INTRODUCTION OF MODERN LPS DRIP SYSTEM OF IRRIGATION IN UPPER BHADRA IRRIGATION PROJECT, KARNATAKA

M G Shivakumar, Superintending Engineer
KNNL, Karnataka, India

R.Cheluvaraju, Chief Engineer
KNNL, Karnataka, India

M Satish, Superintending Engineer
KNNL, Karnataka, India

Keywords

Water use efficiency, LPS drip, module, drought-prone, Pressurized Irrigation Network System (PINS)

Synopsis

Upper Bhadra Project is a major lift irrigation Scheme under implementation in the central region of Karnataka State by Karnataka Neeravari Nigam Limited, a Government of Karnataka undertaking. It involves lifting of water by about 180 m from June to October from the rivers of Tunga and Bhadra in Tungabhadra sub-basin of Krishna basin and is planned to supply water for irrigation to an area of over 2 lakh hectares in drought-prone districts of Chikmagalur, Chitradurga, Tumkur and Davangere.

The Project was started in the year 2008 with the primary objective of providing irrigation facilities. The other objectives of the project are drinking water supply and groundwater recharge by filling up tanks within the command. With the changing trends in the methods of application of water from the conventional open canal system to sprinkler/drip, water use efficiency has become a prime area of concern. With the surface irrigation system where the entire canal system is open canal system, the overall efficiency was arrived at as 50 % in the project planning. Due to the long pending demand of farmers of Tumkur district which is adjacent to Chitradurga district, it became imperative to consider alternative to surface irrigation where the loss of water in the conveyance system is high. In order to improve the water use efficiency significantly to meet the demands for irrigation to additional area, it is now planned to adopt drip irrigation in the entire command area. This will be the first such attempt of its kind in Karnataka State where such a large area of 2.14 lakh hactares in an irrigation project is planned to be brought under drip irrigation. Its success has immense significance not only to the State, but to the entire country.

The drip system is proposed to be run on Low Pressure System (LPS). Here, the main canal will be an open canal and the distribution system below the main canal will be piped system. The entire command area will be divided in to 50 ha modules which will be operated independently which means each module will be connected to the feeder line that draws water from the main canal. Electrical power required to run the pumps on LPS system in a part of the command area where pressure of 1 bar (10.2 m head) is not available and where pressure of more than 1 bar is available, the modules will be run on gravity system of drip not requiring electrical power. It is estimated that about 39 % of area can be irrigated requiring electrical power and the balance 61 % area can be irrigated by gravity flow. This has been possible due to excellent topography of the command area. The LPS drip design eliminates the need of constructing distributaries, laterals, minors and field channels thereby reducing the cost of land acquisition and the delays associated with land acquisition. The piping network is further connected to the modern micro irrigation system. This will ensure water use efficiency of 90% at the farm level. This also increases the overall efficiency of water use from 50% in the conventional open canal system to 81% in the drip irrigation system. This system will have all the advantages that micro-irrigation system offers over flood/furrow irrigation viz. water saving, labour saving, power saving, fertilizer savings, etc. and lesser operation and maintenance costs over open canals. Since the design eliminates the construction of open canals, the project can be completed within shorter span of time. This system operates like a Pressurized Irrigation Network System (PINS) and therefore adequate pressure is available in the pipelines for operation of low pressure micro-irrigation system at the outlets i.e. at the farm level. Further, this eliminates the need of creating electrical infrastructure for irrigation across the command area like in the case of sprinkler/high pressure drip irrigation. The centralized pumping system for each 50 ha module ensures easy operation of the system as flow of water through the network of pipes can be controlled from one place rather than from various locations. This also reduces O&M costs and cost of valves at various locations.

