of traffic at neighbourhood level.
- Access to developments are to be gained from the collector roads.
- Access and Local roads are to be connected to the collector road network
- Collector roads are to be generally designed for higher social interaction, and therefore speeds should be limited to no more than 40kmh, depending on context.
- Village Roads are to be integrated to the Collector Road network

The figures below show the conceptual hierarchy defined for the residential and industrial plots.

Standard Road Elements

The road elements for these road cross-sections need to cater for all users.

In the expressway and arterial roads, the cross-sections should cater for higher vehicular volume, whereas in the sub-arterial and collector roads, emphasis should be given to the public and non-motorised transport users, particularly pedestrians and cyclists, and bus and rapid transit riders.

For the purposes of this master plan, the road widths for the defined roads are set as shown in Fig.7.6.

Road cross-section standardisation can help to ensure road elements are included at this master planning level. To do this, road design guidelines have been developed for use in the master plan (see Table 7.1). These guidelines may be further refined based on the local authority's requirements.

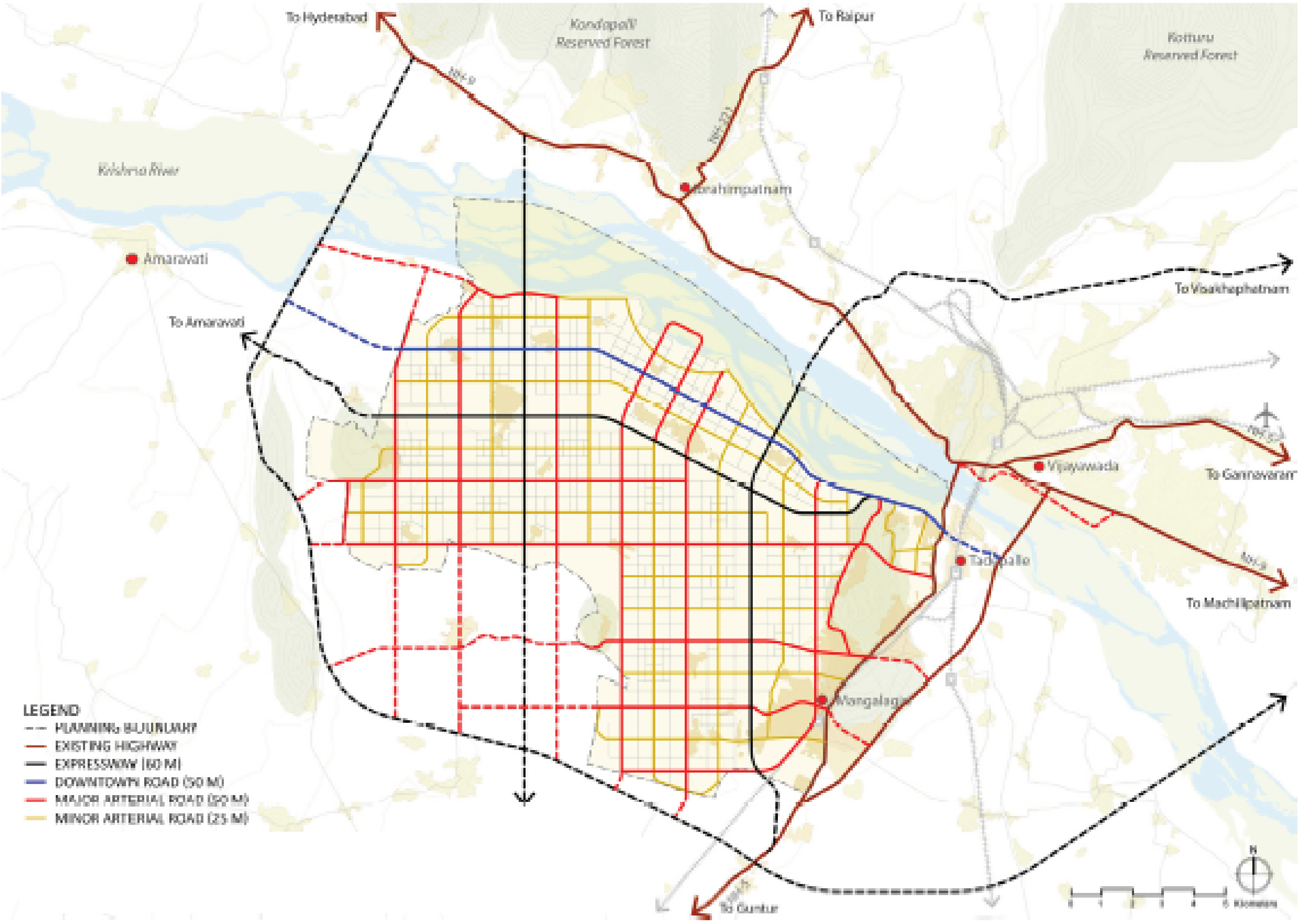


Fig.7.7 Proposed Road Network Plan

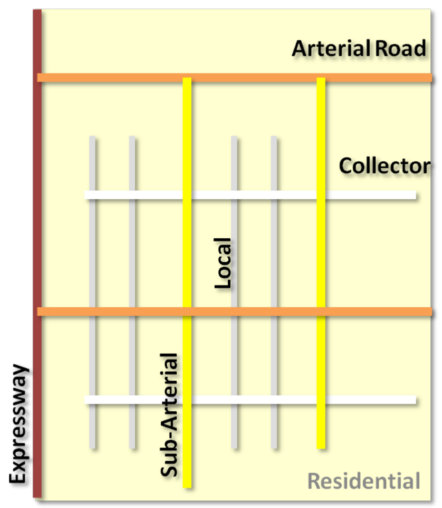


Fig.7.4 Conceptual Residential Road Hierarchy

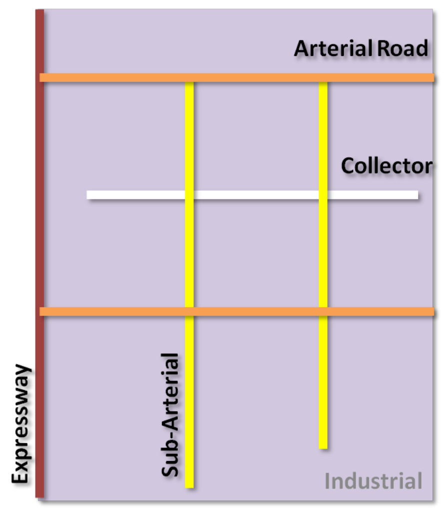


Fig.7.5 Conceptual Industrial Road Hierarchy

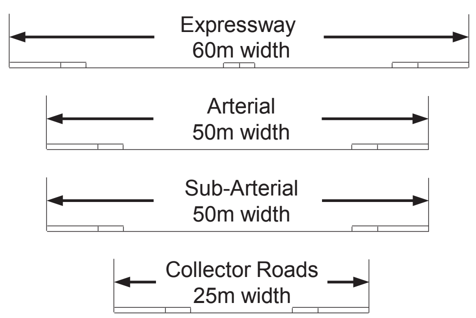


Fig.7.6 Proposed Right of Way Widths

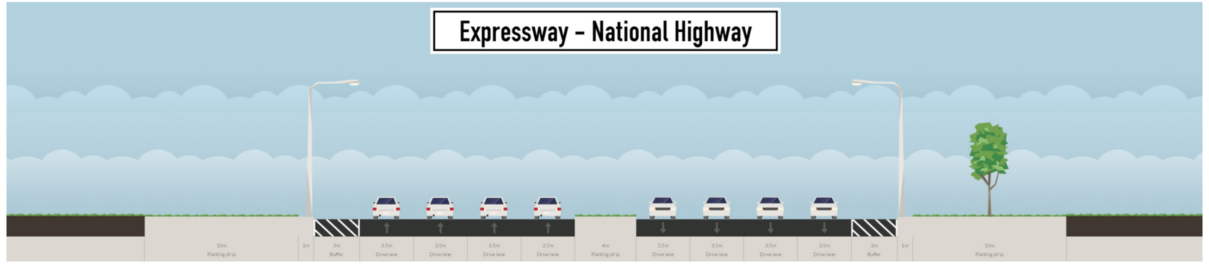
The road sections can be developed with the following facilities:-

- Median – The divider between opposing traffic lanes
- Carriageway – Traffic Lanes for all vehicular traffic
- Rapid Transit Lanes – Dedicated lanes for Rapid Transit
- Hard Shoulder – The emergency stop lanes on expressways
- On-street Parking – On-street parking where traffic movements or speeds are low
- Verge – Easement space provided for utilities, maintaining visibility splays, or drainage
- Planting Strips – For planters / greenery
- Footway – Pedestrian paths
- Cycleway – Cycle paths

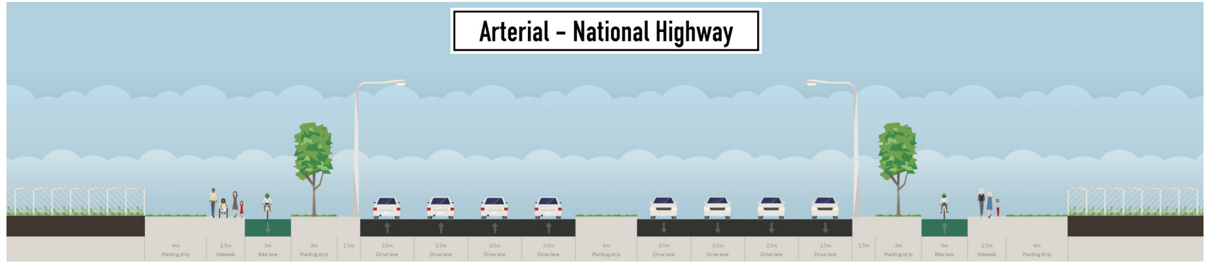
It is recommended that detailed road cross-section guidelines are developed at city level to include geometric design standards as part of development guidelines.

Types	Urban Expressway	Arterial Roads				Sub Arterial Roads				Distributor/ Collector Roads	
	National Highway		Rapid Transit Corridors	Downtown Road	CBD Through-routes		Bus Routes	Commercial Streets	Industrial Roads	Residential Streets	Rural Roads
Description											
Design Speeds & Geometry											
Maximum Speed Limit	80kmh	50kmh	50kmh	50kmh	50kmh	50kmh	50kmh	50kmh	50kmh	30kmh	30kmh
*Geometry Design to International Standards											
Street Dimensions											
Desirable Road Reserve Width	60m		50m			50m			50m	25m	
Typical number of lanes per direction	3 lanes min	3 lanes min	3 lanes min +BRT	2 lanes	3 lanes min	2 lanes min	2 lanes min	2 lanes min	2 lanes min	2 lanes max	2 lanes max
Minimum Carriageway Width	3.5m per lane	3.5m per lane	3.5 m per lane	3.75 m per lane	3.5m per lane	3.5m per lane	3.5m per lane	3.5 m per lane	3.5 m per lane	3.5m per lane	3.5m per lane
Minimum Median Width	4m	4m	4m, 8m @ station locations	5m	4m	2m min (Optional)	2m min (Optional)	2m min (Optional)	2m min (Optional)	-	-
Hard Shoulder	3m	3m	-	-	-	-	-	-	-	-	-
Easement / Verge	2.5-6.0m	2.5-6.0m	Optional	Frontage along Buildings	Optional						2.0-4.0m
Footway	-	-	1.8m min	2m	1.8m min	1.8m min	3m min	2.5m min	1.8m min	1.8m min	-
Cycleway	-	-	1.9m min	2m	1.9m min	1.7m min	1.7m min, or omit	1.7m min, or omit	1.7m min, or omit	1.5m min	-
Planting Strip	-	-	2m	2m	2m	2m	2m	2m	2m	2m	-
Plot Access from Road	No	No	No	Limited	Not Recommended		Yes	Yes	Yes	Yes	Yes
Traffic Calming	No	No	No	No	No	No	No	Allowed	No	Allowed	-
On-street Car Parking	No	No	No	No	No	No	No	No	No	Allowed	Allowed
Public Transport											
Bus Access	Not Recommended	Not Recommended	Not Recommended	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bus Stations				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bus Rapid Transit Lanes	-	-	Yes	Yes	-	-	-	-	-	-	-
Bus Rapid Transit Stations	-	-	Yes	Yes	-	-	-	-	-	-	-
Mass Rapid Transit	-	-	Yes	Yes	-	-	-	-	-	-	-
Other Information											
Statutory Services	In Verge	In Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Planting Strip / Verge	In Verge
Lighting Required	Subject to Safety Requirements		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Subject to Safety Requirements

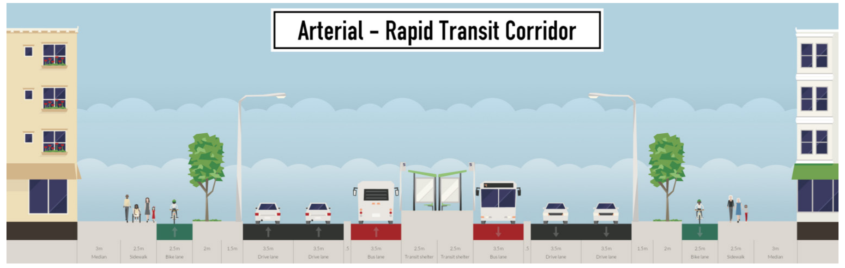
Table 7.1 Road Hierarchy Table



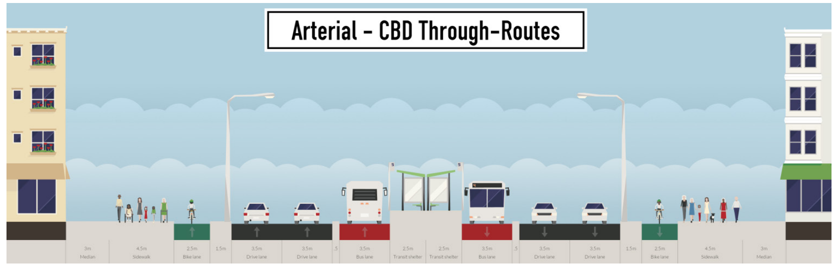
Expressway - National Highway



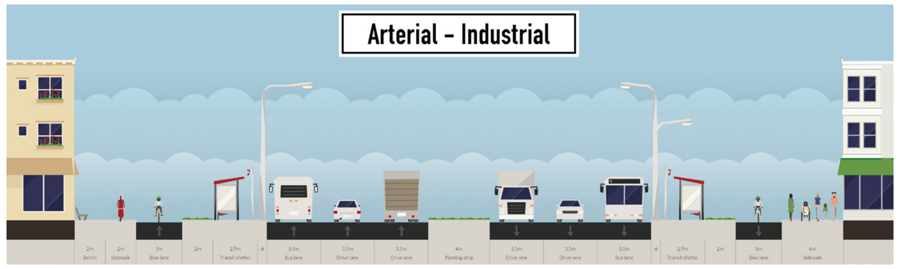
Arterial - National Highway



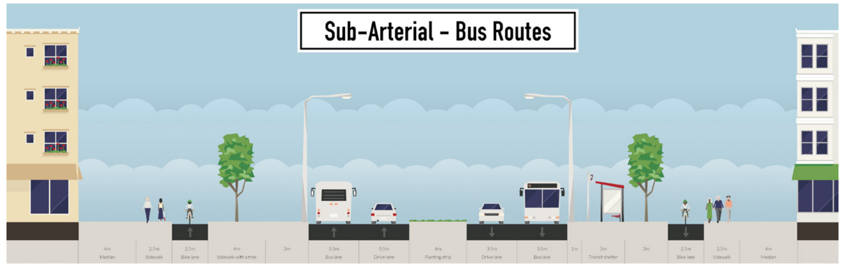
Arterial Roads with Public Transportation Corridor



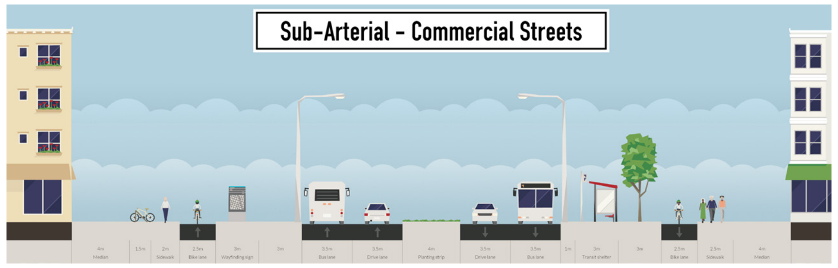
Arterial road within the CBD



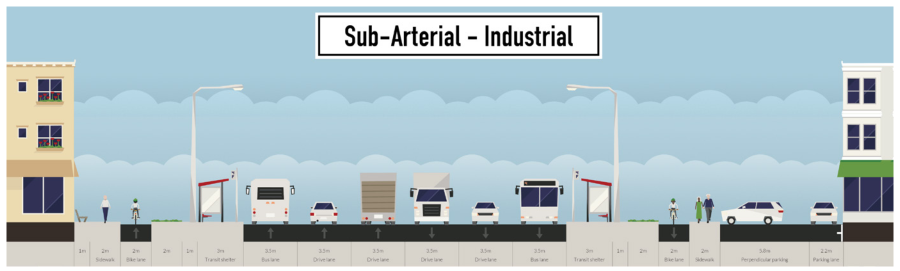
Arterial Roads within Industrial Areas



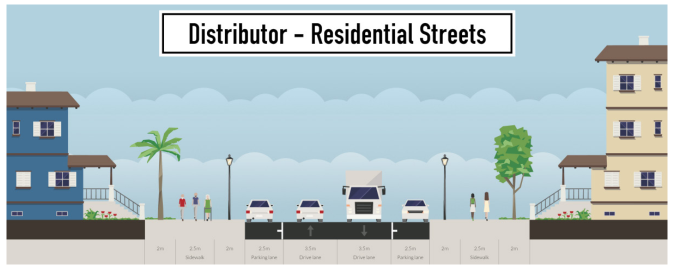
Sub Arterial Roads with Bus Routes



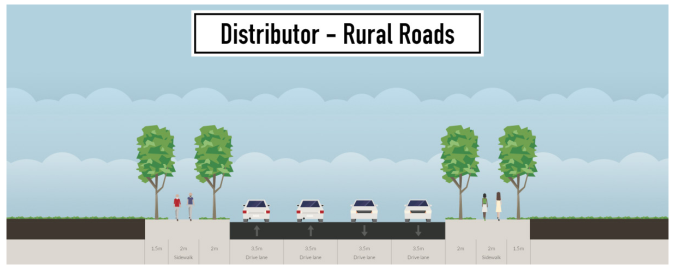
Sub Arterial Roads along commercial streets



Sub-arterial Roads within Industrial Areas



Distributer Roads along Residential Streets



Distributer Roads within Rural areas

Collector Roads within Industrial areas

Fig.7.8 Typical Road Sections

**Note: Refer to larger scale road sections in Appendix 2

7.2.2 Public Transportation Network

Development of a well connected public transportation is critical for the capital city development. This section illustrates the various modes of public transport that have been proposed for the Capital city.

Bus Network

The Andhra Pradesh State Road Transport Corporation (APSRTC) can kickstart the development of the public transportation system by providing bus routes from nearby towns to provide connectivity between the existing villages, neighbouring towns and cities i.e. Vijayawada. This short to medium term strategy will not only provide the local residents with a convenient mode of transport, it will also provide flexibility in terms of public transport due to the ease of adding additional services or routes to provide public transport coverage to and within the Capital City. Once these routes become fully operational and can sustain demand, a higher capacity system, such as mass transit, can be introduced. The bus routes with high public transport usage and passengers volume can be upgraded to mass transit systems such as Bus Rapid Transit.

The mass transit systems will be supplemented by the local public bus system, which would also function as feeder systems connecting to the mass transit. Due to its flexibility in operations and routes, the local bus routes can still run concurrently with the construction of the rapid transit systems to maintain connectivity within the Capital City. These routes running parallel to the mass transit systems can eventually be phased out, or remain as secondary connections, depending on demand and coverage.

Name	BRT	LRT	MRT
Capacity (passengers per vehicle)	50-200	200-300	1,000 - 2,000
Capacity per hour per direction	10,000-45,000	2,000-50,000	30,000 - 70,000
Fare collection	Off-board	On-board	Off-board
Speed (km/h)	27-48	50-70	50-120
Capital cost/km	USD 1-2 million	USD 5-10 million	USD 20-40 million

Table 7.2 Industrial Road Hierarchy

Fig.7.9 Typical Public Transport Systems and Infrastructure

Rapid Transit Networks

Rapid transit system has been proposed as a long term strategy. The Rapid transit system is an efficient public transport system operating in urban areas with high capacity and frequency, and grade separation from other traffic. The most common rapid transit solutions being used around the globe are:

- Bus Rapid Transit (BRT)
- Light Rail Transit (LRT)
- Mass Rapid Transit (MRT)

A comparison of these three systems is given in Table 7.2. Bus rapid transit (BRT) is a bus-based mass transit system. A BRT system generally has specialized design, services and infrastructure to improve system quality and remove the typical causes of delay with a fully dedicated right of way (bus way). BRT aims to achieve high capacity and speed with the flexibility, lower cost and simplicity.

Light Rail Transit (LRT) is a rail-based rapid transit which uses dedicated tracks to guide its vehicles. Typical systems are trams and guided trains. These systems can be built as part of the road network, or as a separated rail system similar to the BRTS.

Mass Rapid Transit (MRT) is also rail-based, but has a carrying capacity much higher than the LRT system. MRT is typically separated from the roads, running on dedicated rail alignments either elevated or underground, as the vehicle speeds need to be high even in an urban zone. MRT requires high capital and running cost and are only built if there is critical passenger mass.

Proposed BRT

Due to BRT's advantages of low initial capital cost and fast implementation, it is purposed to be the initial core transit system for Amaravati. BRT system will be located at only arterial and sub arterial roads where there is sufficient space in the ROW. Five BRT lines in total are purposed and these lines are designed such that all the major townships and vital places in the city such as CBD and transport hub in Amaravati can be reached by BRT system. These BRT lines intersect one another at interchange stations where passengers can change from one BRT line to another and continue their journey until reaching their destination.

Proposed MRT

As a newly established Amaravati Capital city and regional centre, the population in Amaravati is expected to grow exponentially. The BRT system alone can not meet the future passenger capacity, and the need for fast connection inside the city as well in between Amaravati and Vijayawada.