With the above system of LPS drip irrigation, it is feasible to irrigate an area of 214000 ha and fill up a large number of tanks in the command for groundwater recharge and drinking water supply. The work on the Project is commenced and substantial progress has been achieved in the execution of lifting arrangement and the conveyance system. The project is facing many challenges in its implementation which have been addressed appropriately so as to eventually commence irrigation by the year 2016 and complete the project by the year 2020. There are many challenges the project is facing in dealing with forest clearance, land acquisition and agitation by the farmers losing their lands for canals. Particularly, the farmers of the area where the tunnel passes through in Km 41 from Bhadra reservoir are apprehensive that the groundwater in the region will deplete due to tunnel affecting their agriculture which depended heavily on limited groundwater potential. All the issues related to their apprehensions have been addressed scientifically by conducting hydrogeological study along the tunnel alignment and taking appropriate measures to circumvent the difficulties the farmers are likely to face. Another important initiative is to extend irrigation by LPS system of drip above and in the region of tunnel so as to support agriculture over a large area of about 7500 ha. Other than the above, the project had to overcome many impediments in its implementation after entrustment of the three package works; two lifts and tunnel on EPC turn-key contract basis such as delays in land acquisition, power sanction, forest clearance etc. Now, with substantial progress achieved over the last three years, the UBP is poised to become a flagship project of KNNL to benefit the farmers and the State in the years to come.

1. INTRODUCTION

1.1 Upper Bhadra Project (UBP) in the Central region of Karnataka was first mooted in the year 1969 envisaging the construction of storage dams across Bhadra river upstream of Bhadra dam near Magundi village in Chikamagalur district to provide irrigation facilities to drought prone districts; Chikmagalur, Chitradurga, Tumkur and Bellary. There were representations against this proposal by the people affected by the submergence of lands in Chikmagalur district and also by environmentalists who apprehended damage to the environment as the canal was running in Wildlife area.

Taking into consideration the above issues including the aspects of water availability and conveyance, the Scheme was modified with the following provisions;

i) lifting 15 TMC of water from Tunga river to Bhadra reservoir ;
ii) lifting of 21.5 TMC of water from Bhadra Reservoir to delivery chamber near Ajjampura ;
iii) construction of Ajjampur tunnel to deliver water to Chitradurga Branch Canal ;
iv) construction of Chitradurga Branch Canal (CBC) to irrigate 1,07,265 ha &
v) filling up of 156 Minor Irrigation tanks coming under drought prone areas of Chickmagalur, Chitradurga, Kolar & Tumkur districts for drinking water purposes.

1.2 A Detailed Project report with above provisions was prepared amounting to Rs. 5985 crores, comprising of Rs.3388 Crores towards irrigation component and Rs.2597 crores towards drinking water component. The type of irrigation envisaged was surface irrigation with open canal system right up to the field, with project efficiency of 50%.

1.3 Additional demands for irrigation

There were additional demands for increasing area under irrigation from other drought-prone districts, notably from Chikmagalur and Tumkur districts. Conceding the demands, an additional proposal for providing irrigation facility under Tumkur Branch Canal (TBC) under UBP and filling up of tanks was prepared which required additional infrastructure for lifting and conveyance of water. In view of compulsion to manage this additional area under TBC with available waters, it became imperative to explore possibility to irrigate areas in Tumkur district. In this regard, with a view to explore possibility of saving water under CBC with the use of modern technology such as drip irrigation and extend irrigation benefits to area under TBC, a solution suited to the local needs of the region maximizing water use efficiency with minimum use of electric power for operating the micro irrigation system at the farmers' field, using LPS™ (Low Pressure System) has been envisaged.

2. IRRIGATION PLANNING

A proposal to provide water through TBC for irrigation to areas in Chikmagalur, Chitradurga and Tumkur districts has been prepared adopting LPS system of drip irrigation so that it would be possible to irrigate area under CBC and TBC by virtue of higher water use efficiency of 81 %. The salient features of the proposal are ;

- The main Canal will be constructed as open lined canal. The distribution of water below the main canal will be through a network of pipelines.
- It is proposed to install Main Pipelines and Pressurized Irrigation Network and then connect the same to the Drip Irrigation System, thereby increasing the Water Use Efficiency to 90 % in the project area.
- The pipe network carries water to individual Head Unit(s) (One Head Unit for 50 Ha drip modules) located at different places in the command Area. The pipe network will have control

valves near to the Head Unit to control the discharge rate of Water and to ON / OFF the system as per requirement.

- It is proposed to create a network of pipelines (GRP/PVC) instead of constructing distributaries, laterals, minors and field channels. The topography of the command area permits distribution of water by gravity where 1 bar of pressure is available as well as through low pressure drip irrigation system.

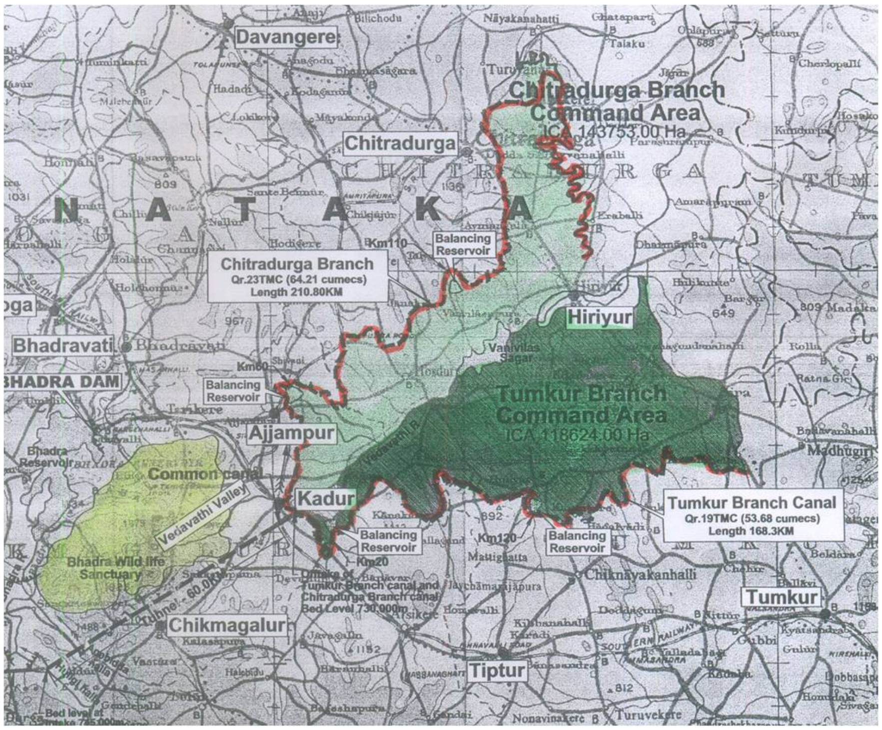

Fig 1 : Index map of project area

2.1 System efficiency under flood irrigation

The efficiencies considered with lined canals are;

Seepage and canal losses from Main Canal & Distributaires - 15%

Operation losses - 10%

Total losses 25%

With these losses, conveyance efficiency - 75%

field channel efficiency - 85%

field efficiency - 80%

Irrigation efficiency = 0.75X0.85X0.80 = 0.50

2.2 System efficiency under drip irrigation

The combined efficiency with drip irrigation works out to 81%, as worked out below.

Seepage and canal losses from Main Canal - 10%

Efficiency of the drip irrigation system below the main canal - 90%

Irrigation efficiency = 0.90X0.90 = 0.81

Due to the increased efficiency of the system under drip irrigation over flood irrigation, it would be possible to provide irrigation under both CBC and TBC for an area of over 2,14,000 ha.

3. LPS SYSTEM OF DRIP IRRIGATION

3.1 Pressure piped irrigation systems

A pressure piped irrigation system is a network installation consisting of pipes, fittings and other devices properly designed and installed to supply water under pressure from the source of the water to the irrigable area. The basic differences between traditional surface irrigation and piped irrigation techniques are;

The flow regime: With traditional surface methods, the size of the stream/canal should be large, while in pressure piped irrigation systems very small flows, even 1 m^3/h, can be utilized.