MRT tracks will be located at elevated corridors above the top-level roads, namely arterial and sub arterial roads. Due to the long implementation time for MRT, the MRT system is to be designed in two phases:

- Phase 1: MRT 1 (26 km) & MRT 2 (31 km)
- Phase 2: MRT 3 (25 km) & MRT 4 (25 km)

Phase 1 is the most important MRT lines that will be required in the medium term. The Phase 2 lines serve to supplement Phase 1 after the city development matures. MRT 1 connects the Amaravati Capital City with the neighbouring city of Vijayawada. This allows for the Vijayawada Airport to be connected to the Capital City allowing a source of demand for the first phase of the MRT roll out. MRT 1 runs through the Capital City East to west connecting to the east to an existing proposed alignment for Vijayawada. The line runs through the CBD area before turning south through the civic zone of the city. This line then runs to the boundary of the planning area, terminating with a depot. There is potential for this line to be extended south in the future if required.

MRT 2 is a predominantly North – South line, connecting the national rail station around Mangalagiri with the CBD. This line allows for interchange onto MRT 1, giving further connectivity to Vijayawada and the civic area. The line turns to the east at the CBD and has space for an alignment reserved to connect out to the historic sites out to the east of the city once the city expands.

MRT 3 will serve both the south east of

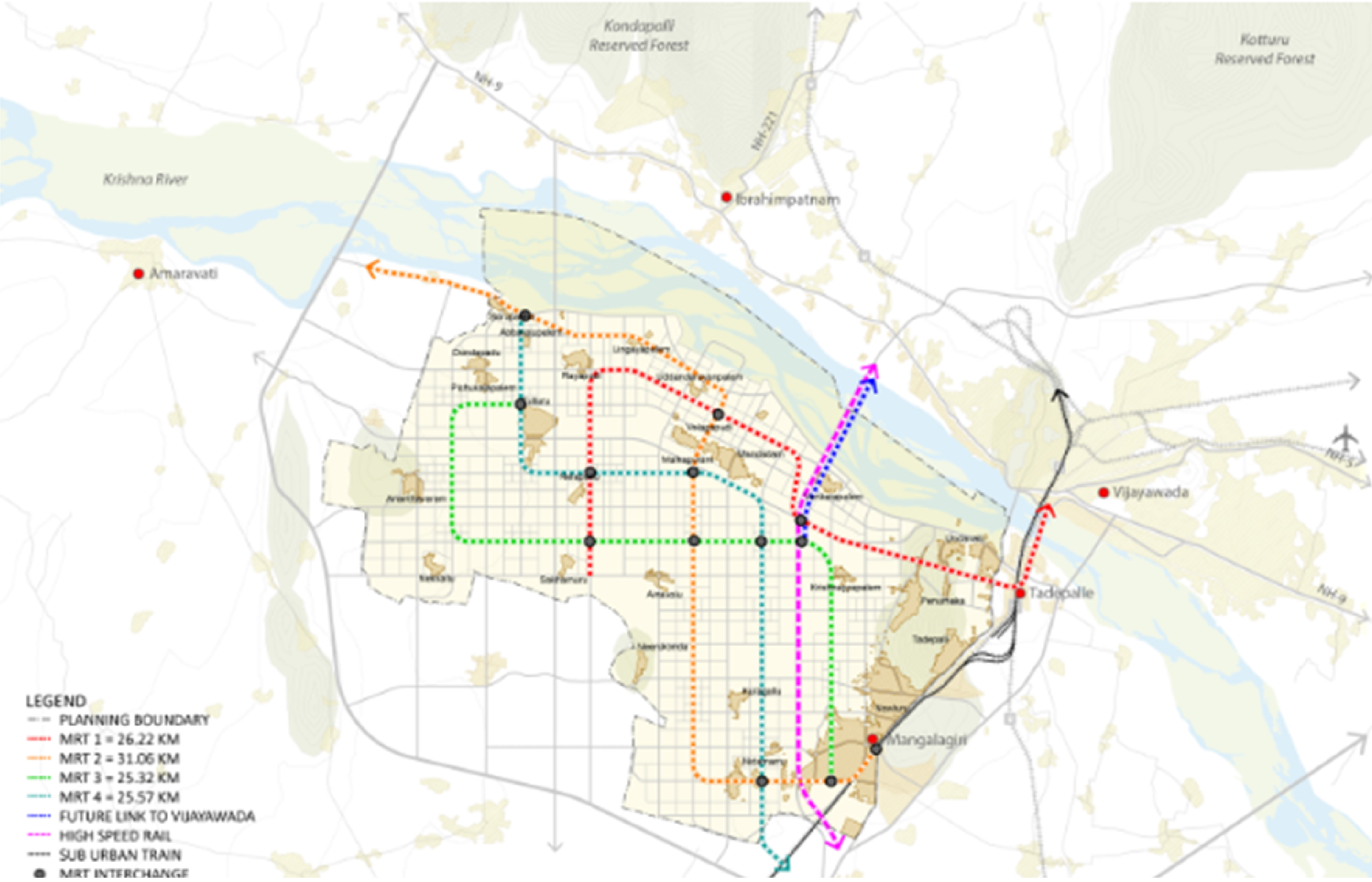


Fig.7.10 Proposed Public Transportation Plan

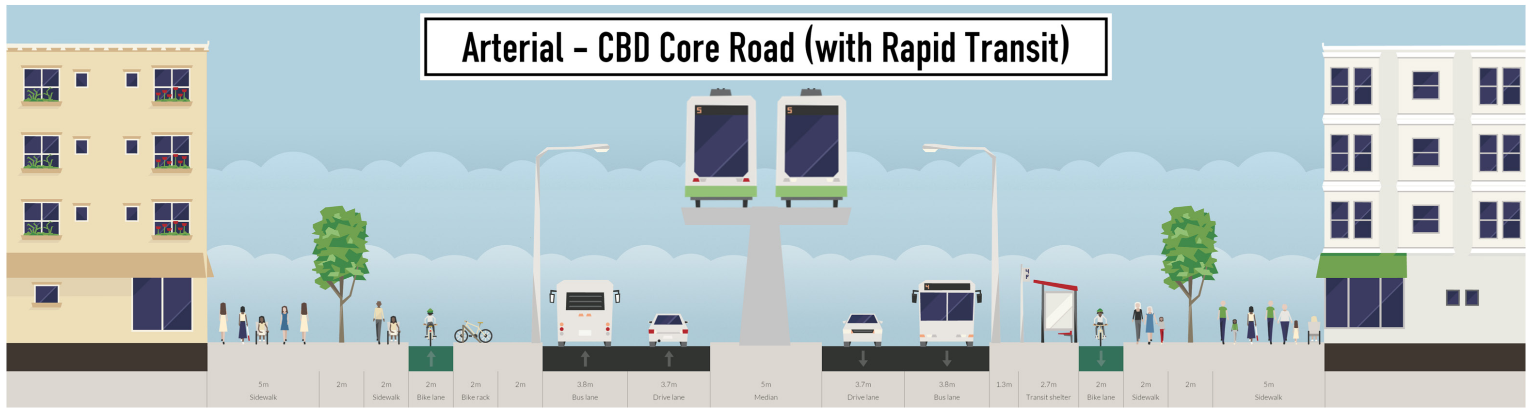


Fig.7.11 Possible Arrangement of Roads with Rapid Transit (Downtown Road)

Amaravati and the northwest by means of a cross city line. Both end termini of the line intersect with other MRT lines in the city. Therefore the system forms a closed loop connecting the east and west sides of the city.

MRT 4 runs along the spine of the City, north to south and should be constructed in the second phase of mass transit construction. This line extends beyond the boundary of the city to the south and has the potential to link the Capital City to Guntur. This line gives the final level of coverage for the mass transport in the city.

High Speed Rail (HSR)

The Indian Ministry of Railways' white-paper "Vision 2020" proposed six potential high-speed rail corridors (HSR) connecting commercial, tourist, and pilgrimage hubs. The corridor which passes through Amaravati city starts from Chennai leads to Vijayawada where it splits into two lines; one towards Hyderabad and the other towards Vijayawada Airport.

Integrated Transport Hubs

Integrated Transport Hubs are a form of Transport-oriented Developments (TOD), and are fully air-conditioned transport interchanges seamlessly linked to rail system, rapid transit and bus stations and adjoining commercial developments such as shopping malls. With this integration, commuters can easily run errands and shop conveniently and comfortably, before transferring to their connecting buses or trains. There are two types of integrated transport hubs proposed in Amaravati.

The first type is located at the proposed location of the high speed rail station. This is the major interchange for the city as it opens up the option of travel directly to the airport as well as other cities in India. By having an area set aside for commercial at the location, facilities such as eateries and shopping can be provided with easy access.

The second type of Transport hubs are relatively smaller in scale than the first type and involves single type of transportation mode. This type of transport hub is located at the interchange stations of different MRT lines where high volume of passengers is expected.

These transport hubs can also act as a hub to allow private vehicle trips to transfer onto public transport. By providing incentives such as car parking, commuters can park at the peripheral transport hubs, and then transferring onto the rapid transit systems to travel to the city centre. This is particularly important for existing villages, as the villagers are likely to travel to these transport hubs before transferring onto a public transit network.

Water Transport Feasibility

Introducing water transport as a mode of public transport is explored in this section. It is suggested that the proposed green and blue network could be adopted as a base for the potential water transport routes.

The potential water navigation routes option is illustrated in Fig.7.12. It covers a network of recreational canals with a total length of 50 kilometres. The benefit of utilising the proposed green and blue network is to intensify the use of water bodies without the construction of substantial new water routes.

A comparison of the cost between the water transport and road transport is shown in Table 7.3. Some findings of the comparison are listed below:

- Construction for waterways may cost up to 4 times higher than roads; however, waterway and road construction costs are highly dependent on the local spatial structure
- In terms of passenger capacity, it is highly dependent on the attributes of the transport systems, i.e., the routes and frequency of the services for both waterways and roads
- Land efficiency for roads is 4-5 times higher than waterways
- Travel speed for roads is 3 times faster than waterways
- Maintenance cost for waterways is 5-7 times higher than roads

In summary, a number of recommendations are proposed for the water transport feasibility:

- Some navigable canals in the green and blue network are possible for the water transport
- It is recommended that the navigable canals in the green and blue network are only for recreational purposes (most newly developed cities only use water canal for recreational purposes because of cost, speed and capacity)
- It is not recommended to use canals for commuting purposes due to its cost, speed and capacity

Fig.7.12 Water Navigation Option

Items	Water Transport (Canals)	Road Transport
Construction Cost*	5-20 € million per km	6-8 € million per km (dual-2 roads)
Passenger Capacity	Narrow boat: 12-98 pax. Water taxi: 64-149 pax. Tourist boat: 18-100 pax.	Car: 5 pax. Bus: 80-120 pax. MRT: 931 pax. per train
Land Efficiency	Approx. 12.5 m^2 per pax.	Approx. 2.8 m^2 per pax.
Travel Speed**	Approx. 16 km/hr	Approx. 40 km/hr (local roads)
Maintenance Cost*	29k - 38k € million per km	5k - 7k € million per km

Source: *Economic Aspects of Inland Waterways, International Navigation Association. ** New York Water Taxi and Road Transport

Table 7.3 Comparison between Water and Road Transport

Fig.7.13 Examples of Water Transport

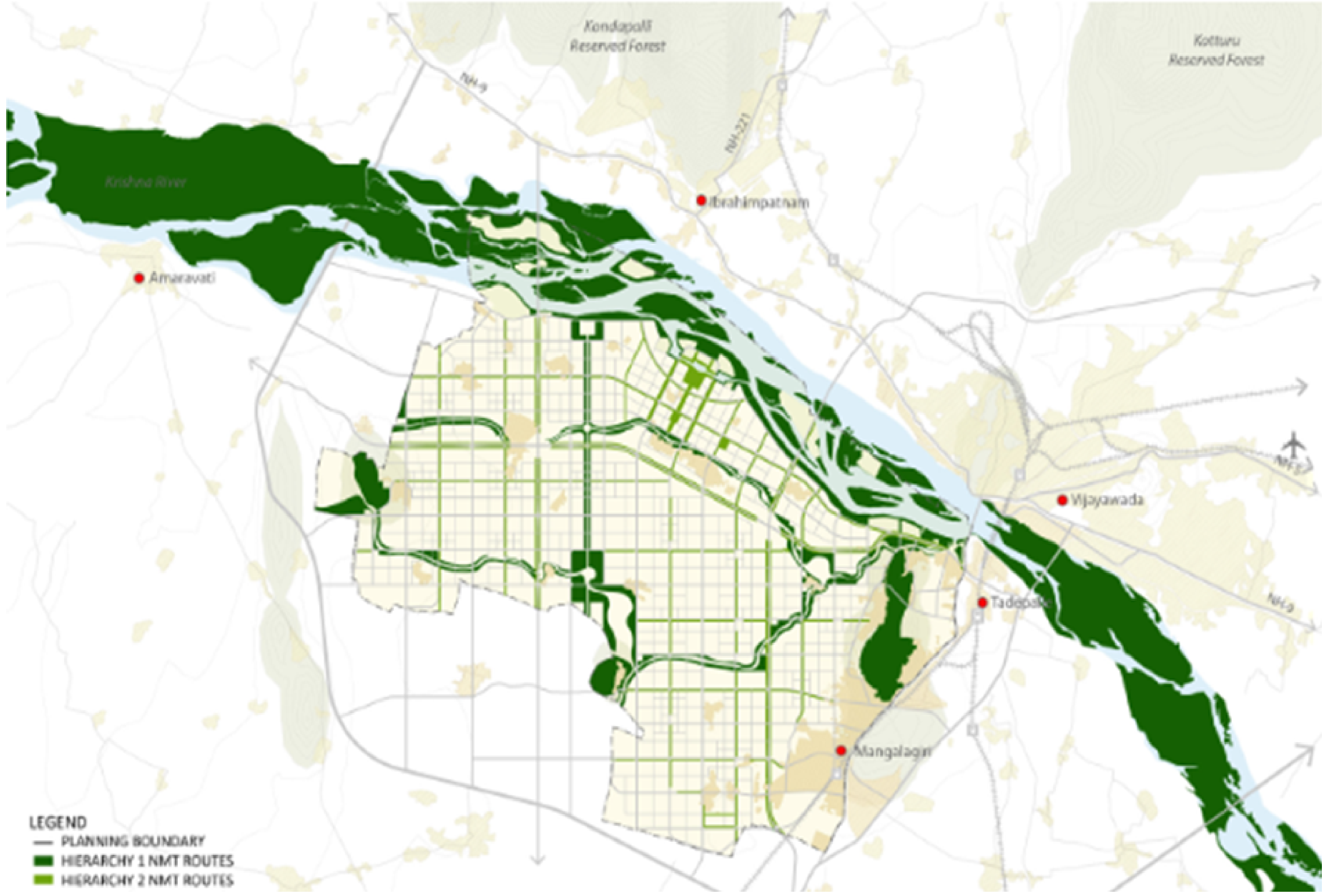


Fig.7.14 Proposed Non Motorized Transport plan

Fig.7.15 Examples of modes of Non-motorized Transport

7.2.3 Pedestrian Friendly City: NMT Plan

Systems that are driven by human or animal power (without use of any fossil fuel) are called non-motorized systems. Such systems have the advantages of not generating air pollution and noise pollution as well as not consuming non-renewable energy. Currently, Non-Motorised Transport (NMT) share in the capital region is the highest among all transportation modes; however dedicated non-motorized transport facilities are not prevalent in the existing road infrastructure. Therefore, it is important to implement proper non-motorised transport networks to ensure the safety of passengers and create environment friendly city transport system.

City Parks

In order to promote non-motorised transport modes such as walking and cycling, more green zones are proposed to make the city NMT-friendly. Several large parks, some medium parks and various small parks are scattered in the city strategically around villages and settlements for both recreation and flood management.

Primary hierarchy network is proposed with routes connecting large and some medium parks, while secondary hierarchy network is proposed with routes connecting the rest medium parks and small parks. Primary hierarchy network and secondary hierarchy network are also interconnected by secondary hierarchy routes. Primary hierarchy network has a total route length of 150 km and secondary hierarchy network has a total route length of 170 km. The two hierarchy networks account for 17% of the city land area.

These hierarchy routes are specially dedicated for pedestrians and cyclists. Park trails with facilities such as resting chairs along the way could enhance walker's experience. Separated bike trails along the greens with proper signage increase safety for cyclists and people on roller skates.

Waterfront Promenade

As a gateway between Amaravati and Vijayawada, the Krishna River is worth to be developed into a recreational place for both local residents and tourists. Lake parks can be built along both sides of the Krishna River creating a 35 km long publicly accessible waterfront trail, connecting the city's east and west. At night, the promenade will be lit with attractive night lighting. People can stroll under the shades of trees and have a panoramic view of the river on the promenade both day and night. Visitors can also hop onto a river taxi to further explore the Krishna River.

On-road Facilities

Pedestrian and cyclists are usually the minorities on the road which impose safety problems. In India, even roads with pedestrian paths, they are encroached by shops and parking of vehicles. Thereby, one of the important parts of NMT Network Plan is the reserving and constructing the pedestrian and cycling paths and infrastructure in the road reserve.

7.3 INTEGRATED URBAN WATER MANAGEMENT

7.3.1 Existing Conditions

After discussions with the Local Authorities and carrying out site investigations, it was identified that the site of the new Capital City faces many challenges, especially in water management.

During the monsoon season, there is a lot of storm water collected in the Krishna River upstream of the Prakasam Barrage, and within the site due to heavy rainfall. Inundation occurs in some of the low lying areas within the Capital City development area. The flood waters eventually dissipate by being discharged into the Krishna River, and then by gravity on into the sea.

During the dry season, the Krishna River is the main source of raw water for potable and agricultural use. This source can run low and lead to a deficit of water supply in the region. The urbanisation process arising from the development of the Capital City will put additional strain on the water supply from the Krishna River.

There are also concerns that there is discharge of partially treated effluent from sewage treatment plants into the Krishna River and the Buckingham Canal. This has the potential to cause serious health issues if not controlled when the population expands.

In summary, some of the key issues identified are:

- Flooding due to the rainfall in the Kondaveeti Vagu catchment in the monsoon season;
- Water availability during the dry seasons; and
- Water pollution in Kondaveeti Vagu and the Krishna River

7.3.2 Proposed Urban Water Cycle

In order to effectively manage water in the new Capital City, a holistic approach to the urban water cycle is required. This will help the Capital City to become self sufficient in water, flood resilient, and have a clean water environment.

Separate sections addressing, sewerage, water supply and flood management in detail have been developed in this Chapter. In order to ensure that these strategies work in concert with each other, they have been developed with the entire urban water cycle in mind.

A summary of the key elements of the objectives is given and how they are inter-related. The strategies defined in each subsequent section are designed to meet each of these objectives.

These objectives should be part of an ongoing water audit in the catchment areas. This needs to be carried out on an annual basis.

7.3.3 Water Supply

Reliable, sufficient and continuous water supply

Ensure that water supply is continuously available even during periods of drought through the storage of raw water.

Clean potable water for all households and users

Water should be treated to World Health Organisation standards where it is of potable quality and that this water is of the same quality once it arrives at the point of use.

Effective demand management

Water is a limited resource. Therefore measures must be put in place to control the usage of water by the end users. This can be through policy and/ or technology

7.3.4 Sewerage

Separate sewerage system

Sewage produced in the region should be conveyed in a dedicated enclosed sewerage system. There must not be a case where the sewage can escape into the storm water network. Rain water should be dealt with in a completely separate system.

Collection of all waste water

The sewerage network should serve all parts of the Capital City to give 100% coverage.

Proper treatment and disposal

The raw sewage should be treated to a level that is suitable for the chosen disposal method and is acceptable to be discharged into the surrounding waters without any environmental impact.

7.3.5 Flood Management

Prevent flooding in the Capital City

Flooding in the Capital City is unacceptable. Therefore robust strategies must be put in place with levels of redundancy to prevent this from happening.

Make flood water available for usage

Water is an important resource and whilst any flood management scheme must focus on preventing inundation it should not make water unavailable to the Capital City. Therefore, flood mitigation measures should control, but not totally remove water.

Maintain raw water supply throughout the year

Whilst too much water is a problem, as too little water can also pose issues in the Capital City. Where there are water resources in the city, it is important that these are maintained throughout the year.

Fig.7.16 Prakasam Barrage

7.3.6 OVERLAPPING MEASURES

Each of these objectives overlap to a certain degree. This overlap is summarised as follows and in Fig.7.17.

As can be seen it is essential that the actions of one element of the water management cycle does not have a negative impact on others.

Rainwater Harvesting

Storage of rainwater within the Capital City will augment the supply of raw water during the dry season. This can be achieved by means of detention ponds and storage reservoirs.

By intercepting and diverting rainfall into these storage reservoirs, this will also help to mitigate flooding within the Capital City. It is important that whilst flooding is prevented, the strategy must not impact on water availability.

Pollution Control

By creating storage reservoirs to conserve rainwater, the Capital City gains an additional source of raw water supply for potable use during the dry season. These reservoirs can also be designed with biofeatures such as swales which would help polish the water quality. This will help to address the water pollution issue, and at the same time, create another source of water supply albeit for non-potable use.

Treated Effluent as a Water Resource

The augmentation of raw water supply helps to reduce the water demand placed on the Krishna River. This strain can be further reduced by exploring alternative water sources.

Sewage effluent, if treated to a high enough standard and quality, can be safely used for many purposes including irrigation and industry.

Active-Beautiful-Clean Waters (ABC) features such as swales and detention ponds can also be used for flood management, and also to polish treated effluent before discharging into the waterbodies.

Further details of the individual stages of the urban water cycle will be elaborated in the following sections.

Fig.7.18 shows the conceptual urban water cycle for the Capital City.

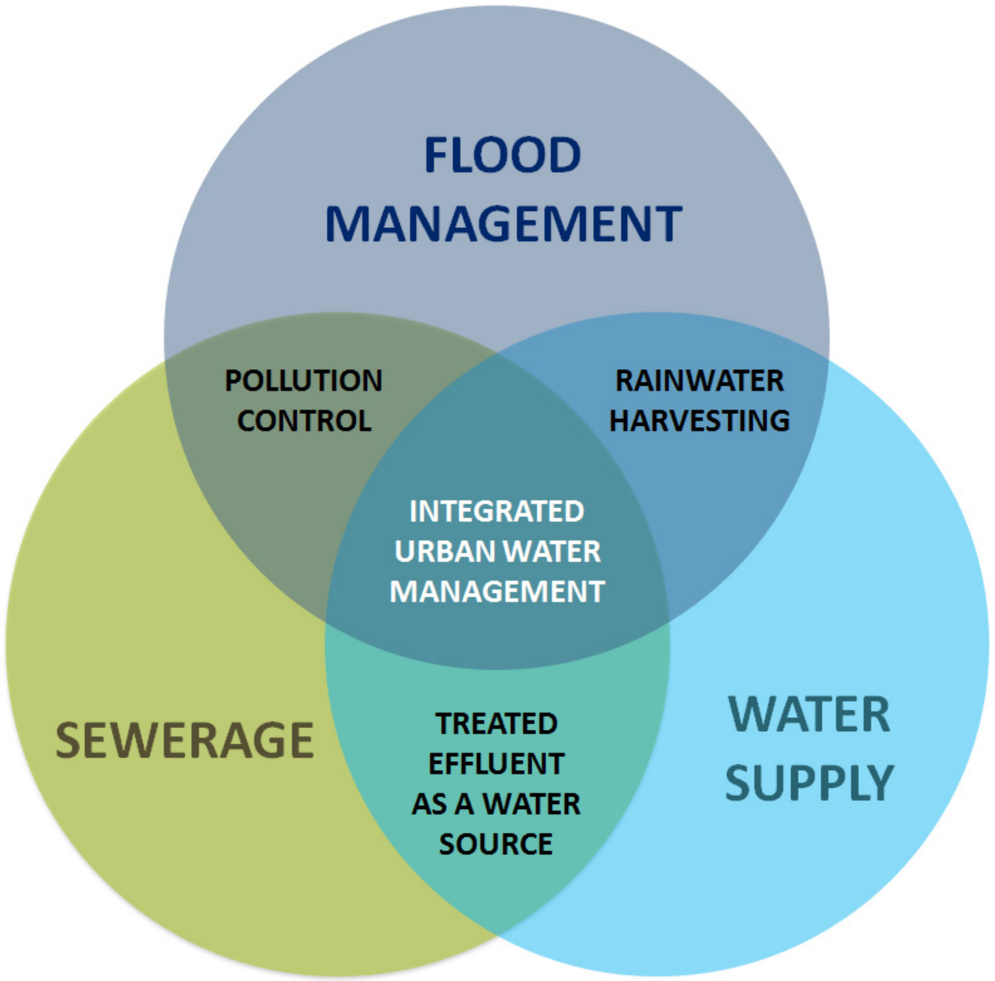


Fig.7.17 Integrated Urban Water Management

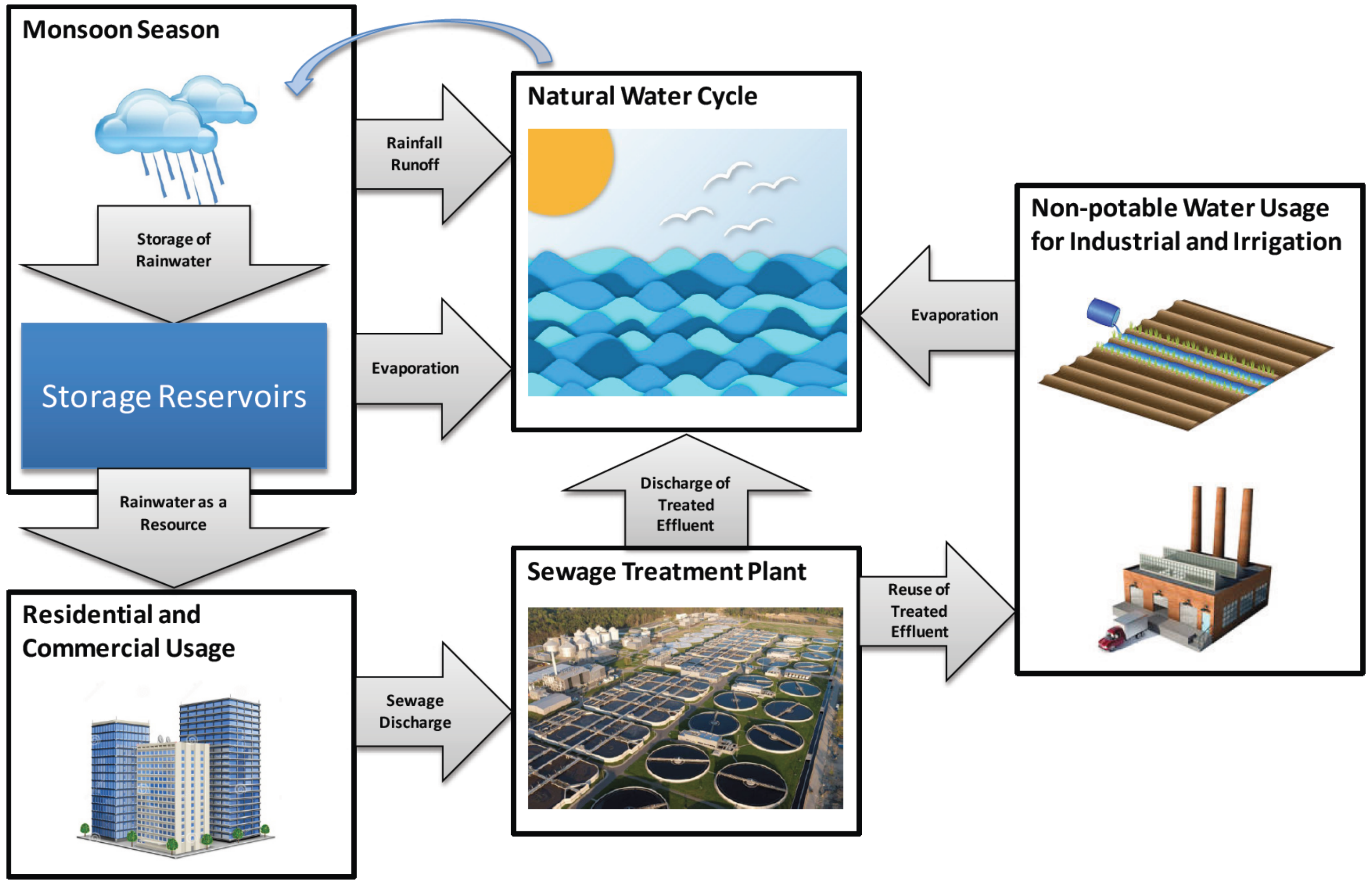


Fig.7.18 Proposed Urban Water Cycle

7.4 FLOOD MANAGEMENT

7.4.1 Existing Conditions

Inundation of Amaravati

The Krishna River is a major inter-state river flowing through the states of Maharastra, Karnataka, Telangana and Andhra Pradesh.

The Capital City is located approximately 100km upstream of the mouth of Krishna River, along the southern bank. Kondaveeti Vagu is a tributary to Krishna River, as shown in Fig.7.19.

The Kondaveeti Vagu catchment draining towards the Krishna River has a total area of 453 km². Kondaveeti Vagu originates from the Kondaveedu Hill Range and joins the Krishna River upstream of existing Prakasam Barrage. Together with its own tributaries, Kondaveeti Vagu flows across the Capital City and causes inundation over about 13,500 acres of land every year during the monsoon season.

This catchment on average receives 1,073 mm of annual rainfall. The total quantity of water received from rainfall is 17.16 thousand million cubic feet (TMC) per year. Storm water runoff is estimated at about 3.84 TMC. 80% of this surface runoff will be received by this catchment and discharged to the sea via the Krishna River without any utilisation during the monsoon period.

The inundation of the low lying areas within the Capital City development area will usually last for 5 to 7 days during each spell of heavy rain and this occurs two to three times annually.

Of the 13,500 acres of the inundation area, about 10,600 acres is within the planning area of the Capital City. Therefore, the Kondaveeti Vagu flood issue is a critical issue that needs to be addressed in detail after the master planning stage.

A detailed flood analysis of Kondaveeti Vagu, as proposed by the Government of Andhra Pradesh Water Resources Department, is in progress. This will be completed subsequent to the finalisation of this report.

Fig.7.19 also shows the extent of the flooding area within the Kondaveeti Vagu Catchment, as reported by CRDA. Based on historical records, floods are caused by the following reasons:

- An under-designed local drainage network to convey the storm water
- The high water level in the Krishna River preventing Kondaveeti Vagu from discharging by gravity

There is an existing bund along the Krishna River, which prevents fluvial flooding in the Capital City area when the water level in the Krishna River is high. Based on satellite imagery, the level of the existing bund was identified at between 3 to 5 metres above the highest recorded flood level in Krishna River of +21.7m. The bund was constructed using simple earthwork. The current structural condition of the bund is unknown.

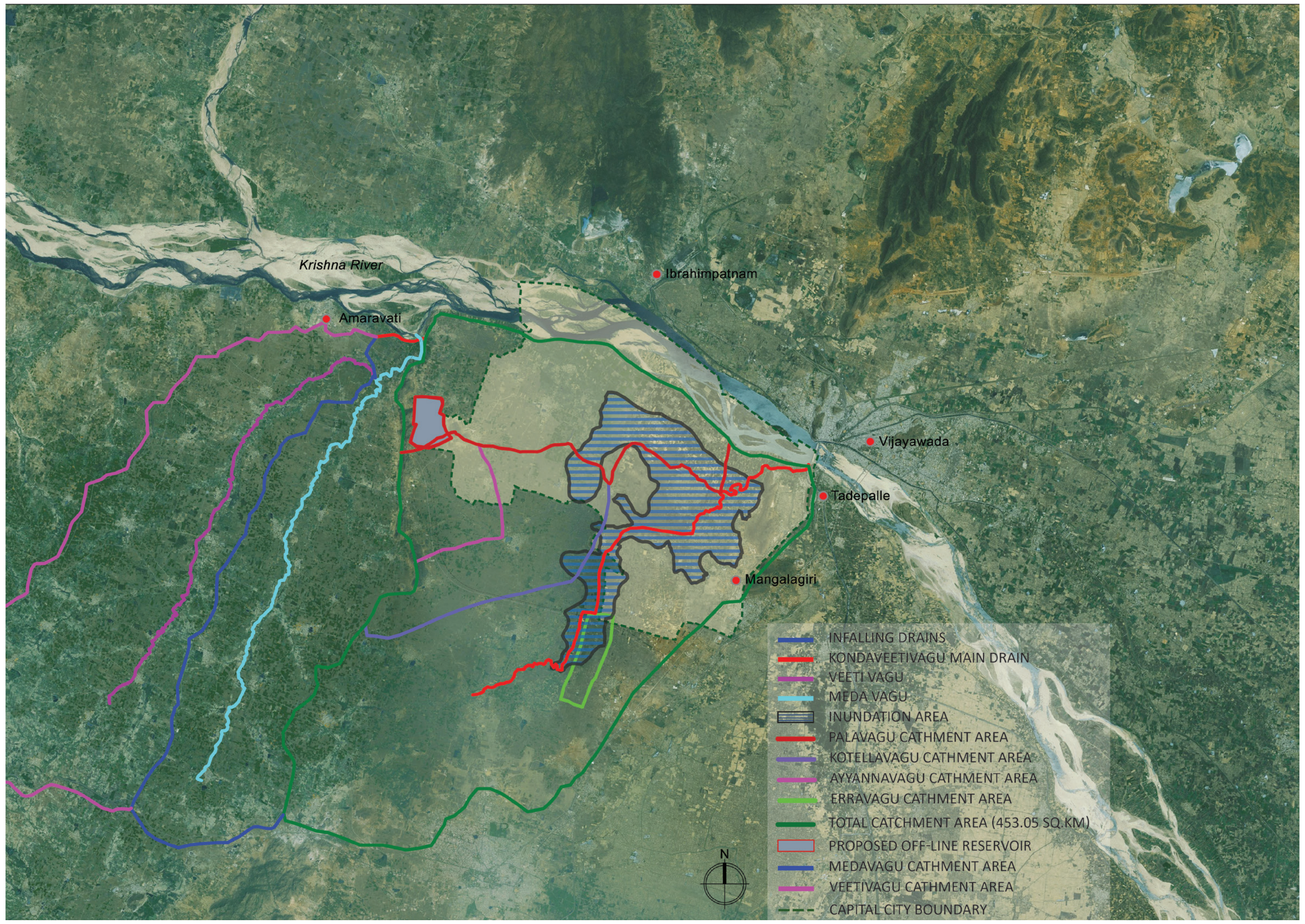


Fig.7.19 Catchment and Indundation Area of Kondaveeti Vagu (CRDA, 2015)

Fig.7.20 Photo of Existing Bund

Fig.7.21 Photo of Krishna River

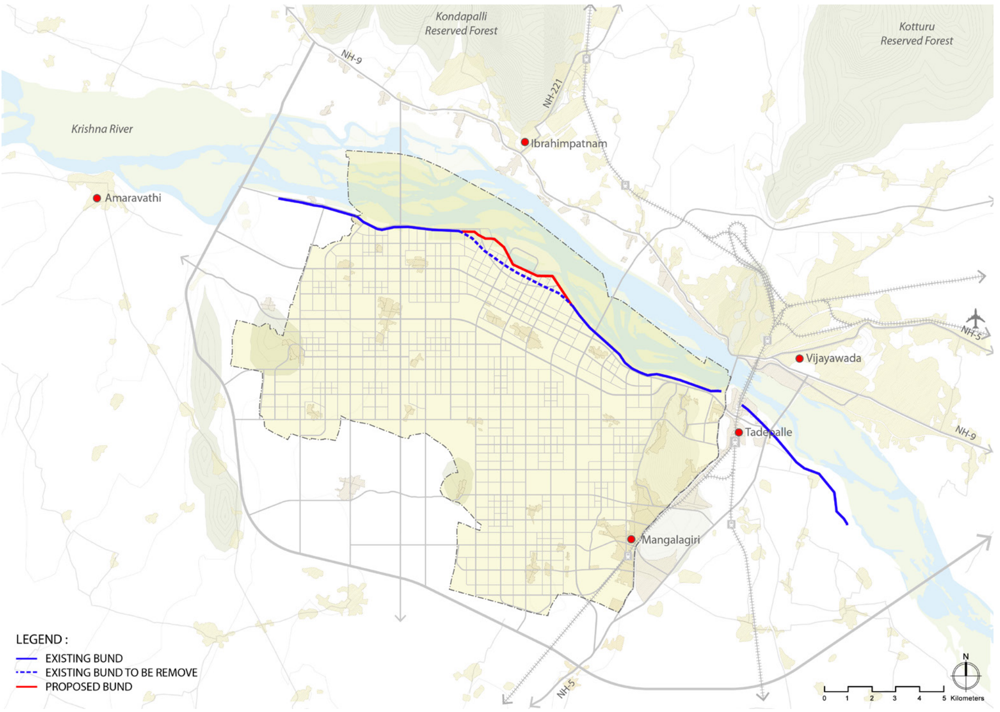


Fig.7.23 Prevent: Reinforce and Realign Krishna River Bund

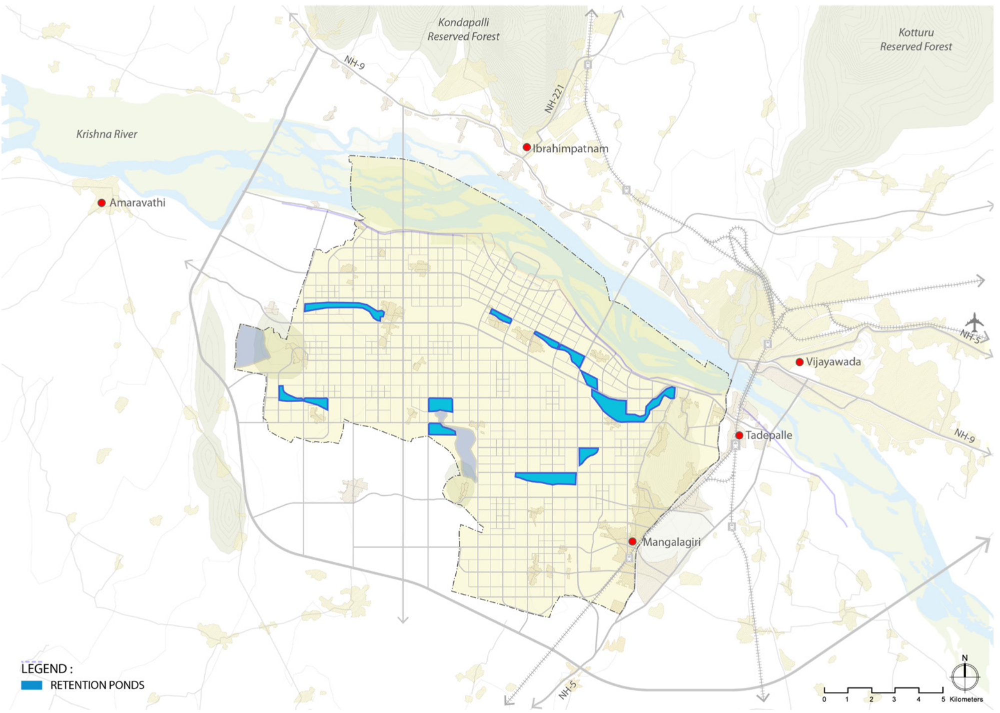


Fig.7.24 Control: Detain Stormwater in Internal Detention Ponds

7.4.2 Proposed Flood Management Strategies

The land in the Capital City area is mostly open space or rural with agriculture land. With the urbanisation of the catchment area, the surface runoff volume and speed are expected to increase tremendously. Flood risks will rise if there is lack of proper storm water management provided as part of the development. To mitigate the potential flooding issues and to build up a sustainable storm water management system, flood management strategies are proposed as follows (refer to Fig.7.22):

- Prevent: Reinforce and realign the existing the Krishna River Bund
- Control: Detain storm water in detention ponds within Capital City and in external sites within the catchment area
- Conserve: Create raw water storage using reservoirs
- Buffer: Provide an extensive green and blue drainage network
- Dispose: Discharge excess water into the Krishna River
- Protect: Raising of the proposed platform levels to above the design flood level

7.4.3 Concept Proposals

Prevent: Reinforce and Realign the Existing Krishna River Bund

The existing river bund along the Krishna River is approximately 3 to 5m above the highest recorded flood level of the Krishna River. This bund should be realigned closer to the river where required, strengthened, and reinforced to prevent flooding from the Krishna River.

The realignment of the Krishna River Bund is proposed for the Seed Development area where the initial start-up phase will take place. This will protect an additional land area between the Krishna River and the seed area for development.

It is recommended that after the construction of the new bund, the existing bund be removed to enable the development of this area. (Refer to Fig.7.23)

Control: Detain Storm Water

Detention ponds will be a key component in the flood management strategy for the Capital City. The ponds can serve as temporary storage to retain storm water runoff, and provide enough buffer to prevent flooding.

Ten detention ponds have been proposed within the Capital City to mitigate flooding and improve the storm water control. Detention ponds are proposed at the low-lying areas, the junctions of two different streams, and at the new water bodies proposed within the green and blue plan. The location of the detention ponds are determined based on the future land use. Most of the ponds are sited within the vicinity of green spaces to maximise their use as green spaces (See Fig.7.24).

These detention ponds are to detain storm water runoff during heavy rainfall, and then discharge slowly into the reservoirs for water conservation.

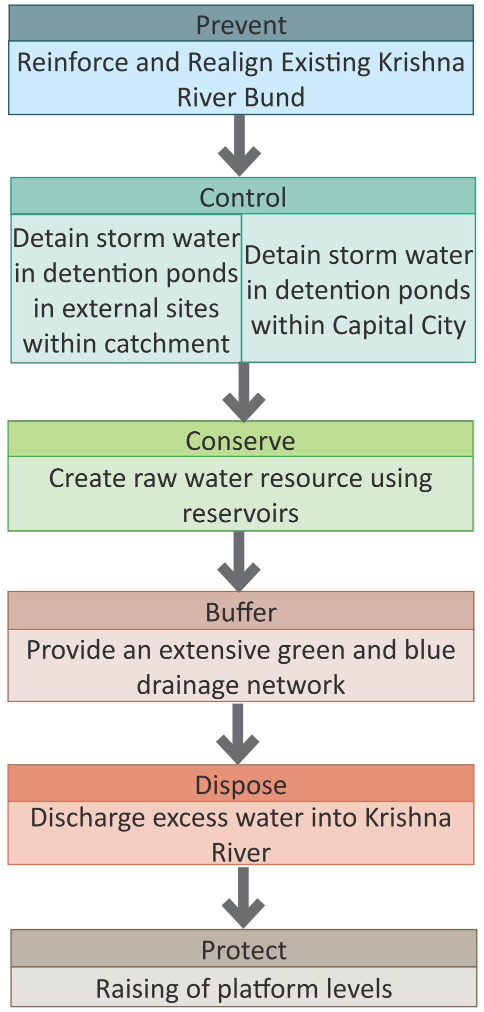


Fig.7.22 Proposed Flood Management Strategies

Control: Detain Storm Water Externally

In addition to the internal detention ponds within the Capital City, it is recommended that two external detention ponds be constructed outside the Capital City boundary to detain water upstream close to source. This will help to reduce surface runoff into the Capital City planning area. This will also provide additional control measures to retain water upstream during heavy storm events.