- **The route direction of the flow:** With traditional surface methods the water is conveyed from the source and distributed to the field through open canals by gravity following the field contours. The piped system conveys and distributes water in closed pipes by pressure following the most convenient (shortest) route, regardless of slope and topography of the area.
- **The area irrigated simultaneously:** With traditional surface methods the water is applied in large volumes per unit of area, while piped irrigation systems distribute the water at small rates over a very large area.
- **The external energy (pressure) required:** Traditional surface gravity methods do not need external energy for operation, while piped irrigation systems require about 1-3 bar depending on site topography and type of emitter used, which is provided from a pumping unit or from a supply tank situated at a high point.

3.2 Network layout

The pipelines that convey and distribute water to the individual plots are buried, so as to protect from farming operations. Off-take hydrants, rising on the surface, are located at various spots according to the planned layout. With surface methods the irrigation water can be delivered directly to the open ditches feeding the furrows or the basins. In drip irrigation, the hydrants are coupled with smaller manifold feeder pipelines placed along the edges of the plots. These feed the lateral irrigating lines which are laid along the plant rows perpendicular to the manifolds. The laterals are equipped with water emitters at designed spaces and distribute uniformly the irrigation water to the plants under certain pressure.

In the piped system, the main component parts are:

- The control station (head control unit);
- The mains and sub-mains (pipelines);
- The manifolds (feeder pipelines);
- The laterals (irrigating pipelines) with the emitters.

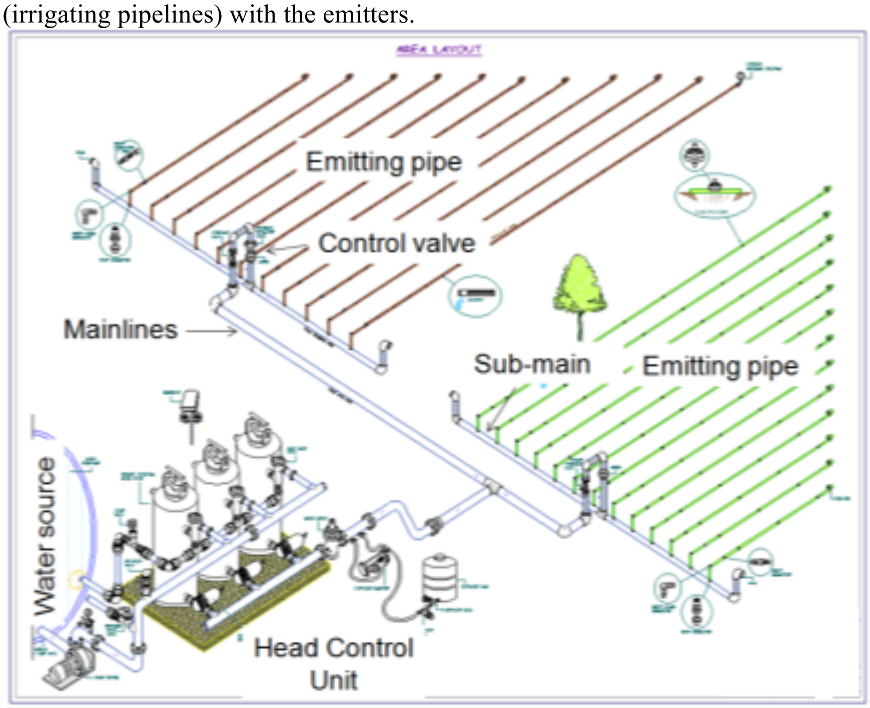

Fig 2 General drip irrigation layout

Head control: This consists of a PVC supply line installed horizontally at a minimum height of 60 cm above ground. It is equipped with safety equipments like air release valve, a check valve, a shut-off valve between the two outlets and a filter. There are different types of filters like hydro cyclone filter, media/grave filter, screen filter; disc filter etc whose selection is depends on source and quality of water. Where a gravel filter or a hydro cyclone sand separator is needed, it is installed at the beginning of the unit complex.