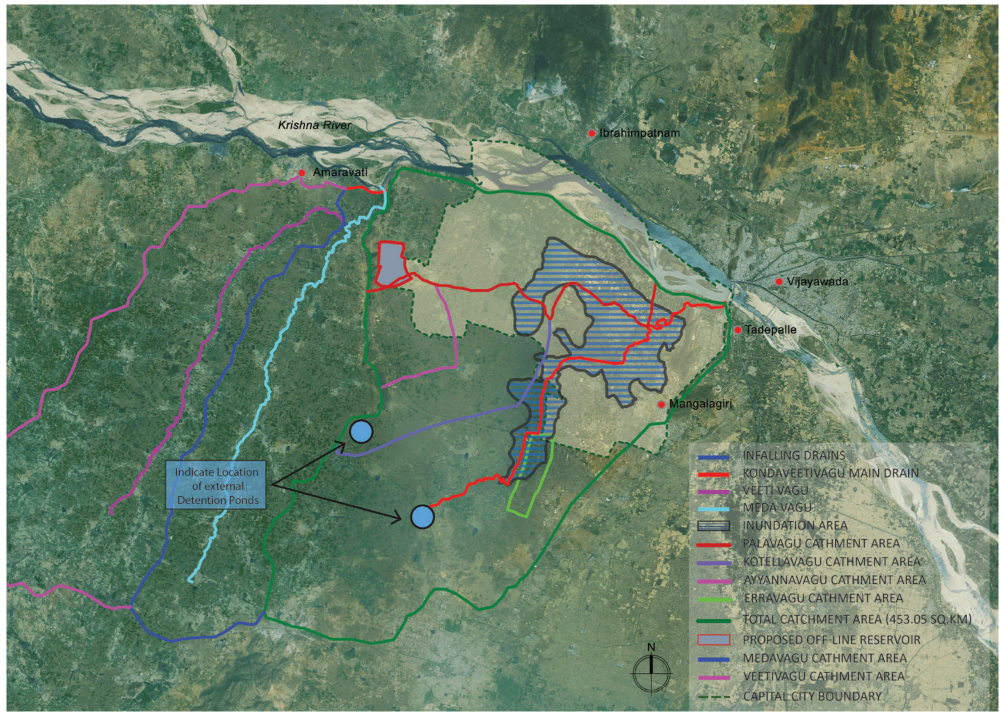


Fig.7.25 Control: Detain Stormwater in External Detention Ponds

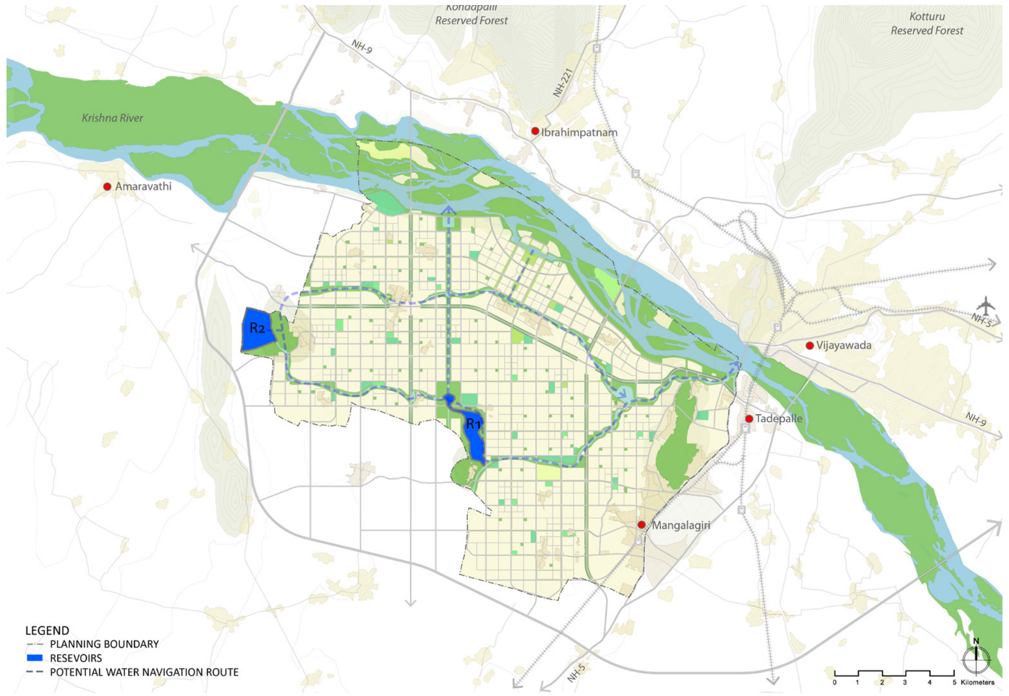


Fig.7.26 Indicative locations of Reservoirs 1 and 2 and canal network

The proposed locations of the two detention ponds are shown in Fig.7.25.

The design and size of these ponds are subject to a detailed hydraulic study of the Kondaveeti Vagu after the master planning stage. The additional land outside need to be acquired from the boundary of the Capital City for the construction of these external ponds.

Conserve: Create raw water storage using Reservoirs

Two reservoirs have been proposed within the Capital City (see Fig.7.26). Reservoir R1 is fed by storm water from the south-eastern half of the City through various detention ponds. Reservoir R2 is located at a high level, and is fed using pumps from Reservoir R1, the Krishna River and the nearby detention ponds within the Capital City.

The two reservoirs will augment water supply to the Capital City by providing raw water storage. The feasibility study of Reservoir R2 is currently being undertaken by the Water Resources Department. The estimated storage capacity of Reservoir R2 is 5 TMCs.

Further it should be made sure to carry out a water yield study to determine the storage capacity of Reservoir R1 after the completion of the master plan.

Buffer: Provide an extensive green and blue drainage network using canals

There is currently no proper delineated green buffer within the existing land of the Capital City. In terms of flood management, a proper storm water drainage network, including a flood buffer, would be required to collect and discharge the storm water runoff efficiently. An extensive green and blue drainage network has been proposed in the Capital City. A minimum buffer of 30m is proposed to be reserved along all the major canals. In the future, there should be no development of permanent structures within these flood control reserves. Fig.7.27 shows a typical cross-section utilised in the green and blue network.

In Fig.7.27 it can be seen that as part of the blue network a series of permanent channels is proposed. These channels will retain water permanently in them to form a canal network around the city.

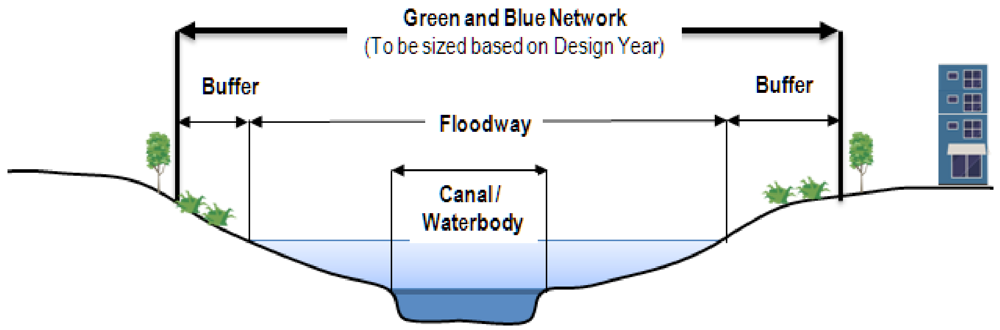


Fig.7.27 Typical Cross-section for Green and Blue Network showing Canals

As part of this system opportunities for leisure activities will be created. This includes both leisure boats and water taxis. This will allow the park users to be able to navigate around the entire city without the need to use the road network.

Dispose: Discharge excess water into Krishna River

As a final measure of protection, it is recommended that a comprehensive system of sluice gates and pumps are provided at the outfalls of the Capital City boundary where the surface runoff discharges into the Krishna River.

When the reservoirs are 100% full, the sluice gates will be opened to discharge the excess storm water into the Krishna River. However, for extreme rainfall events where water level in the Krishna River is high, and excess storm water cannot be discharged via gravity to the river. The sluice gates will then be closed to prevent backwater effects from the Krishna River, and discharge pumps will be activated to pump out the excess storm water to the Krishna River.

All disposed water should be monitored to check for water quality and interventions undertaken if quality is found to be sub acceptable.

Protect: Raising of Platform levels

It is recognised that the Capital City requires extra protection from flooding, for example, the CBD area, major

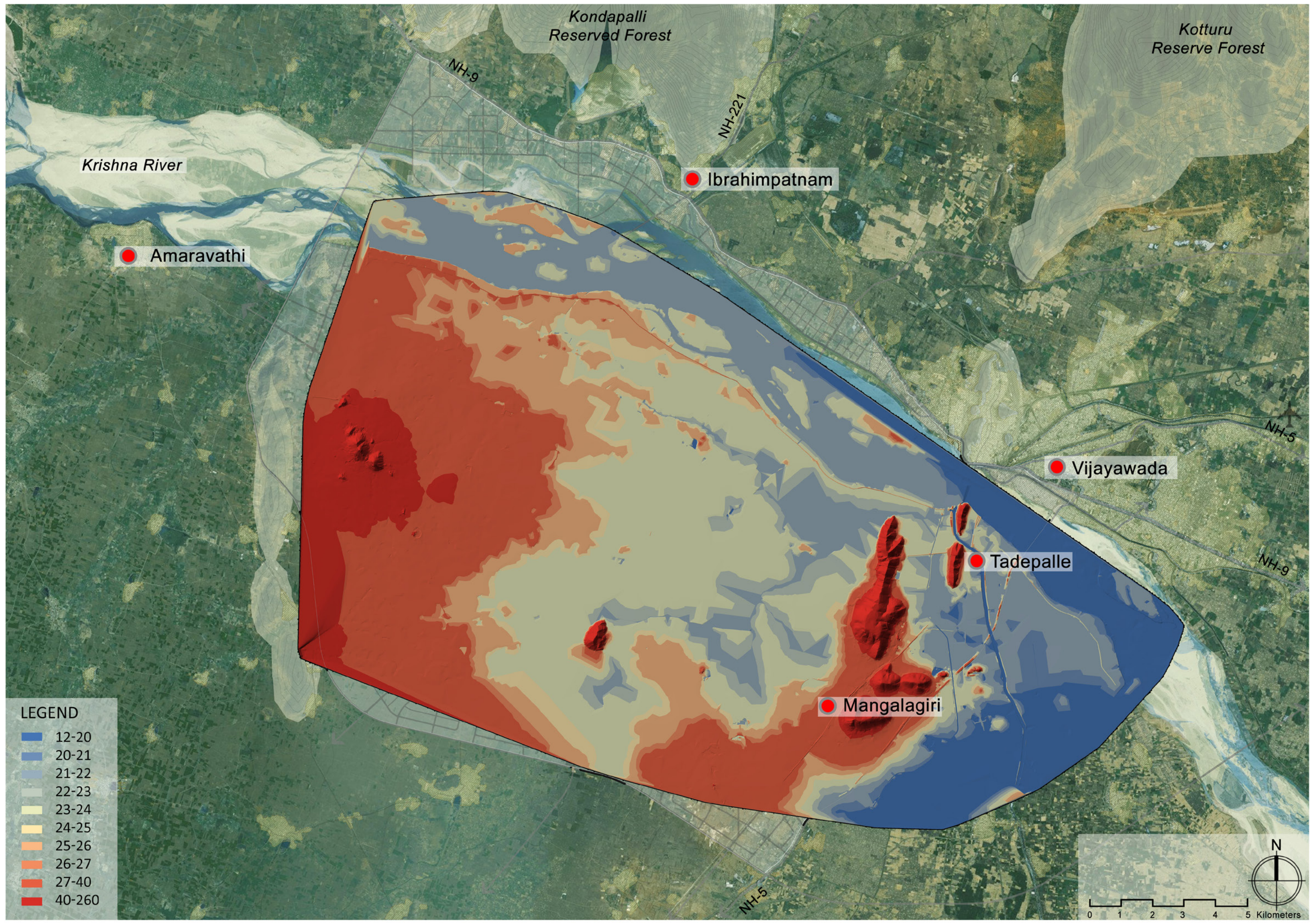


Fig.7.28 2m DEM Contour image showing the low lying areas (CRDA, 2015)

transport corridors, utility installations such as water treatment plants, electrical substations and others.

A minimum development platform level should be set for the Capital City to ensure that these areas are not affected by flooding. This can be done by setting the proposed platform levels of the Capital City higher than the historical flood level within the site. A general top-up level is not recommended for the entire site, and a detailed hydraulic study is required to identify the proposed platform levels for the different areas within the Capital City. As a rule of thumb, the existing ground level should be topped up to a level higher than the maximum predicted flood level in each particular zone.

Based on the topographical survey, as shown in Fig.7.28, it is noted that the ground level of the existing villages are at +25m above mean sea level (AMSL). In addition, it is understood that the historical flood level of the Krishna River is at around +21.7m AMSL. Hence, the minimum platform level for future developments within the Capital City should be set at +25m AMSL or at a level higher than the historical flood level in the particular area, subject to further detailed hydrological studies for the Kondaveeti Vagu catchment.

7.4.4 Further Detailed Studies Required

The following detailed studies shall be undertaken before the construction of the Capital City:

Detailed study of reinforcing the Existing Krishna River Bund

The existing bund is made using simple earthworks years ago to provide a barrier preventing flash floods from breaching the Krishna River bund. It is necessary to partially re-design or reinforce the existing bund to provide a higher level of protection, taking into consideration of the effect of climate change which could lead to extreme storm events in the future.

A detailed study of the existing bund, its current condition, and its potential level of protection is required. This will identify further improvement works required to upgrade the bund in the sections not to be realigned. This study may also include modern bund reinforcement construction methods and phasing of construction.

Detailed Hydraulic Study of Kondaveeti Vagu

The planning for the flood management system requires a detailed hydrological study of the Kondaveeti Vagu catchment, and also a detailed study on the potential water yield from this catchment. Due to the complex variables involved in the detailed planning of flood management, it is recommended that the development of flood management measures be done in stages.

Feasibility Study of the Detention Ponds in external sites

The proposed locations of the external detention ponds have been advised by the Local Authorities and are indicative only. It should be commissioned further studies for the site selection, catchment size, size of detention ponds, etc.

Feasibility Study of the Detention Ponds within the Capital City

The proposed locations of the internal detention ponds shown are indicative and are subject to further detailed study. These detention ponds are located within the green buffers. However, the design and locations may be revised and resized based on detailed site conditions such as soil type, topographical conditions and existing land use.

Feasibility Study for Reservoir R1 and Hydraulic Studies for both reservoirs

Two reservoirs have been proposed in the master plan. A feasibility study of the Reservoir R2 west of the Capital City is currently being undertaken by the Local Authorities. To supplement this reservoir, an additional reservoir, Reservoir R1 is proposed in this master plan. Feasibility study should be conducted to confirm its location and capability after the master planning stage. In addition, hydraulic studies for both Reservoirs R1 and R2 are essential to ascertain the balance between water supply and demand.

7.5 WATER SUPPLY

7.5.1 EXISTING CONDITIONS

SOURCES OF RAW WATER

The current issue facing the Capital City is the reliability of raw water source to supply to the Capital City.

Currently, the water supply situation in the vicinity of the Capital City site, such as in Vijayawada and Guntur is sufficient but will not be able to support the future developments in the Capital City.

There are two major conventional sources of water which can be used for the Capital City:-

- Krishna River; and
- Kondaveeti Vagu

The existing villages located within the Capital City site are supplementing their water supply by extracting ground water. Groundwater extraction is mainly used for irrigation and to meet their daily domestic requirements.

This minor source of water is unreliable as it depends on the water table, and as such, is not recommended as a source of raw water for the new Capital City.

Unconventional sources of water, for example, treated effluent, are also currently used within Vijayawada for irrigation purposes.

7.5.2 WATER SUPPLY STRATEGIES

A reliable water supply system is imperative to support the future developments in the Capital City. To increase the attractiveness of the City, the quality of the potable water supply to the City should be of a high standard which allows people to drink straight from the tap.

The following strategies are recommended to ensure a long-term and sustainable water supply to the Capital City.

There are three overarching water supply strategies which will guide the development of this infrastructure in the Capital City:-

- Reliable, Sufficient and Continuous Water Supply
- Clean potable water for all households
- Effective Demand Management

Reliable, Sufficient and Continuous Water Supply

Conventional water sources such as the Krishna River and the inter-basin transfers and Kondaveeti Vagu are able to provide sufficient supply of water for the Capital City.

However, it was identified that without proper storage facilities, the surplus water that arrives during the monsoon or rainy seasons would be wasted and discharged into sea.

It is therefore critical for CRDA to develop new storage reservoirs along Krishna River to support the long term water demand of the Capital City and put these in place before fully developing the City.

Rainfall within the Kondaveeti Vagu catchment could be captured to provide a source of raw water. This can be done by constructing reservoirs to store the runoff.

While these reservoirs would need to have sufficient capacity to store as much of the rainfall as possible, the rainfall may not be sufficient. In this case, they could also be recharged by drawing raw water from the Krishna River and utilizing raw water from the upstream Pulichintala Dam.

Active Beautiful and Clean Waters features such as detention ponds can also be introduced to retain water and act as potential storage reservoirs where suitable.

There is also opportunity to develop rain-water harvesting systems in the Capital City. However, this would be carried out at the development level.

Conceptually, rain-water harvesting systems would capture surface runoff within each development, and these would be used in each development for non-potable uses, such as flushing toilets and/or watering of plants.

In many cities, unaccounted-for water losses may be up to 30% of the water produced.

To increase potential water supply and unwasted water, it is recommended that the water supply network development includes the use of good quality pipes, proper construction, and monitoring measures to detect leaks.

Clean potable water for all households

Amaravati aspires to be one of the most liveable Capital Cities in India. It is important to set a high quality for water supply where one can drink directly from the tap. Hence, it is important to improve the quality of the water supply to the Capital City.

Effective Demand Management

Treated effluent would be more costly, and therefore some demand control may be required.

Water demand may be managed by introducing hardware measures such as water saving fixtures, pressure management, losses / non-revenue water reduction and soft measures such as water tariffs/metering and pricing design, education and behaviour change programs.

This can help in reducing the demand on the water supply using less costly efforts.

CRDA needs to study the soft measures, and provide an overall Water Demand Management framework to identify the cost-effective solutions that may reduce water demand significantly with minimal effort and cost.

In addition, commercial and industrial entities may be provided with subsidies to invest in water-saving fixtures and solutions to alleviate pressure on water demand.

Fig.7.29 Pulichintala Dam

7.5.3 POTENTIAL SOURCES OF WATER

For the Capital City, there are 3 potential sources of water supply identified:-

- Water from Krishna River, with augmentation from Godavari River
- Surface Runoff from Kondaveeti Vagu
- Water from Unconventional Sources, such as reuse of treated wastewater

Water from Krishna River

As a major raw water source, the Krishna River is shared among four states. The State of Andhra Pradesh is located at the lower reaches of the River. The total water demand for all four riparian states is about 4,200 TMC.

Approximately 2,060 TMC is available from the Krishna River if 75% dependability, or reliability, is assumed.

Table 7.4 shows the water balance analysis for Krishna River and Prakasam Barrage, as provided by CRDA officials during site visits. The water balance analysis indicates that there is sufficient raw water supply to support the future developments in the Capital City.

Supply from Krishna River to Prakasam Barrage is approximately 111 TMC annually. There is an on-going project constructing an inter-basin canal from the East Godavari District linking Godavari River to the Krishna River upstream of the Capital City.

This increases the potential water supply to Prakasam Barrage to approximately 191 TMC annually.

After deducting current irrigation and drinking demands, there is an estimated surplus of 35 TMC annually.

Table 7.4 Water Balance Analysis for Krishna River and Prakasam Barrage

Ref	Description	Quantity (TMC/yr)	Remarks
Krishna River			
A	Total annual effective water available for allocation	2060.00	To be shared among four states
	Pulichinthala Catchment		
B	Allocation to Nagarjuna Sagar Reservoir	80.00	Allocated for the Pulichinthala Catchment by Krishna Water Council
C	Deduction from allocation	(20.00)	Deduction due to water savings downstream of Prakasam Barrage.
D	Effective Allocation from Upstream	60.00	
E	Pulichinthala Reservoir's catchment's annual yield	101.00	
F	Evaporation	(9.00)	
G	Infiltration	(1.00)	
H	Total Inflow to Pulichintala Reservoir	151.00	D+E+F+G
J	Allocation Transfer from Godavari River	(40.00)	Offset by Diversion from Godavari River, (L)
K	Supply to Prakasam Barrage from Pulichintala Catchment	111.00	This represents potential supply to Prakasam Barrage
Godavari Lift Canal Project (projected completion in 2016)			
L	Diversion from Godavari River	80.00	To be released downstream of Pulichinthala Dam
Prakasam Barrage (3-5 TMC storage)			
M	Total Inflow to Prakasam Barrage	191.00	
N	Wet Season Irrigation (aka 1st crop irrigation)	(136.00)	
P	Drinking	(15.00)	
Q	**Estimated Surplus at Prakasam Barrage after completion of Godavari Lift Canal Project**	**40.00**	**Currently 35 TMC/yr allocated to Andhra Pradesh**

The projected surplus of 35 TMC/yr from Godavari River will be released upstream of Prakasam Barrage.

Storage facilities are required to store the surplus from Godavari River. Prakasam Barrage has a storage capacity of 3 to 5 TMCs, and therefore much of the underutilised surplus would flow into the sea.

In the near term, the increase in water demand from the Seed Development can be met by the raw water currently available in the Krishna River.

Surface Runoff from Kondaveeti Vagu

The second conventional source of water for the Capital City is the Kondaveeti Vagu.

As previously described in the Flood Management Strategies section, Kondaveeti Vagu catchment receives approximately 3.8 TMC of surface runoff every year, and these currently discharge into Krishna River without being utilised.

Upon urbanisation of the Capital City, the surface runoff would increase, and would be discharged to the sea if not conserved or retained.

There is currently no infrastructure in the Capital City to retain this surface runoff.

Water from Unconventional Sources

In addition to the conventional sources of water, the unconventional sources of raw water should be explored in the detailed study for water supply to the Capital City.

Current unconventional sources include treated effluent (to be discussed in Section 7.6) which can be used to supplement water supply for non-potable use.

In the future, treated effluent can continue to be used in Vijayawada for horticultural and agricultural purposes. In the long run, by treating effluent to higher standards, these treated effluents can even be used by industry.

Dual reticulation systems may also be implemented, and may encourage the reuse of treated effluent. However, a feasibility study would need to be conducted to determine whether such system is required, as dual-reticulation system is costly to implement and there is a risk of cross-connection which will contaminate the potable water. If there is sufficient water capacity from conventional sources, dual reticulation may not be necessary.

In the very long term, desalination plants may be built along the coastline of Andhra Pradesh as an alternative water source to supplement the water supply to the Capital City. While this scenario is unlikely, this can be a contingency plan to mitigate climate change effects in case Andhra Pradesh faces drier and longer monsoon seasons in the future.

7.5.4 WATER DEMAND PROJECTION

By 2050, the Capital City would have experienced rapid urbanisation and population growth.

This will have a huge impact on the future water demand. In this master plan, the demand for base municipal and industrial water usage have been projected.

These projections are useful in determining the gap between the existing water supply and future demand, and this will then allow the future supply to be planned for.

These projections are preliminary, and further demand studies are required as the Capital City develops to ensure that the supply of water demand can be maintained.

MUNICIPAL WATER DEMAND

Water demand for residential land use was estimated based on the population projection by 2050. For other land uses, i.e. commercial and institutional land uses, the water demand was calculated based on gross floor area (GFA). The water demand unit rates were derived after benchmarking against the various water supply planning guidelines in India, Singapore, Malaysia and South Africa. Table 7.5 shows the water demand unit rates used for the purposes of the Capital City study.

Total municipal water demand in 2050 is estimated to be 557 MLD (0.02 TMC/day) as shown in Table 7.6.

INDUSTRIAL WATER DEMAND

Several industrial clusters have been proposed within the Capital City. The major industrial zones are located in the south of the Capital City. The other zones are industrial pockets located within residential townships. The water demand was calculated based on the proposed plot area with the unit rates ranging from 15 to 140 m³/ha/day depending on the type of industry. Total industrial water demand in 2050 is estimated to be 62.2 MLD, including 53.7 MLD (0.0019 TMC/day) potable water and 8.5 MLD (0.0003 TMC/day) recycled water. A summary of Industrial water demand is shown in Table 7.7.

As summarised in Table 7.8, the total water demand for 2050 is 610.7 MLD potable water (0.021 TMC/day) and 8.5 MLD non-potable water (0.0003 TMC/day).

Table 7.5 Water Demand Rates used for Municipal Water demand projections

Type	Unit Rate	Unit
Residential	150	lpcd
Commercial	6	l/m²/d
Institutional	2.5	l/m²/d

Table 7.6 Projected Municipal Water Demand for 2050

Land Use Type	Water Demand (MLD)
Residential	370
Commercial	143
Institutional	44
Total	557

Table 7.7 Projected Industrial Water Demand for 2050

Land Use	Water Demand (MLD)		
	Potable	Non- potable	Total
Industrial	53.7	8.5	62.2

Table 7.8 Summary of Water Demand Projection

Land Use	Water Demand (MLD)		
	Potable	Non- potable	Total
Municipal	556.6	0	556.6
Industrial	53.7	8.5	62.2
Total	610.7	8.5	618.7

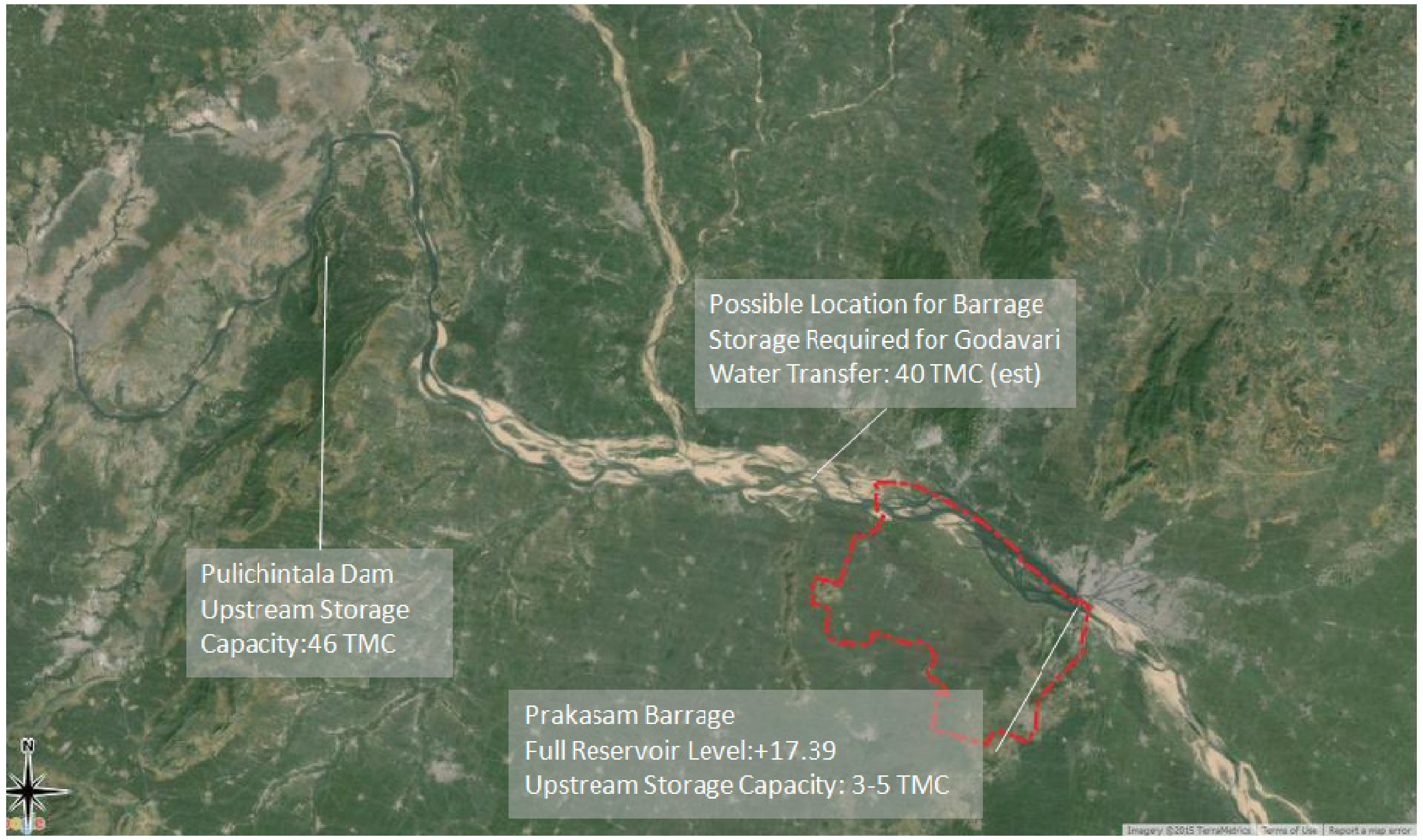


Fig.7.30 Existing and Possible Barrage Locations (CRDA, 2015)

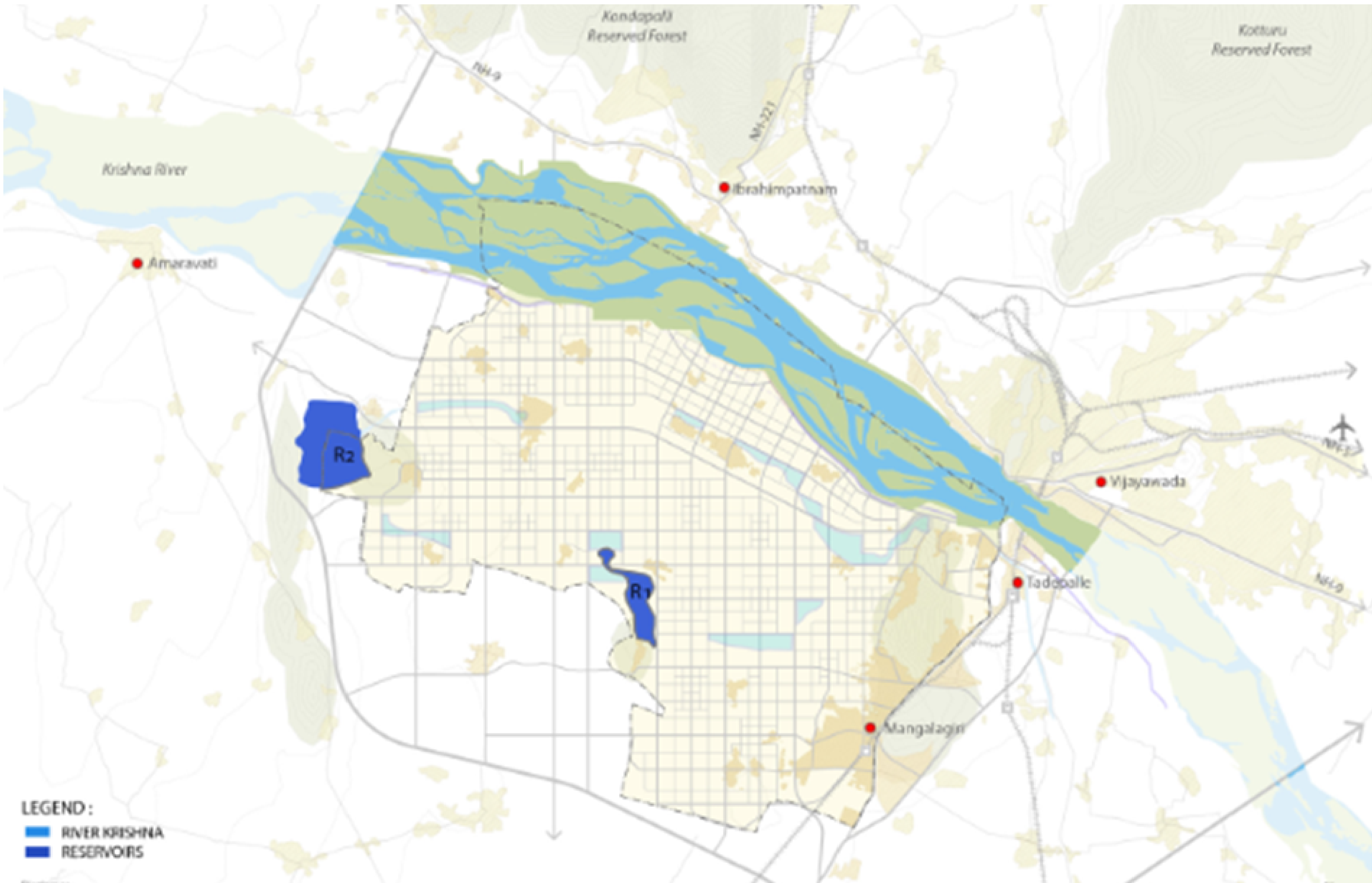


Fig.7.31 Water Supply Resources for Capital City

Fig.7.32 Example of Storage Reservoir

Fig.7.33 Example of Rainwater Harvesting Facilities

7.5.5 WATER SUPPLY PROPOSALS

The key measures to support the overall water supply strategies are:-

- Create storage reservoirs along Krishna River to store raw water from Krishna River and water diverted from Godavari River
- Create storage reservoirs to collect surface runoff and flood water from Kondaveeti Vagu
- Implement rain water harvesting at individual developments
- Reuse of treated wastewater for non-potable use

Create Storage Reservoirs along Krishna River

Additional storage facilities are required to store raw water from Krishna River and Godavari River.

Change of land use from agriculture to other uses in the Capital City will reduce the demand for irrigation water and result in an increase of unutilised raw water. This could also be stored, hence, there is a need to create storage reservoirs outside the Capital City with sufficient capacity to store raw water to supply to the proposed water treatment plants to meet the long term water demand.

Fig.7.30 shows the existing storage reservoirs along Krishna River. There are current plans to create an additional storage upstream of the Capital City to store water from the Godavari Water Transfer and Pulichintala Dam.

Create Storage Reservoirs Within the Capital City

One of the conventional sources of water supply is storm water collected within the Kondaveeti Vagu catchment. Two reservoirs, R1 and R2 are proposed within the Capital City to intercept and store the rain water during the monsoon season.

The total capacity of the proposed reservoirs is estimated at 6 TMC. The 2 reservoirs should be linked and integrated to balance and optimise the total storage capacity. After the completion of these two reservoirs, the raw water supply for the Capital City will be from both the Krishna River and the new storage reservoirs (see Fig.7.31).

Implement Rainwater Harvesting at Individual Developments

Rainwater harvesting presents an opportunity to collect storm water for non-potable uses as the Capital City receives moderate annual rainfall of 1,073 mm per annum.

An approach that CRDA could take is to make installations of rain water harvesting systems compulsory for large urban developments within the Capital City.

Reuse of Treated Wastewater for Non-potable Use

As 80% of the potable water consumed will become wastewater, the wastewater from the Capital City can

be treated and reused for non-potable use. The treatment technology depends on the quality of waste water collected and its intended end use. If the entire Capital City is sewered in the future, it could supply enough of non-potable water for industrial use, thus reducing the dependence on potable water.

The excess treated effluent could then be stored and reused for irrigation purposes, and depending on demand and the quality of discharge, could be recycled for industrial usage.

7.5.6 WATER SUPPLY SYSTEMS

According to the demand projections, the Capital City needs to generate 606.7MLD (0.021 TMC/day) or 221445.5 ML (7.8 TMC) of potable water per year by 2050. As a modern and liveable city, the Capital City must be served by a reliable and complete water supply system. To provide a complete water supply system, the following water supply infrastructure has been taken into consideration:

- Water Treatment Plants
- Water Distribution Centres
- Water Supply Network

Water Treatment Plants

There are currently no existing WTPs within the Capital City area. The nearest WTP is located at Vijayawada and this plant is reaching its service limit.

To ensure the quality of potable water and increase water accessibility, it is necessary to construct new WTPs within the Capital City. For water supply, the entire City shall be divided into various supply zones. Each zone shall be served by one WTP and a corresponding water supply distribution system.

The water treatment plants planned for should have adequate redundancy to cater to treatment contingencies while the pipe networks are duly looped to provide the supply feed contingencies.

The capacity for the WTPs shall be based on the sum of water demand projections in their service zone.
The locations shall be selected after taking into consideration the following aspects:

- Distance to the water source – selected locations should be close enough to the raw water source to optimise transmission pipe length.
- Future land use plan – the treatment plants may be located near greenery, open spaces, and near future growth areas that will consume large amounts of water, for example, the industrial clusters and high-density residential townships.

As shown in Fig.7.34, the entire Capital City has been divided into three indicative supply zones, each served by a WTP. The capacities of each WTP are estimated based on the demand projection of their supply zones.

WTP 1 will take water from the Krishna River. WTP 2 draws water from Reservoir R2 and WTP 3 will draw water from Reservoir R1. Table 7.9 summarises the service zone, water source and capacity of each WTP.

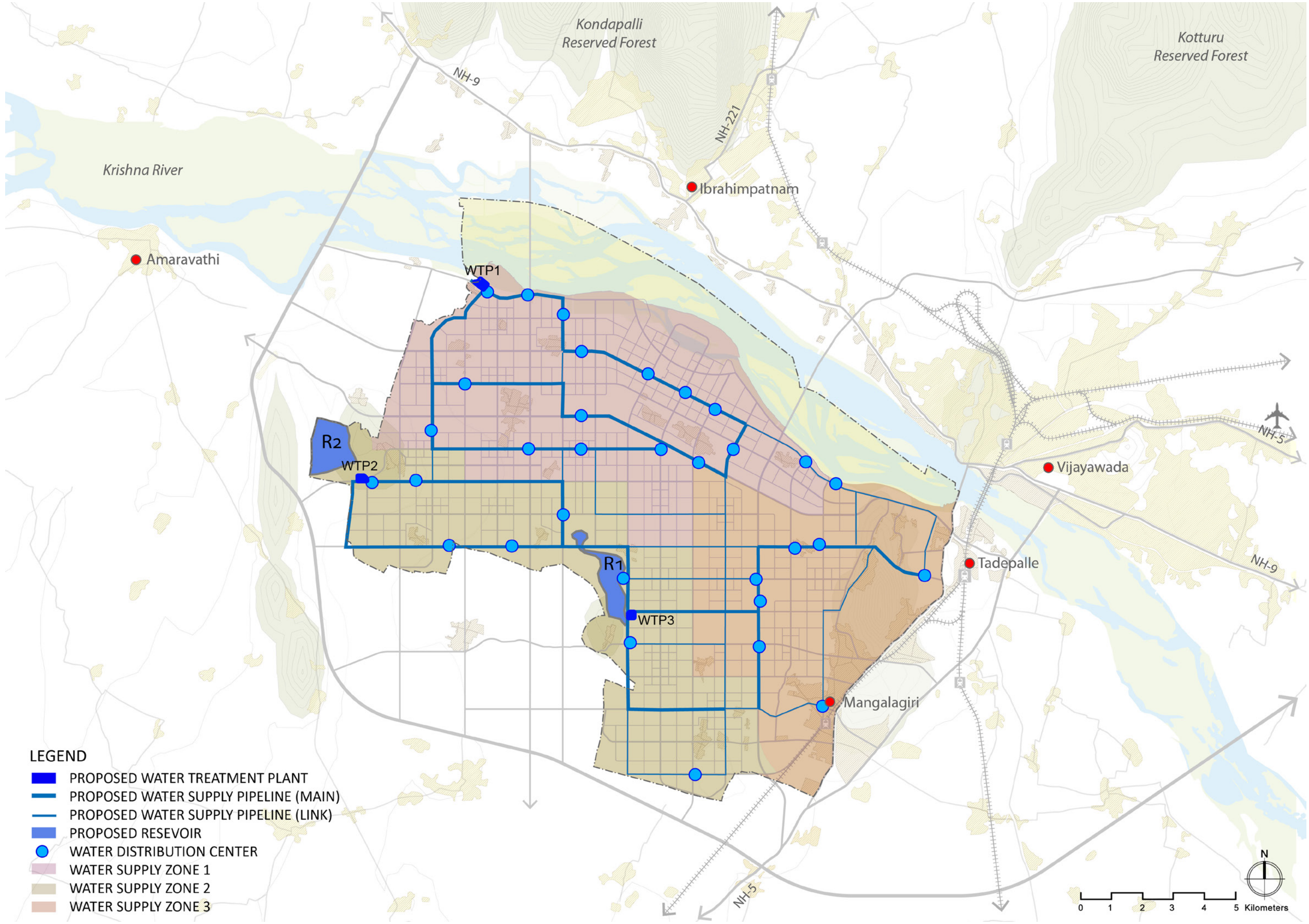


Fig.7.34 Indicative Water Supply Pipeline Network and Water Distribution Centres for the Capital City

Fig.7.35 Examples of Water Treatment Plants

Treated water shall be pumped from the WTP to various water distribution centres (WDC) within each supply zone.

Each WDC comprises of at least one storage tank, pumping station, and also several water towers. To achieve the desired pressure to supply water by gravity to the farthest point in its service zone, each WDC should be located on high ground. It is recommended that the pressure in the distribution network is maintained between 1.5 - 4 bars.

After the master planning stage, CRDA should carry out a detailed feasibility study to confirm the suitability of the proposed WTP locations, their intake channels, the supply capacities and redundancy in plant capacity.

The study should also address the high turbidity, and the quality of raw water from Krishna River during the monsoon period which could have an impact on the WTP.

Water Distribution Centres

WDCs have been proposed to allow temporary storage of treated water from the WTP before the treated water is distributed to individual developments by gravity.

The WDCs may be designed to have 1-day storage capacity. However, this should be studied further to determine the optimal storage capacity required based on international standards.

Up to three WDCs have been proposed for each township. After the master planning stage, there will be a need to carry out detailed feasibility studies for each WDC to confirm the number and the suitability of the locations and their capacities.

Sitting of the treated water tanks should be on high ground where possible, for flat terrain, the treated tanks will have to elevated to regulate the treated water supply during peaks of the day using gravity flow.

The current proposals are to have ground tanks to provide storage at each WDC, however direct pumping to the water towers is also possible. A detailed study should be carried out to determine the most suitable system to be implemented in the Capital City.

Water Supply Network

An extensive water supply network has been proposed within the Capital City. The alignments provided are indicative only. The pipe networks should be tied in with the road infrastructure plan with sufficient alignments, and pipe size should be laid to provide for future growth and contingencies.

By providing a loop, or interconnected pipeline system to connect each service zone, the network can provide redundancy during maintenance and repair. The water pipeline corridors are to be reserved along road side tables and within green corridors.

Table 7.9 Proposed Water Treatment Plant Capacity

Water Treatment Plant	Service Zone	Water Source	Capacity (MLD)
WTP1	1	Krishna River	270
WTP2	2	R2	200
WTP3	3	R1	160

7.5.7 CRITICAL ISSUES FOR WATER SUPPLY

There is a need to address reliability of water supply in terms of dependable yield, reflecting the yield-storage relationship (a function of catchment area, long term records of rainfall data, storage capacity and inflow to the reservoirs). It is recommended that a yield study be conducted to ensure that the water supply to the Capital City is adequate and continuous. The water quality of the various sources, particularly raw water from the rivers must also be studied.

Another key issue related to water supply is the lack of storage facilities for raw water from the Krishna River, raw water diverted from the Godavari River and runoff from Kondaveeti Vagu. Even with the proposed Reservoirs R1 and R2 within the Capital City, there is still a shortage of storage capacity for raw water to ensure a constant supply of raw water to the proposed water treatments plants throughout the year. This is because the augmentation of water from Godavari River is seasonal, and therefore cannot be considered a reliable source, unless the supply can be captured.

Hence, it is imperative to develop sufficient storage reservoirs within or outside the Capital City to store the raw water collected during the monsoon season to supply to the proposed water treatment plants throughout the year.

To this end, a detailed feasibility study of the proposed external storage reservoirs, in addition to Reservoirs R1 and R2 and the proposed additional barrage upstream of the Capital City should be undertaken immediately after the master planning stage to determine the size, locations, pumping of high volume over high heads and other facilities to ensure a sustainable and high quality of water supply to the Capital City.

Reuse of treated wastewater should also be studied and considered as a potential source of water as reliability may be an issue.

Other than the annual raw water supply figure allocated to AP provided for conceptual planning, it is important to conduct detailed study the supply pattern to AP over the years to ensure uninterrupted supply to the Capital City. The detailed study should also cover the contingency plans for a prolonged drought situation which may occur.

7.6 SEWERAGE

7.6.1 Existing Conditions

There is currently no formal sewerage system within the Capital City site. Traditional pit latrines are predominantly used by the local residents in the villages. A report by the non-government organisation, Centre for Science and Environment (CSE), Delhi, based on surveys of wastewater profiles of 71 Indian cities, highlights the lack of infrastructure and neglect of sewage with less than 30 percent of the country's officially recorded sewage being treated in proper facilities. About 70-80 percent of India's wastewater ends up in its rivers and lakes.

A lack of modern sanitation can cause contamination of water resources and environmental degradation. Many Indian cities suffer water scarcity and pollution problems caused by encroachments into lakes and water bodies. Inequity of water and sewage disposal infrastructure between rich and poor areas is another phenomenon in Indian cities, with high-income zones having most of the available amenities.

To be a model city in India, it is essential to develop a modern sewerage network and treatment system for the proposed Capital City.

The network should be developed to protect the environment and to ensure the quality of life in the City.

7.6.2 Waste Water Strategies

The following strategies are recommended to provide a sustainable and an environmentally friendly wastewater system to the Capital City:-

- Development of a Modern Sewerage System covering 100% of the City
- Wastewater Treatment to International Standards
- Prevention of untreated discharge in the water bodies, particularly Krishna River.

Development of a Modern Sewerage System

A modern and comprehensive sewerage network should be developed to serve all the Capital City.

The coverage of the proposed sewerage network should encompass 100% of the Capital City. This sewerage network should be a completely separate system from the storm water drainage network.

In the short term, pit latrines which are being used at the existing villages within the Capital City should be phased out and replaced with septic tanks.

In the long term, a piped sewer network connecting all households within the villages can be developed to connect the sewer network serving the Capital City to convey wastewater to the sewage treatment plants (STPs) for treatment. These STPs should have a 200m buffer around them.

Wastewater Treatment to International Standards

Sewage effluent, when treated to a high discharge quality, e.g. discharge effluent quality of Biological Oxygen Demand (10 mg/l), Suspended Solids (10 mg/l) and Chemical Oxygen Demand (10 mg/l), can be re-used in non-potable applications to supplement the water supply, for example in industries, agriculture or horticulture.

By re-using treated sewage effluent, the non-potable water demand for the Capital City can be met without the need for additional supply of raw water.

A combination of these two strategies will ensure that sewage that is produced within the Capital City can be treated completely, and therefore would be safe for discharge into the waterways in the vicinity of the Capital City.

The key measures to support the overall wastewater management strategies are:-

- Separate Sewerage System
- Comprehensive Sewerage Network
- High Quality Treatment System
- Proper Disposal or Effective Reuse of Recycled Water

7.6.3 Sewage Flow Projection

A sewage flow projection has been established to analyse the gap between the existing conditions and future demands by 2050.