Main pipeline: It is the largest diameter pipeline of the network, capable of conveying the flow of the system under favourable hydraulic conditions of flow velocity and friction losses. The pipes used are buried permanent assembly high density polyethylene (HDPE) ranging from 63 to 160 mm (2-6 in) depending on the area of the farm.

Sub mains: These are smaller diameter pipelines which extend from the main lines and to which the system flow is diverted for distribution to the various plots. The pipes are the same kind as the mains.
Emitting Manifolds: it consists of pipelines of a smaller diameter than the submains and is connected perpendicular to the submains which supplies water drop by drop to the root zone area of crop. They are of LDPE pipes in sizes of 12, 16, 20, 25, 32 mm.
Emitters: Emitter is a device fitted on an emitting pipe, is operated under pressure to discharge water by continuous drops (drippers).

These component parts replace the ones in the traditional surface systems, i.e. the distributaries, laterals, minors, field channels and the furrows in the plot.

Method of application of water

Drip irrigation by drippers / emitters: The water is delivered to the plants without being spread over the entire area but by being applied in low rates to a limited soil surface area around the plants. The water delivery method and the kind of the water emitter are the main characteristics of a piped irrigation system. They influence and specify the pressure, flow capacity of the system and duration of application.

The flow capacity of a system is the water flow (in cubic metres per hour or litres per second) designed to meet the irrigation requirements of the area at peak demand. It is inversely proportional to the duration of application. It is generally designed so as to economize on pipe size and other equipments. The duration of application is the time required for the completion of one irrigation cycle.

3.3 Broad design details

It is proposed to install Main Pipelines and Pressurized Irrigation Network and then connect the same to the Drip Irrigation System. The broad design details are given below.

1. Distribution design

The distribution design will have the following;

i.The distributaries will be converted in to main Pipelines.
ii.Water will be distributed through pipelines below the main canal.
iii. The pipe network carries water to individual Head Unit(s) (One Head Unit for 50 Ha Drip modules) located at different places in the command Area. The pipe network will have control Valves near to the Head Unit to control the discharge rate of water and to ON / OFF the system as per requirement.

2.Salient features

It is proposed to create a network of pipelines (GRP/PVC) below the level of main canal. Considering the topography at site, the entire project area can be operated by **GRAVITY** as well as through **LOW PRESSURE DRIP IRRIGATION SYSTEM** depending upon the availability of minimum pressure of 1 bar in the irrigation area for operation of LPS system. Where minimum pressure of 1 bar is available (10.2 m head of water), the LPS drip system will be operated under gravity without requiring power and where the required minimum pressure of 1 bar (10.2 m) is not available, the LPS system will be operated with power. The criteria followed in the drip design are;

i. Drip irrigation System is designed in multiple module of an average area of 50 Ha. For 50Ha module, one head unit is proposed. There should be continuous flow into the pipe network from the Main Canal to operate the Micro-irrigation System on continuous basis.
ii. Centralized pumping from the pump house in each 50 Ha module will be operating under LPS.
Advantages:
   - The centralized pumping system ensures easy operation of the system as flow of water through the network of pipes can be controlled from one place rather than from various locations.
   - This also reduces O&M costs and cost of valves at various locations.
iii. The drip irrigation system is a permanent system. The mains and sub-mains are installed underground and the field control valves above surface. Hence, there is no need for shifting of pipes and nozzles every day. The farmers need to only ON / OFF their respective field control valves on their need basis.
iv. The drip irrigation system can be operated on daily or on alternate day basis. Considering the water requirement, climatic conditions, soil type, water holding capacity and crop growth stage, and the drip irrigation efficiency, provision is made in the design to irrigate the crop on daily or alternative day basis as per the requirement. Peak water requirement on daily basis works out to 3.2 mm per day.
v. Each 50Ha module is provided with secondary infield filtration with necessary safety equipments and control valves, mainlines, submains and emitting manifolds. The design process is common to all the zones of the command area of CBC. What will be varying is the design of main pipe line from the main canal which will feed water to each zone which in turn will either be gravity fed depending upon head available or under LPS system requiring little power. Drip Irrigation System will have suitable Filtration units,

Mains, Sub-mains, Control Valves, Flush Valves, and Drip lines with Integral drippers/emitters. Due to variability of crops, common fertigation may not be possible, so fertigation equipments are suggested at field level.

vi. Irrigation scheduling of a sample block 50 ha is worked out and given below.