This allows the sizing of the land to be reserved for the future Sewage Treatment Plants (STPs).

Municipal waste water

For the purposes of this study, the sewage flow in 2050 is projected based on the assumption that 80% of the potable water consumed daily will be collected as sewage. Sewage generated by the residential areas within industrial clusters is considered as part of the municipal wastewater. The total municipal sewage flow is projected at 445 MLD or 0.02 TMC/day (refer to Table 7.10).

Industrial waste water

Industrial sewage generated is estimated based on 80% of the potable water consumed and 10% infiltration rate. The total industrial waste water flow in 2050 is estimated at 53.7 MLD or 0.002 TMC/day (refer to Table 7.11). It is recommended that for the heavy industry clusters, a separate collection system is developed.

7.6.4 Wastewater Proposals

Based on the demand projection, the total capacity of the proposed STPs should be 500 MLD or 0.02 TMC/day by 2050 to meet the demand. It is vital to develop a comprehensive sewerage network and sewage treatment plants to process the waste water from the Capital City.

Separate Sewerage System

To manage the wastewater generated from the daily activities within the Capital City, the Capital City is divided

Township	Sewage Generated (MLD)
1	3.7
2	13.2
3	14.6
4	26.5
5	3.5
6	11.8
7	14.4
8	14.4
9	19.3
10	15.5
11	3.9
12	9.7
13	15.4
14	22.1
15	12.9
16	14.7
17	27.6
18	17.2
19	13.8
20	23.1
21	10.9
22	14.5
23	10.2
24	16.5
25	27.8
26	66.0
27	2.1
Total	445

Table 7.10 Projected Municipal Sewage Generation (Million Litres per Day, MLD)

Township	Industrial Waste Water (MLD)
Industrial	53.7

Table 7.11 Projected Industrial Sewage Generation (Million Litres per Day, MLD)

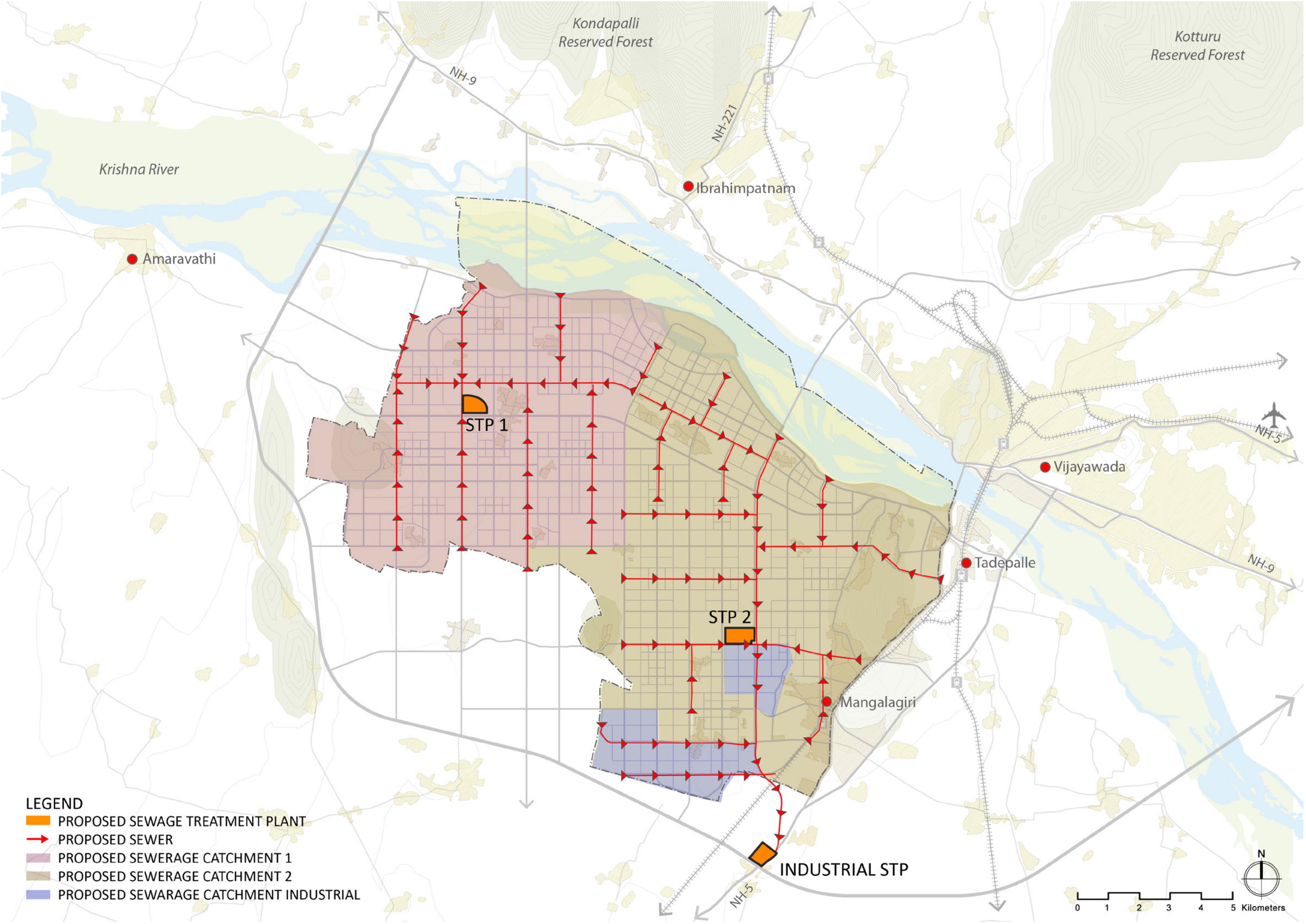


Fig.7.36 Proposed Wastewater Management System

into 3 sewerage catchments. Each catchment would be served by an STP (refer to Fig.7.36). A dedicated industrial STP should be provided to serve the southern industrial clusters. The proposed STPs are located at the low lying areas to allow collection of sewage by gravity. These should accessible by road and should be located within close proximity of water bodies for discharge of the treated sewage effluent.

The land reserved for the STPs should be sufficient to build the necessary sewage treatment capacity. The STPs can be built in phases using modules and expanded where the need arises, so that the initial capital expenditure can be kept to the minimum. For example, an initial 40MLD STP can be built in the allocated site, and once a threshold is met (i.e. operational 30MLD demand), a second module can be constructed.

Comprehensive Sewerage Network

A gravity sewerage system is recommended for collecting the sewage to reduce the need for pumping. It should be designed with minimum number of lifting stations where possible, while maintaining self-cleansing velocities. The alignment of the trunk sewers shall follow the proposed utilities corridor along the arterial road to provide access for installation and maintenance. After the master planning stage, a detailed feasibility study should be carried out for the sewerage system to confirm the suitability of the sewerage system, proposed locations of the STPs, effluent discharge locations and treatment technology.

The dried sludge from the proposed sewage treatment plant can be used as fertiliser in the short term, however in the long term, these can be transported to the external Integrated Solid Waste Management Facility (ISWMF) in the future for disposal.

High Quality Treatment System

The sewage effluent in the STPs if treated to meet stringent standards, which can then be used to supply directly to the industries for non-potable use. Discharge to the waterways and detention ponds is also possible by treating the sewage to a high discharge quality. If the sewage effluent is treated to the standards of BOD (10 mg/l), COD (10 mg/l) and SS (10 mg/l), it can be discharged to any waterways or recycled for industrial use.

The municipal STPs will not only receive domestic waste water from the households, but also industrial waste water generated from the small industrial pockets located within the residential townships. The industrial waste water must be pre-treated on-site before discharging into the municipal sewerage network. It is critical to periodically check the quality of the pre-treated industrial waste water before it flows into the municipal sewerage network. This will also improve the quality of the treated effluent, and reduce the cost of the treatment, as there would not be requirement for additional processes i.e. removal of heavy metals etc.

Proper Disposal or Effective Reuse of Recycled Water

Some of the treated sewage effluent generated from the individual STPs could be stored at the STPs and supply for non-potable use, such as irrigation of the landscaped areas within the Capital City. The treated sewage effluent could be loaded on to water tankers for irrigation during the dry season or distributed to the landscape areas in the parks or along the roadside through a network of irrigation pipelines.

Storage will need to be provided for the non-potable use, and the excess may be discharged to the waterways or to the detention ponds to mix with the raw water as an additional source of raw water for the proposed water treatment plants.

7.6.5 Critical Issues for Sewerage

The main issue related to wastewater management is the lack of wastewater collection and treatment facilities in and around the Capital City to support the future developments. Hence, a detailed feasibility study should be conducted for the wastewater management system immediately after the master planning stage to ensure that the facilities are in place to serve the Seed Development and the entire Capital City in the future.

7.7 SOLID WASTE

7.7.1 Existing Conditions

Current Waste Generation

The Capital City site is largely a green field site with some existing villages. There is currently informal solid waste collection or processing taking place.

Rubbish is generally disposed of by burning or is sent to the nearby dumpsites. The closest facilities are the landfill sites in Vijayawada and a municipal dumpyard at Guntur. The locations of these sites are shown in Fig.7.37.

Vijayawada and Guntur are the only large Urban Local Bodies (ULB) in the Capital Region with a population of more than 500,000.

Currently 450 – 500 tons of Municipal Solid Waste (MSW) are collected daily in Vijayawada and disposed at the Jakkampudi dump site. Around 300 tons of MSW are collected daily in Guntur. This is disposed of at the Naidupet dump site.

Current Waste Collection

The primary waste collection is carried out by individual workers going door to door, collecting waste onto hand carts from each household before being transferred to bin points (see Fig.7.38).

These bin points are dirty, odorous and unhygienic. At these locations, manual sorting takes place, often in the road way, to remove the recyclable and higher value waste items such as plastics, bottles and metals. The remaining waste is then disposed into skips.

Once the waste is consolidated into skips, the secondary collection system of using lorries to pick up the skips and to transport them to the land fill sites for dumping.

In some cases, the lorries would move the MSW to another larger transfer point prior to the dumpsites.

Current Waste Treatment

The dumping sites at Vijayawada are nearing capacity with the site at Jakkampudi being scheduled to close by the end of 2015. These sites cannot be relied upon to accept the solid waste from the Capital City (see Fig.7.39).

There are negotiations taking place currently to use a site at Ibrahim Patnam to take over from Jakkampudi. The dump site used by Guntur is at Naidupet. This site is approximately 30 hectares and has an expected lifespan of another 20-25 years.

The operations and maintenance of the existing dump sites are poor, posing environmental health and nuisance to workers and nearby residential areas.

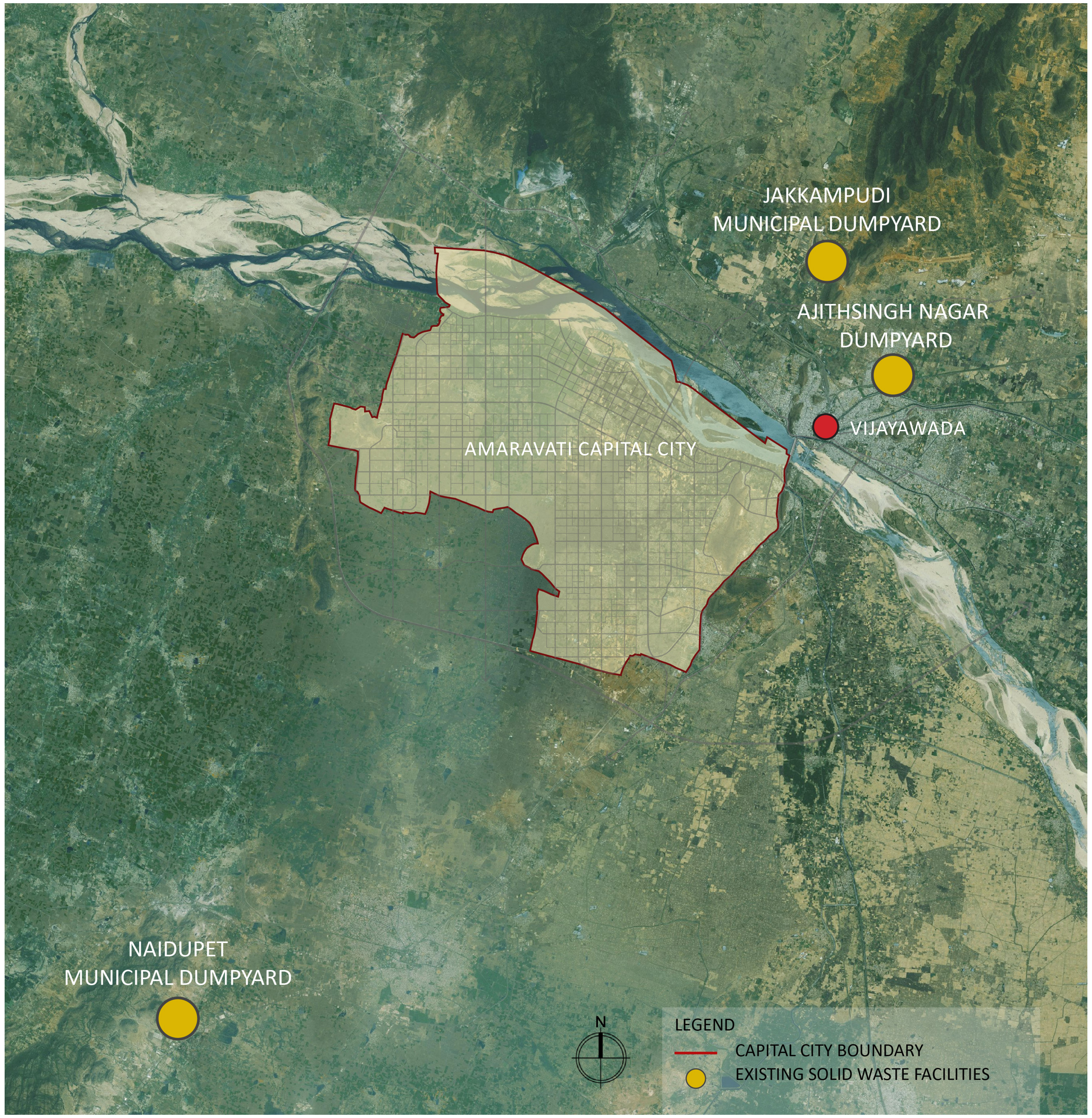


Fig.7.37 Existing Solid Waste Facilities near the Capital City

Fig.7.38 Door to Door Collection in Vijayawada

Fig.7.39 Existing Solid Waste to Energy (WTE) Plant in Ajithsingh Nagar, Vijayawada

Future Developments

The current waste management system needs modernisation and reorganisation if it is to effectively serve the new Capital City.

The existing dump site at Naidupet has been identified as a possible location for a new solid waste facility. At this location, there is sufficient space to expand the dumping area and/or to construct new solid waste management facilities.

7.7.2 Solid waste management Strategies

To make the new Capital City an attractive and liveable city, a solid waste management system which is convenient, reliable and consistent in service must be put in place.

To provide sufficient capacity for disposal for the Capital City, it is important to develop long and short term plans for Vijayawada and Guntur.

Meeting the needs of these cities will lay the foundations for building up the required capacity and facilities for the Capital City in the future.

This will also, in turn, encompass the infrastructure plans for the entire Andhra Pradesh Capital Region including Amaravati, the Capital City Seed Development and other smaller ULBs and villages.

There are three overarching strategies which will guide the development of solid waste management in the Capital City:-

- Towards Zero Waste
- Solid Waste as a Resource
- Recover energy from Waste

TOWARDS ZERO WASTE

The most fundamental approach to managing solid waste is to not produce it in the first place.

By reducing the production at source, it is possible to control solid waste without the need for increased infrastructure or processing.

An example of reducing waste is the reduction of use of packaging when selling goods.

These types of initiatives have often been championed by NGOs.

SOLID WASTE AS A RESOURCE

From the environmental point of view, solid waste does not have to be considered an environmental problem - it can also be considered as a potential resource.

By managing waste correctly from the point of the production all the way to disposal, several types of resources can be recovered from the waste:

- Recyclable waste, such as plastics, metals and organic waste;
- Combustible waste for energy production; and
- Organic matter for composting.

RECOVER ENERGY FROM WASTE

Energy recovery from waste is a concept of converting non-recyclable waste material into heat, electricity, or fuel.

This can be accomplished by the use of Waste to Energy (WTE) Plant. This is most commonly done in the form of an incinerator that can burn solid waste and use this energy to produce electricity.

The following long term proposals will seek to address the requirements of the Capital City when it is fully developed:-

- Rehabilitation of Current Collection Systems
- Treatment of Waste at Integrated Solid Waste Management Facilities (ISWMF)
- Special Solid Waste Management
- Inculcate Responsible Public Behaviour on Waste
- Encourage Use of Technology
- Regulation, Legislation and Enforcement
- Flexibility in a Robust Plan

7.7.3 Solid Waste Projections

Solid waste generation will increase significantly as a result of the projected population and economic growth in the Capital City. Solid waste generated from for the Capital City is projected up to 2050 in this study.

These projections are based on the national average. The following projections are to be used as a starting point for estimating solid waste generation, and are subject to further detailed studies regarding the waste volume and characteristics representative of local waste.

Municipal Waste

The current municipal solid waste generation rate is estimated at 0.5 kg/capita/day[1]. It is assumed that with the population and economy grow in the Capital City, the solid waste generation rate in the future will increase.

According to the 'Sustainable Solid Waste Management in India' study by Columbia University in 2012, the waste generation rate is expected to increase linearly over time.

Based on this assumption, the waste generation rate is estimated at 0.813 kg/capita/day by 2050 (Refer to Table 7.12).

The projected municipal waste generation in 2050 is calculated based on this rate together with the projected population for the various proposed townships in the Capital City, and is summarised in Table 7.13.

In total, the estimated waste generated from the entire Capital City is 2,018 tonnes per day.

Industrial Waste

Based on the land use distribution and the type of industries, the industrial solid waste generation has been worked out as shown in Table 7.14.

The solid waste generation rate varies from 150 to 210 kg/ha/day for different types of industry.

The ultimate solid waste generation for the industrial development has been worked out to be an average of 255 tonnes per day.

Year	Waste Generation Rate (kg/Capita/day)
2001	0.439
2011	0.498
2021	0.569
2031	0.693
2036	0.693
2041	0.741
2050	0.813

Table 7.14 Projected Waste Generation Rate (kg per capita per day)

Township	Solid Waste (tons/day)
1	21.5
2	36.8
3	94.5
4	153.2
5	17.4
6	63.2
7	70.7
8	78.5
9	110.2
10	53.9
11	0.5
12	51.1
13	56.1
14	114.3
15	50.3
16	81.4
17	168.4
18	52.9
19	81.2
20	127.2
21	63.8
22	52.5
23	69.2
24	75.5
25	111.9
26	161.7
27	-
Total	2,018

Table 7.12 Projected Municipal Solid Waste Generation for Yr 2050 (tons/day)

LAND USE	Waste Generation Rate (tons/day)
R&D	20
General Industrial Zone	210
LOGISTICS ZONE	24
TOTAL	255

Table 7.13 Projected Industrial Solid Waste Generation for Yr 2050 (tons/day)

7.7.4 Proposed Short Term Solid Waste Management System

The development of the new Capital City will take place over many years before the Capital City is fully developed. Therefore, both short term and long term proposals must be put in place to take care of the solid waste generated from the Capital City.

The short term strategy is to solve the current solid waste problems being faced by Vijayawada and Guntur which in turn will take care of the solid waste from the initial phases of development in the Capital City.

In the short term, it is recommended that the operation and maintenance of the existing dump site at Naidupet be improved to receive the solid waste from the Capital City, Vijayawada and Guntur, as well as the smaller nearby ULBs in the vicinity.

A sanitary landfill must also be developed at the existing dump site at Naidupet. Hence, there is a need to improve the operations and maintenance of Naidupet dump site and upgrade it to a sanitary landfill.

Further there is a need to conduct a detailed feasibility study on the short term improvement to the solid waste management system to serve the Capital City.

These short-term strategies will lead on to the development of the long-term strategies, for example, the sanitary landfill can also be further developed as one of the facilities in the Integrated Solid Waste Management Facility (ISWMF).

7.7.5 Proposed Long Term Solid Waste Management System

The following proposals have been formulated to achieve the long-term strategies:-

- Rehabilitation of Current Collection Systems
- Treatment of Waste at Integrated Solid Waste Management Facilities (ISWMF)
- Special Solid Waste Management
- Inculcate Responsible Public Behaviour on Waste
- Encourage Use of Technology
- Regulation, Legislation and Enforcement
- Flexibility in a Robust Plan

1 Source: Position Paper on the Solid Waste Managemetn Sector in India, Department of Economic Affairs, Ministry of Finance, 2009

Rehabilitation of Current Collection Systems

The current system employed for the collection of waste is not efficient. The two principal short-comings are the environmental damage caused by the inadequate consolidation facilities and the extraction of combustible items in the solid waste itself before reaching the dumping site. Unless these issues are addressed, it will not be possible to support a modern solid waste processing system. The collection system is the critical link that supports the rest of the waste management chain.

The current system of using hand carts should be modernised and motorised. The area an individual collector is able to cover by foot is relatively small and so this leads to the requirement of many bin points in residential areas.

These facilities are currently unsightly and pose an environmental threat to the public. By increasing the coverage area of primary collection using motorised carts, the number of these bin points can be reduced. As these bin points are being consolidated, the bin points can be modernised to include sorting facility and a compactor. Based on current estimates, 15-20 bin points can be merged into one bin centre.

The sorting of the rubbish at these centres should take place in a dedicated building that can allow mechanised bulk-handling and compaction. These new facilities will help to ensure that a dependable and consistent supply of solid waste is transported to the designated dump site.
As the livelihood of the waste collectors are dependent on the existing solid waste management system, it is important that these people are taken care of during the consolidation of the bin points. To ensure that livelihoods are not lost, the consolidation centres should be formed by cooperatives made up of the existing waste collectors.

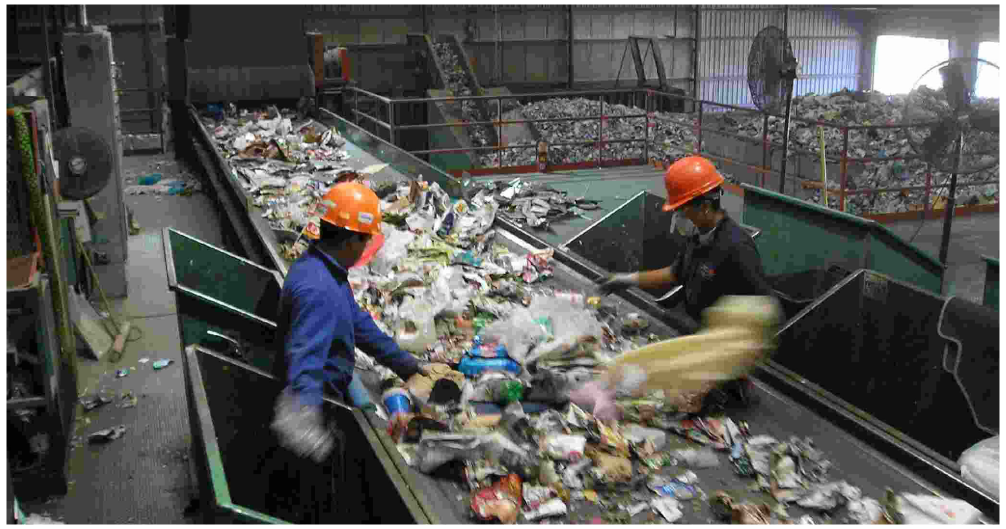


Fig.7.40 Closed Waste Sorting (Missouri Department of Natural Resources, 2015)

This way, the lives of the people involved in the collection chain can be improved as they will no longer be exposed to potentially harmful materials whilst still providing an income through the recyclables collected and sorted at the consolidation centres.

With a stream-lined, closed collection system in place, it will be possible to support more sophisticated and environmentally friendly forms of solid waste treatment (see Fig.7.40).

For the new Capital City, a modern waste collection system must be put in place to increase the attractiveness of the Capital City. Door-to-door collection systems can be implemented for landed properties where residents dispose the rubbish into bins located outside the properties along the roads.

Rubbish trucks would go from house to house to empty the bins on a regular basis. For high-rise residential buildings, individual refuse chutes or centralised refuse chutes should be provided for residents to dispose rubbish.

Rubbish would be collected at collection bins located at the ground floor. These bins would be emptied to a motorised vehicle. The motorised cart or truck would then transfer the waste to a bin centre for collection by larger rubbish trucks.

Alternatively, compactors can be provided at the bottom of centralised refuse chutes for direct collection by rubbish trucks without the need of a bin centre as a transfer station.

For high-income group (HIG) housing, modern collection technologies such as pneumatic waste collection systems may be considered. The implementation of the various modern waste collection systems can be done through a set of building development guidelines.

As the system of collection is being modernised, the existing dump site should be upgraded to become a sanitary landfill. A sanitary landfill has formal processes in place to isolate the waste away from the environment and to handle and compact the waste.

This can help to maximise the lifespan of the facilities and to help mitigate environmental damage such as leachate escaping from the site.

TREATMENT OF WASTE AT INTEGRATED SOLID WASTE MANAGEMENT FACILITY (ISWMF)

Integrated Solid Waste Management is a comprehensive waste prevention, collection, recycling, composting, and disposal programme.

The major ISWM activities are waste prevention, recycling and composting, and combustion and as well as disposal in properly designed, constructed, and managed landfills.

While the collection of waste can be carried out externally, the segregation of waste from recyclables to compost and even to combustible waste can be carried out at the integrated facility.

Recycling and composting facilities can be co-located with the segregation facility so that waste can be dealt with in the same compound.

After these processes, the remaining waste that can be converted to energy at a Waste-to-Energy (WTE) plant, and the by-products of the WTE (mostly ash) can then be transported to an engineered landfill nearby.

The following is a list of typical facilities in an Integrated Solid Waste Management Facility:-

- Sorting/Material Recovery Plant
- Anaerobic Digestion (AD)/Compost Plant
- WTE (Waste-To-Energy) Plant
- Engineered Landfill
- Bio-medical Waste Incinerator
- Construction & Demolition (C&D) Waste Recycling Plant
- Other waste recycling plants and facilities

There are current plans to develop an ISWMF at an existing landfill site in Naidupet, near Guntur, to treat waste from Guntur Municipal Corporation.

The existing open dumping ground at Naidupet has not reached its capacity and is a relatively large site of 30 hectares. The comparatively short distance to this site from the Capital City means that in the early stages of the development, the existing dump site is suitable to serve the Capital City, particularly the seed development.

The size of the site means efforts can be made to modernise the processing whilst the dumping operations

continue. This modernisation of solid waste management system can be carried out through the concept of integrated solid waste management.

To kickstart the development of the Integrated Solid Waste Management Facility in Naidupet, it is recommended that a WTE plant be constructed.

From site observations, there is sufficient volume of MSW collected from Vijayawada and Guntur, which can provide enough waste material for a WTE plant. In addition, the characteristics of the existing MSW may also be suitable for incineration at WTE plants. Further detailed studies such as waste characteristic studies would be needed to verify these before proceeding with the WTE plant in Naidupet.

This will help to reduce the volume of waste being dumped at the ISWMF and further extend the lifespan of this site. This energy production would also help to offset energy demands.

Fig.7.41 shows the possible routes for solid waste transfer from the Capital City to the IWSMF in Naidupet Guntur.

There are several thermal and non thermal technologies available for converting the solid waste to energy. The most common and widely used is incineration. This can reduce the volume of waste by up to 90% leaving only incinerator bottom ash which in turn can either be dumped or recycled.

Technologies such as gasification require very specialised machinery and personnel that can be difficult to maintain whilst giving only marginal benefits. Therefore, a well established technology such as incineration will be more likely to succeed.

When constructed, the WTE Plant could take in total 800 tons of material per day. Whilst this will meet the requirements of Vijayawada and Guntur it will not meet the requirements of the Capital City. Therefore the design of the plant must be modular to allow for future expansion.

To construct a facility such as a WTE plant, large scale investment must be made. These funds may not be readily available as all the capital investment must be made upfront.

Therefore, an option for the Government is to partner with a private entity through a Public Private Partnership (PPP) programme to develop the WTE plant. This could be in the form of licensing to operate or through a build-operate and transfer arrangement.

In order to attract private investment there must be several key elements in place:-

Premium Tariffs
The generation of clean energy should attract a premium over conventional forms. This can be in the form of a higher tariff rate paid per million unit of generation. This premium can encourage alternative generation and by association cleaner solid waste disposal methods.

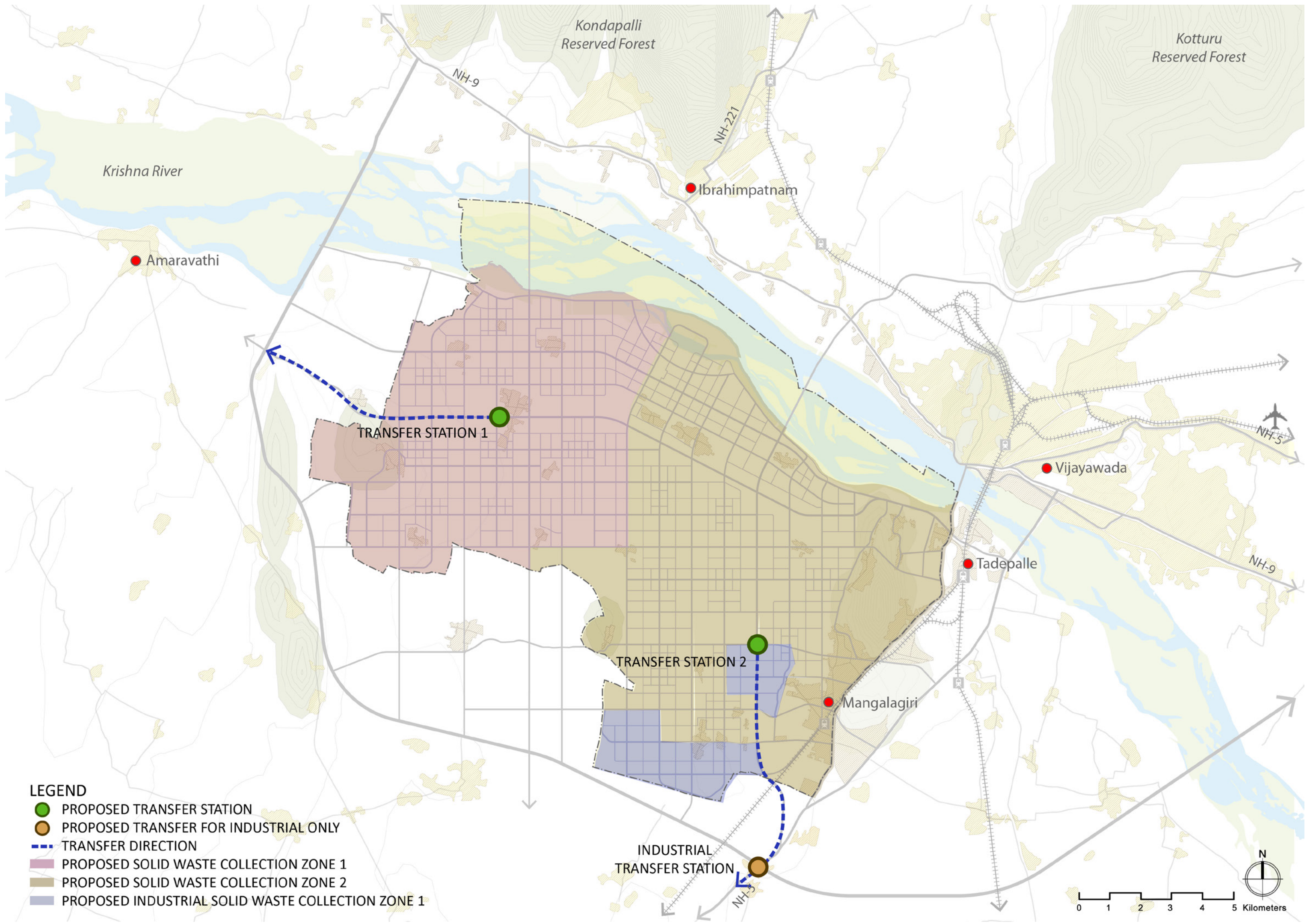


Fig.7.41 Indicative Solid Waste Transfer Stations and the Solid Waste Transfer Direction

Ownership of waste
The operator of the WTE plant must be guaranteed a constant supply of solid waste with specific characteristics. Problems have been encountered in other sites where the rubbish is too wet or does not have sufficiently high calorific value. In such cases the plant would become financially non-viable.

To avoid this, a closed supply chain of rubbish should be implement, whereby there is ownership of the rubbish once it is in the collection chain.

If the disposal company has full control of their supply chain then they are in a strong position to guarantee a constant supply.

To this end, the proposed consolidation centres with compactor can be constructed by the owner of the WTE plant so that the waste collected at the consolidation centres are owned by the WTE plant.

Tipping Levies

To help make the plant financially viable it should be allowed the operator to levy a tipping fee if required. Not charging for tipping would maximise the amount of waste received at the plant but this might not be attractive to a prospective investor. Therefore allowance for fees should be made to allow for a levy if desired.

Special Solid Waste Management

As part of development of the solid waste management system, it is important that the solid waste management providers are engaged to identify systems to manage special waste.

Some of the special waste that would be required to be treated within the Capital City are hazardous waste, clinical waste and heavy industrial waste.

In regards to the clinical waste, the World Health Organisation (WHO) has published Guidance for Healthcare Waste Management, which are to be adhered to in order to achieve safe and sustainable management of health-care waste.

Typically these wastes would be contained, transported and disposed off-site by a specialist waste management service.

Similarly, industrial hazardous waste varies from industry to industry. In this situation, a separate regime would be required for the collection, treatment and disposal of waste from different industries.

This poses a difficult challenge for the municipal waste management systems. Similar to the clinical waste, it is recommended that specialists are engaged for these services. The providers for these specialised wastes are typically from the private sector.

As such, it is important to engage these providers when developing the Capital City waste management strategy.

Inculcate Responsible Public Behaviour on Waste

Public participation is crucial to achieve the vision of “Towards Zero Waste”.

Fig.7.42 Hazardous Waste Symbols (Todd Waste Management, UK ,2015)

The Capital City Waste Management Strategy will be required to provide guidance on how to engage the stakeholders, for example through Public Education Campaigns, using consistent marketing (see Fig.7.43), working with businesses and residents, solid waste management service providers, and incentive policies.

To address this, a scheme can be introduced for households and waste collection workers where the households would segregate recyclables at source and the profits from sale of recyclables be passed on to the waste collection workers.

The scheme will improve the productivity of the workers as they can now focus on their primary job of collecting MSW, instead of spending time to pick out recyclables from MSW.

Encourage Use of Technology

The technological level of waste collection in India is still at the early stages of development. This provides an opportunity for the Capital City to implement modern and smart technologies for solid waste management.

For example, pneumatic waste conveyance systems for waste collection at household level have been implemented successfully in Singapore and Japan. Automated waste sorting machines using autoclaves or mechanical sorting can be introduced in the Integrated Solid Waste Management Facilities.

Fig.7.43 Recycling Bins along Orchard Road, Singapore

Regulation, Legislation and Enforcement

One of the potential key issues with waste collection in the Capital City is legislative framework and regulations must be in place to support the waste industry.

Regulations and legislations for the solid waste management can be implemented at the industrial and commercial level, for example by mandating recycling for certain industries such as packaging, etc.

At the commercial and industrial level, audits and incentives may be provided by a regulatory body to ensure that proper waste management is achieved by commercial and industrial entities.

Regulations can also be provided at collection level. The phasing out of bin points may deny waste collection workers the earnings they make from picking out recyclables from the MSW collected from households.

Regulatory measures can also be introduced at household level by implementing waste collection fees. By adding cost to disposing rubbish, consumers may become more savvy and recycle more where possible.

By adjusting the fees for recycling and general waste, the waste quality can also be partially controlled, for example collection fees can be set lower for waste which has been pre-segregated

at household level, compared to un-segregated waste. Reduction in waste collection fees may be given to households with good records of recycling.

Suitable enforcement would be required to ensure that these legislations and regulations are followed.

Flexibility in a Robust Plan

Ultimately, the infrastructure provisions within the Capital City will depend on the proposed Solid Waste Management framework that will be implemented.

While the Integrated Solid Waste Management Facilities would be located outside the Capital City, technological, social and legislative advances in the next 35 years would guide the development of the collection, segregation and treatment of waste in the Capital City.

As such, it is of utmost importance that a robust approach is adapted to ensure solid waste infrastructure can be provided within the City, whatever the form may be.

Therefore, space has been reserved at the Capital City Master Plan to ensure that infrastructure such as transfer stations, bin centres, sorting centres or even pneumatic waste collection systems can be provided if required.

7.7.6 Critical Issues for Solid Waste Management

The main issue related to solid waste management is the lack of a comprehensive primary and secondary collection system and disposal and treatment facilities for the solid waste generated from the Capital City.

Although the solid waste generated from the Seed Development can be collected and disposed directly at the Naidupet dumping ground, CRDA should look into long term solutions to manage all the solid waste generated from the Capital City.

The proposed Integrated Solid Waste Management Facility at Naidupet is a medium to long-term solution for solid waste management and it requires heavy investment from either the government or from the private sector.

To ensure the financial viability of the ISWMF, and also facilities such as WTE, it is important that there is a critical mass and constant supply of solid waste to the WTE daily so that sufficient waste can be incinerated to generate electricity.

As the WTE requires a constant supply of appropriate solid waste to ensure its viability, new collection systems would be required to complement the WTE plant requirements.

Hence, it is criticalto conductdetailed feasibility study of a complete solid waste management system to serve the Capital City after the master planning stage using the framework for an Integrated Solid Waste Management Master Plan for Andhra Pradesh.

This is particularly important in the case of developing the ISWM Centre and WTE Plant as these will require a considerable investment of resources both in terms of time and money.

It is recommended that further studies should see the viability of constructing a WTE plant through a PPP programme to serve the Capital City.

Fig.7.44 Modern Solid Waste Management Recovery and Transfer Centre, Tacoma, US.

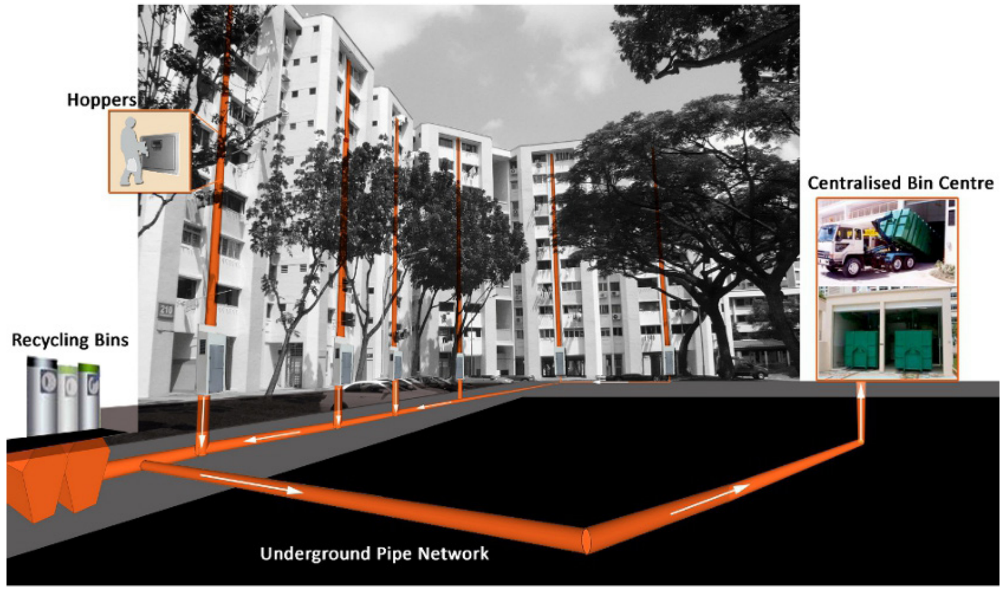


Fig.7.45 Pneumatic Waste Collection System in Singapore, (HDB 2015)

7.8 POWER SUPPLY

7.8.1 Existing Conditions

The nearest power plant is the Vijayawada Thermal Power Plant (VTPP), which is located just outside the northern boundary of the Capital City on the northern bank of the Krishna River. This power plant is coal–fired.

There is an allocation of 1,000 MW and planned 800 MW from the upgrading of the Vijayawada Thermal Power Plant to supply to the Capital City. However, this supply to the Capital City must be guaranteed for the entire Master Plan to be realised. Even with this committed supply, it is still not sufficient to meet the long-term demand of the Capital City. There needs to be a detailed development strategy in place to ensure that the Capital City power demands are met.

The Capital City area is well located to connect to the national power grid of India. There are currently several transmission lines running through the development area. The power lines currently link the Vijayawada Thermal Power Plant to a primary electrical substation which distributes power to the existing towns and villages within the Capital City area and the south of the Capital City, including Thullur.

Fig.7.46 shows the existing alignments of the overhead power lines running through the development site.

The age of the transmission and generation equipment in the region is currently not known. This will be a factor in the investment program for the region, therefore this should be established as part of the detailed study to be conducted after the master planning stage.

7.8.2 POWER SUPPLY REQUIREMENTS

There is a hierarchy of importance in any power supply strategy where different aspects of power supply should be addressed in order. If a prior issue is not addressed, then the subsequent work would be compromised.

The following strategies are recommended to ensure long term and sustainable power supply to the Capital City:-

- Availability of Supply
- Adequacy of Supply
- Reliability of Supply
- Quality of Supply; and
- Efficiency of Supply

Availability of Supply

For any modern city, it is vital that all parts of the Capital City have access to electricity.

To ensure that people and investment are attracted to the Capital City, it is imperative to provide a reliable source of power supply to support the modern lifestyle, employment centres and the industries.

If power cannot be accessed, then generation becomes a secondary issue. It is therefore essential in the plan that space is reserved for power

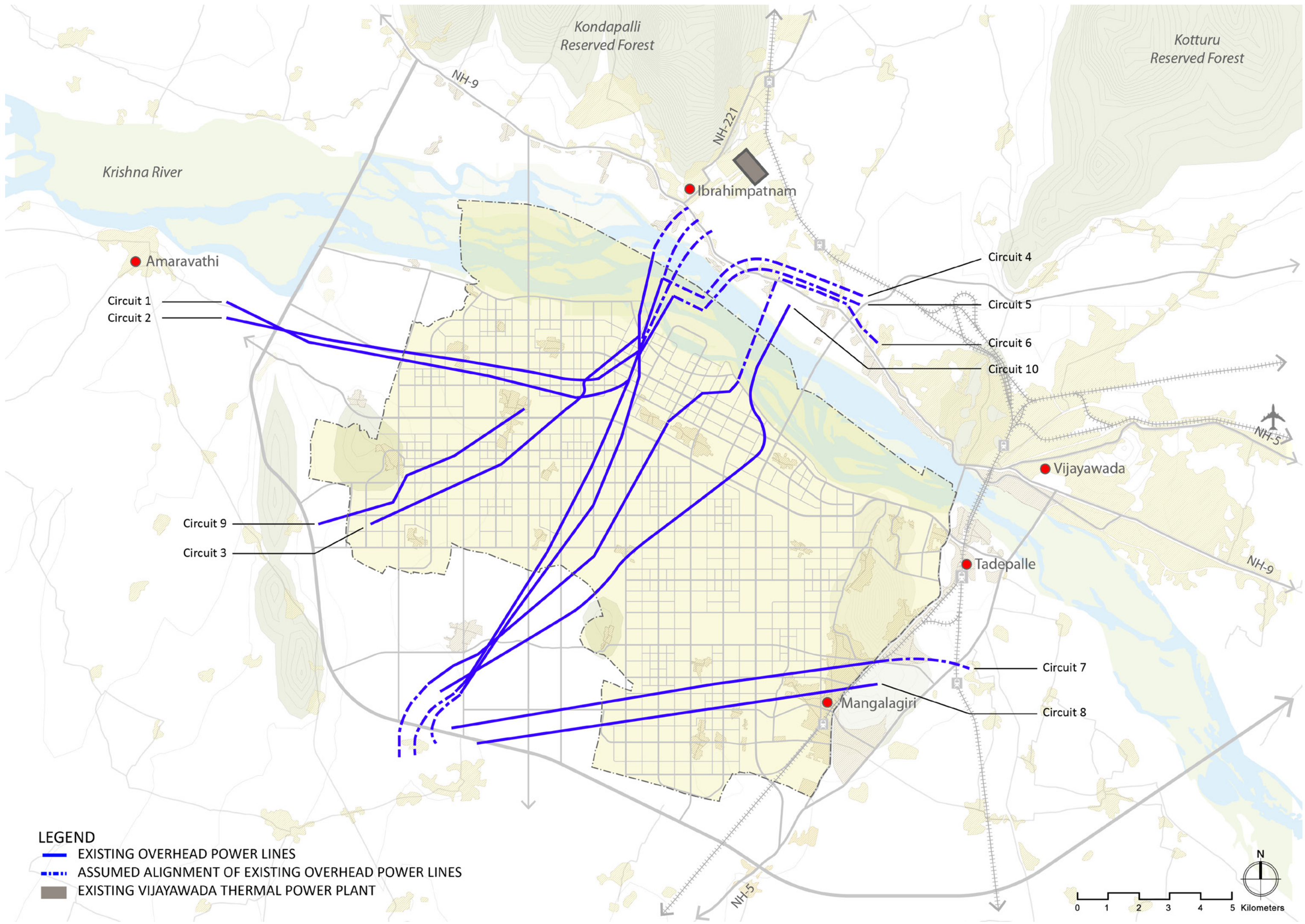


Fig.7.46 Existing Locations of Overhead Power Lines in Capital City Boundary

infrastructure to extend in appropriate sizes across the entire Capital City.

Adequacy of Supply

Once the issue of extending the supply to all households and industry is resolved, then the issue of adequacy of the supply being received should be addressed.

In order to attract a wider range of industry, higher electricity loads will need to be supported. How this is supplied is also important - if there is spare capacity available to a developer in a short space of time, then the location of the site will be much more attractive than if a developer has to wait for months or years before the supply is provided.

Therefore, a buffer in the supply of electricity should be planned for to attract investment to the Capital City.

Reliability of Supply

Another important aspect to be addressed is the reliability of supply. If the supply is not constant, not only will the population in the Capital City be dissatisfied, commercial and industrial investors would also be discouraged. Factory production would be disrupted by interruptions in power supply. Therefore, investors will be looking for assurance that a steady power supply can be guaranteed.

Quality of Supply

Many high tech industries require a high quality supply. The quality of supply is measured in variations in voltage. Small voltage drops might not have a large effect on household supply but can damage industrial equipment.

Therefore, in order to attract high-tech industries to invest in the Capital City, the quality of the supply must be addressed.

Efficiency of Supply

Transmission is not the only aspect to making power commercially attractive and socially amenable. Cost is a critical factor. Whilst this is not under the direct control of the concerned authority, schemes such as off peak tariffs should be supported.

Efficiency in terms of generation should not just cover fiscal cost but should also consider environmental cost. Cleaner technologies can avoid later environmental and social costs for electricity generation. To stimulate these cleaner technologies preferential generation tariffs should be considered.

Based on the above strategies, the following proposals are recommended for the Capital City:-

- Reliable Power Generation
- Development of Renewable Energy
- Secure and Stable Power Supply Network
- Investment in High Quality System
- Demand Management and Public Education

Table 7.15 Power Supply Demand Factors

Land Use Type	Demand Factor (W/m² GFA)	Diversity Factor
Commercial	50	0.6
Institution	40	0.6
Mix Use	30(Residential) 50(Commercial)	0.6
Residential	30	0.6
General Industry	50	0.6
Logistics	20	0.6
R&D	50	0.6
Communal Facilities	1200 kW/km²	

7.8.3 Power Supply Projections

Power demand is expected to increase as a result of rapid urbanisation and population growth. Demand projections for municipal use industrial use have been established and described in the following sections.

Municipal Power Demand

Municipal power demand has been established based on demand factor, land use areas and Gross Floor Area (GFA) of the proposed developments. As not all the electrical equipment are drawing a load at the same time, a diversity factor is also taken into consideration.

Demand factors for power demand are listed in Table 7.15. The demand factors have been defined based on the typical demand of developed countries by different landuse. By doing so, the estimates are conservative. These demand factors may be reviewed in the detailed study and revised where applicable. In addition, communal facilities power demand such as street lighting and landscape lighting, has been assumed to be 1,200 kW/km^2.

The projected municipal power demand is 2,921MW, as shown in Table 7.16. 10% power loss during transmission and distribution has been included.

Industrial Power Demand

Industrial power demand was estimated based on the proposed plot area with the demand factors depend on the type of industry. Total industrial power demand is estimated to be 889MW, summarised in Table 7.16.

7.8.4 Power Supply Proposals

The following gives an overview on how each of the requirements for power supply are being addressed in the master plan. Whilst these are not exhaustive, they detail the reservations that have been made in the land use plan.

Reliable Power Generation

In the short term generation will be met by the Vijayawada Thermal Power Plant (VTPP) located close to the Capital City. Existing power lines running through the site mean that obtaining connection to source is relatively straight forward.

Within the plan, allowance has been made for the city to connect to the national grid. This will allow electricity supply from other parts of India to be transmitted to the Capital City and will reduce the reliance on having generation close to the urban area.

Development of Renewable Energy

While a shortfall of power is not expected in the short term, the demand of power supply will increase drastically when the City further develops.

Development of renewable energy sources can be considered to supplement the conventional power supply to the Capital City.

Table 7.16 Power Supply Demand Projections

Land Use		Power Demand (Mw)
Municipal	COMMERCIAL	737
	MIX USED	35
	RESIDENTIAL	1656
	INSTITUTION	232
Industrial	GENERALINDUSTRY	770
	LOGISTICS	44
	R&D	75
Communal Facilities		260
Total		3,809

This can be done by encouraging the development of renewable energy sources such as solar, biomass, and waste to energy facilities within the Capital City via policies and development guidelines.

In addition, by implementing modern grid technologies such as bidirectional meters, the Capital City may also sell excess energy produced from the renewable energy sources i.e. solar panels back to the grid as an additional source of supply, therefore reducing supply demand from the national power grid.

Secure and Stable Power Supply Network

The road cross section has provision for underground power cables in the service corridors.

Along the major roads provision has been reserved allowing for larger ducting to be laid. Along the expressways there is a larger reserve to allow for cheaper forms of transmission if required.

It is recommended that the power supply within the Capital City should be through an underground transmission and distribution network.
By doing so, the power lines within the Capital City are less susceptible to outages during extreme events such as cyclones and high-wind thunderstorms.

In addition, the requirements for maintenance of these underground cables are reduced due to the underground protection. An additional benefit is in aesthetics - there would not be any unsightly overhead power lines running through the City.

In the lifetime of any electricity transmission network, there will be equipment issues even with regular maintenance. Therefore a minimum of single redundancy should be built into the power supply system.

This way, spare equipment can kick in seamlessly without any interruption to supply. To this end, sufficient land has been reserved to house the necessary equipment for distribution in the land use plan .

Another consideration could be the use of a mesh network for distribution rather than a radial system.

The power is transmitted at higher voltages direct into the city centre requiring less distribution cabling. However this requires that an electrical substation of considerable size to be built in the down town area.

These should be considered in the detailed design study of the power supply network after the planning stage.

Investment in High Quality System

To improve the quality of the power supply, high quality equipment should be installed at the outset.

The cost of replacing this equipment at a later date will offset any short-term savings that are made.

Fig.7.47 Proposed Long Term Transmission Line Alignments for Capital City

Fig.7.49 Existing Vijayawada Thermal Power Plant

Fig.7.48 Existing Pylons leading to Thullur

Fig.7.47 shows the conceptual plan of transmission line alignments serving the Capital City. The existing transmission lines running through the Capital City are to be diverted to the periphery of the Capital City. These lines will connect to substations in the perimeter, which will then distribute power to the smaller substations located strategically within the Capital City via the new underground power network.

It should essential that the Central Government buys into an investment program to improve power supply to the region.

Demand Management and Public Education

Other than augmenting the power supply, it is also important to introduce soft approaches to power conservation, i.e. introduce energy-efficiency buildings in the Capital City, educate the public on energy conservation, and introduce a comprehensive tiered pricing strategy to encourage efficient use of energy.

This can help to reduce the Capital City's demand of energy, therefore allowing the City to operate with lower energy requirements.

7.8.5 CRITICAL ISSUES FOR POWER SUPPLY

There are many elements that need to be addressed in the power sector. The following is deemed to be critical and should be prioritised in the next steps in the development of the Capital City.

It is important to free up the land currently encumbered by the transmission lines. These need to be planned early as the entire project to divert these will likely run into several years.

By rediverting these transmission lines in the early years, and developing the underground transmission network early in the development of the Capital City, capital costs can also be kept low due to less complexities.

It is also important to introduce redundancy into the system planning. This should be part of all plans. This would be very difficult and costly to try and retrofit the power supply system at a later date. This redundancy will be a key factor and distinguishing element in the services that are supplied to industry in Andra Pradesh and surrounding states. This will help to bring in investment and promote economic growth.

Vijayawada Thermal Power Plant (VTPP) is a regional power plant and it supplies power to areas within and outside the Capital City. Although it has spare capacity currently and has set aside about 1,000 MW for the development of the new Capital City, the government should ensure that the spare capacity is not eroded by other demand outside of the Capital City.

The Government of Andhra Pradesh should also put in place concrete steps to demonstrate how it can supply the 1,000 MW to the Capital City. This is crucial to ensure the viability of the Capital City. Even with the 1,000 MW reserved for the Capital City, there is still a need to source for additional supply to meet the ultimate demand of the Capital City of 3766 MW with newer and more modern technologies.

There must be a study further to conduct a detailed feasibility study on the need to upgrade the VTTP and the need to construct a new power plant to meet the ultimate power demand from the Capital City.

As the electricity energy grid in India expands and develops, it will be vital that the Capital City is connected to this National Grid. The National grid will give access to power generation across the country and help alleviate the need to construct power generation in the Capital City locale.

Fig.7.50 First High-Voltage Direct-Current (HVDC) transmission line in India

7.9 INDUSTRIAL INFRASTRUCTURE PLANS

7.9.1 Introduction

Infrastructure development plays a paramount role in determining the success of new Capital City development. Comprehensive infrastructure and utilities services shall be provided in tandem with the phasing development of the Capital City. These include storm water drainage, water supply, sewerage, solid waste disposal, power supply, and telecommunications.

The strategic directions for infrastructure planning of the Capital City development are aimed to achieve the following:

- To provide highest standard and quality of infrastructure and utilities services
- To optimize the use and efficiency of existing infrastructure
- To gear towards supporting a clean, sustainable and high quality living

7.9.2 PLANNING METHODOLOGY

The methodology used for the planning of the various infrastructure services:

- Meeting with the relevant local authorities and compilation and analysis of the data gathered
- A site visit to the planning area covered in the Broad Infrastructure Plan
- Forecast of utilities requirements and recommendation on the infrastructure provisions

7.9.3 PLANNING ASSUMPTIONS

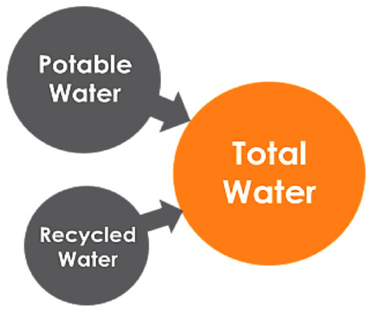
The following assumptions have been adopted for the Broad Infrastructure Planning:

- The proposed infrastructure provisions are catered for the proposed Capital City planning area only. However, these proposed infrastructure provisions can make use of the existing infrastructure systems, if upgrading or capacity expansion permits.
- Findings and Deliverables from Market Study and Physical Planning teams for the proposed Capital City planning area, such as Land Use Distribution, Population Projection and Industry Analysis will form the main basis for the infrastructure planning.
- The major industries identified are Food & Beverages, Electronics / Hardware, Packaging, Printing and Logistics

WATER SUPPLY

The water supply assessment provides the estimated projection of the water demand for potable & recycled water usage for the proposed industrial zone within the Capital City development.

Total water demand depends on the unit water demand rate for industries. This will vary in accordance to the spectrum of industries and industrial



process. Based on the industries identified, the unit water demand rate varies from 15 to 140 m³/ha/d.

Based on the proposed unit water demand and the proposed land use distribution & projected population, as well as other assumptions described earlier, the total water demand has been worked out as shown in Table 7.17. Total water demand includes potable water plus recycled water. The ultimate total water demand for the industrial development has been worked out to be about 62,163 m³/d which is 53,628 m³/d potable water together with 8,485 m³/d of recycled water.

Both potable water and recycled water shall be used for the industrial zone within the Capital City. To meet the ultimate water requirements, a water treatment plant is proposed to meet potable water requirement and the source for recycled water will be from the proposed IETP (Industrial Effluent Treatment Plant) within the development.

The recycled water can be used for non-

Industries Type	R&D	General Industrial Zone	Logistics Zone	Total
Land Area (Ha)	113	1,167	134	1,414
Total Average Water Demand (m3/d)	6,881	53,149	2,133	62,163
Potable Water Demand (m3/d)	5,458	47,865	355	53,678
Recycled Water Demand (m3/d)	1,424	5,284	1,777	8,485
Sewage	4,746	42,115	355	47,216
Solid Waste Generated (T/d)	20	210	24	255
Power Demand (MW)	75	770	44	889
Telecom Demand (Lines)	12,220	56,568	3,910	72,698

Table 7.17 Broad Utilities Demand (Industrial Zones)

potable purposes such as landscaping, cooling and others. In order to achieve this, dual water supplies and distribution systems are proposed for potable water and recycled water.

SEWERAGE

The conceptual sewerage plan addresses the broad concepts of the sewerage system and location of IETP (Industrial Effluent Treatment Plant). The objectives of the sewerage system are to cater for the anticipated peak discharge requirements and to pre-treat the waste water to the required discharge standards. Various demand estimation and requirement of facilities are then worked out based on the land use distribution and population projection.

The sewage generation computation is based on 80% of the average potable water demand plus 10% infiltration rate. Based on the land use distribution and population projection of the various planning areas, the sewage generation has been worked out as shown in Table 7.17. The ultimate sewage generation for the industrial development has been worked out to be about 47,216 m^3/d.

Individual industries shall be required to pre-treat their wastewater to acceptable standards, prior to discharging into the proposed sewerage. An example for limit of trade effluent standards extracted from Public Utilities Board, Singapore is shown in Table 7.18. In case of any overflow into the water body, the quality of the effluent after treatment shall meet the standards for discharge in accordance to the local standards.

Some important issues when siting an IETP are locations near receiving water bodies (such as natural drain/channel), distance from sewage generation area, and the topography of the area. The sewage will be treated at the IETP and the treated effluent will be recycled. The quality of the effluent after treatment shall meet the local standards. The proposed location of Industrial Effluent Treatment Plant is shown in Fig.7.45

The proposed IETP serves only the southern Industrial zone where light to medium industries are proposed. Sewage generated from other industrial zones which are mostly service based and light industry shall be treated in proposed sewage treatment plant located at north eastern part of Capital City.

Parameter	Limit of Trade Effluent	Parameter	Limit of Trade Effluent
BOD (5days @ 20oC)	400	Fluoride	15
COD	600	Iron	50
Suspended solids	400	Lead	5
Total dissolved solids	3000	Manganese	10
pH	6 – 9	Mercury	0.5
Arsenic	5	Nickel	10
Barium	10	Oil and grease	60
Beryllium	5	Phenols	0.5
Boron	5	Selenium	10
Cadmium	1	Silver	5
Chloride	1000	Sulfate	1000
Chromium	5	Sulfide	1
Copper	5	Zinc	10
Cyanide	2		

Table 7.18 Wastewater - Quality Limits (mg/L except where otherwise stated)

Source: Requirements for Discharge of Trade Effluent into the Public Sewers" Public Utilities Board, Singapore

SOLID WASTE DISPOSAL

This section shall address the generation of solid waste for the industrial development.

Based on the land use distribution and the type of industries, the solid waste generation has been worked out as shown in Table 7.17. Solid waste generation rate varies from 150 to 210 kg/ha/d for different types of industry proposed. The ultimate solid waste generation for the industrial development has been worked out to be about 255 tons/day.

Industrial waste generated is collected, segregated and stored in transfer station before being sent to landfill disposal or incineration plant. The proposed location of transfer station is shown in Fig.7.52.

These stations shall provide facilities to sort and store recyclable wastes. These not only reduce the non-bio-degradable wastes disposed of in the site, but at the same, minimize the amount of solid wastes to be disposed.

Therefore, in addition to providing more convenient service to system customers, these stations also serve to reduce the amount of vehicular traffic at the landfill site.

Fig.7.51 Typical Solid waste disposal flowchart

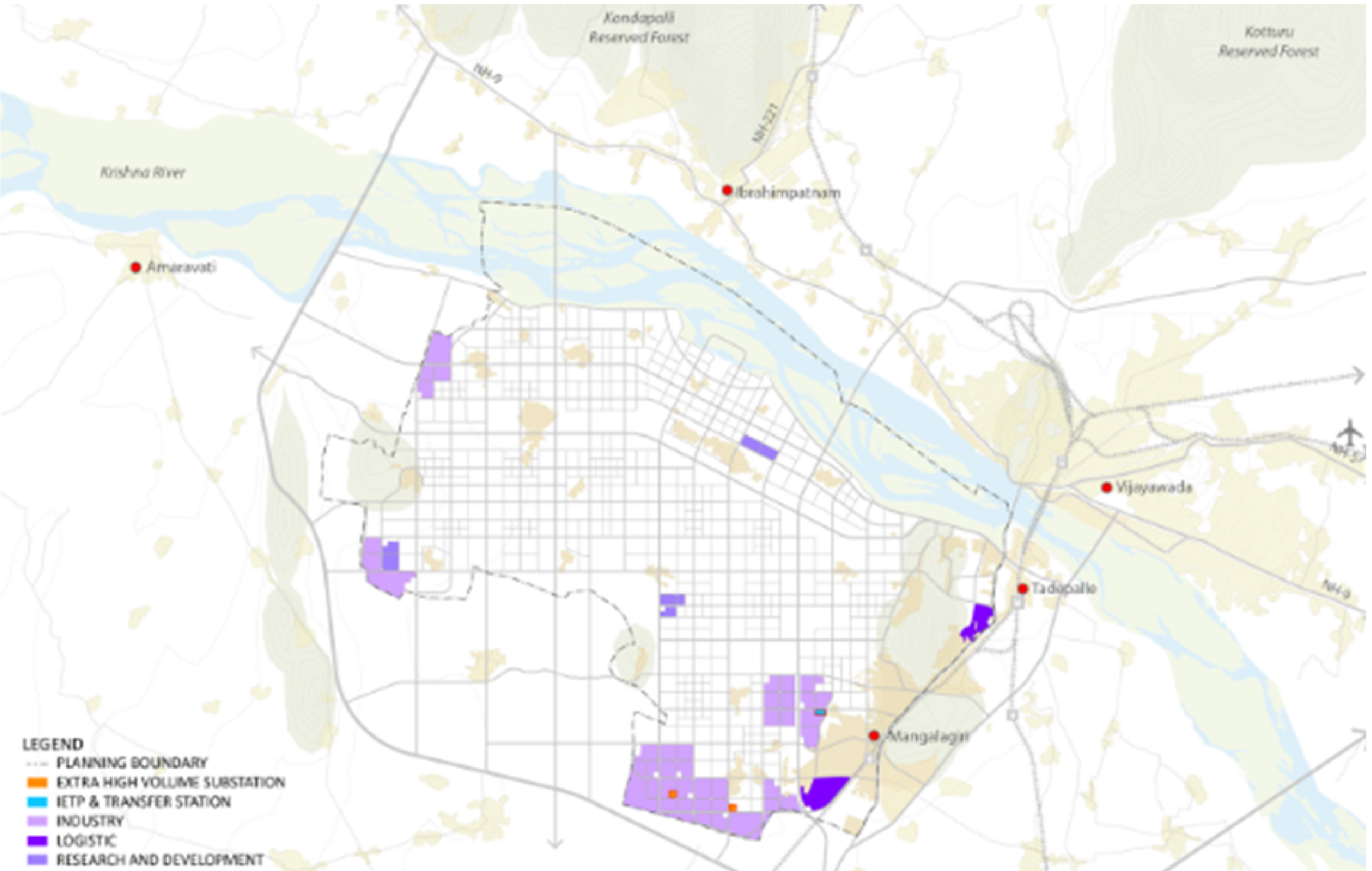


Fig.7.52 Proposed Location of Extra High Voltage Sub-Stations – S/S (2Nos), Industrial Effluent Treatment Plant – IETP & Transfer Station - TS



POWER SUPPLY

Power is one of the critical infrastructure for the prosperity and growth of the proposed Capital City.

The electricity demand figure is based on the assumption that the study area will be fully developed at that time, the market conditions are as per the proposed land use and industrial processes are similar to the focused industries. In the early years of the development, the electricity demand will be low and the growth varies according to the actual market condition. Modular expansions and close monitoring of the electricity take-up rate are recommended. Unit power demand rate varies in the range of $20W/m^2$ to $50W/m^2$. The electrical power demand estimated is shown in Table 7.17. The ultimate power demand projection for the industrial development has been worked out to be about 889 MW. 10% loss in power transmission and distribution has been included.

The location of proposed extra high voltage sub-stations is shown in Fig.7.52.

TELECOMMUNICATION

The development of the new Capital City will require new telecommunications infrastructure to serve the needs of the area. As the project is starting from virtually a clean slate, this presents a great opportunity for the city to build a state-of-the-art ICT infrastructure that will rival the best in the region. The new infrastructure will enable the Capital City to not only serve the new industries and institutions but also better serve its populace with better e-Government services.

Based on the proposed land use and projected population, the telecom demand has been worked out and shown in Table 7.17. The ultimate telecom demand for the industrial development has been worked out to be about 72,700 lines.

To ensure a robust network, a ring configuration is recommended for the main trunk route. Depending on the extent of resilience required, the last leg to the customer's premises can be a ring or a star configuration. For the industries, the Government agencies and the more critical public institutions, we are suggesting a loop configuration for a more robust network.

7.10 CONCLUSION

In a nutshell, the establishment of the industrial zones will benefit the Amaravati Capital City and the existing settlements in the following ways as Fig.7.53 illustrates:

- To drive up employment growth
- To increase and diversify value added economic activities
- To improve productivity levels
- To rise income levels
- To realize and commercialize the concepts originated in R&D clusters

More detailed studies, analysis and plans are required to further guide the implementation efforts for the development. These will include feasibility study, business plan, urban design, land sales documents, detailed infrastructure and engineering plans, etc. These plans are essential to ensure timely and coordinated provision of infrastructure as well as community facilities so that architects and engineers can work out the detailed design drawing for the construction of infrastructure and buildings.

The Industrial Zones for the Capital City should be read in conjunction with the Zoning Plan for the planning parameters, overall strategic direction, and framework and the role that the Capital City plays. The guidelines will be important in allowing investors & talents a fully transparent view of the upcoming developments in Amaravati, aid in their business planning and heighten their confidence in the future of Amaravati – The Intellectual Capital.

Fig.7.53 Dynamic Role of Industrial Landscape complementing Existing and New City