3. Advantages of LPS drip irrigation

1) This design eliminates the need of constructing distributaries, laterals, minors and filed channels thereby reducing the cost of land acquisition and the delays associated with land acquisition.
2) The piping network is further connected to the modern micro irrigation system. This will ensure water use efficiency of 90% at the farm level.
3) This also increases the overall efficiency of water use from 50% in the conventional open canal system to 81% in the drip irrigation system.
4) This system will have all the advantages that micro-irrigation system offers over flood/furrow irrigation viz. water saving, labour saving, power saving, fertilizer savings, etc.
5) Lesser operations and maintenance costs over open canals.
6) Since the design eliminates the construction of open canals, the project can be completed within a shorter span of time.
7) This system operates like a Pressurized Irrigation Network System (PINS) and therefore adequate pressure is available in the pipelines for Operation of LOW PRESSURE Micro-Irrigation system at the outlets at the farm level. This eliminates the need of creating electrical infrastructure for irrigation across the command area like in the case of sprinkler/high pressure drip irrigation.
8) The centralized pumping system ensures easy operation of the system as flow of water through the network of pipes can be controlled from one place rather than from various locations.
9) This also reduces O&M costs and cost of valves at various locations.

4. Drip modules

Block 1 under CBC which is having CCA of of 250.ha is considered for designing LPS drip system and its operation.

Location - Latitude - 13°45'30'

Longitude - 76° 3' 44.90"E

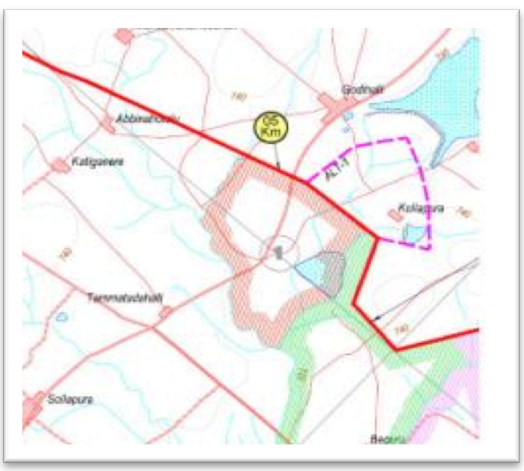

Fig 3 Block 1 of CBC

Fig 4 Block 1 of CBC google image

The Gross Command Area (GCA) under Block 1 of Chitradurga Branch Canal (CBC) is about 280 Ha, of which 90 % is considered as Cultural Command area (CCA). Total CCA of 250 Ha is designed with 5 zones of an average area of about 50 Ha.

Design Details

An abstract of irrigation data and operation schedule for 50 Ha zone is furnished below. The design considerations are explained subsequently.

i. Irrigation data

Crop		Mixed
System		Drip

Area (ha)	a	50.00
Emitter		DripNet Presuure Compensated (DNPC)
Emitter discharge (lph)	b	0.60
Emitter spacing (m)	c	0.40
Lateral spacing (m)	d	1.25
Application rate (AR) (mm/hr)	e = b/(c x d)	1.20
PWR (mm/day)	f	3.20
Shift duration (Hr)	g = f/e	2.67
No. of shifts/day	h	8.00
Actual operating hrs/day	i = g x h	21.36
Shift area (ha)	j = a / h	6.25
Shift flow (m3/hr)	k = j x e x 10	75.00
Water Source		Canal
Flow rate variation (%)		0.0

ii.Daily and alternate day irrigation

Drip irrigation system can be operated on daily or alternate day basis. There is no difference in system design except time of irrigation. **Drip irrigation system design for daily irrigation holds good even for alternate day irrigation with change in time of irrigation.** In alternate day irrigation, the crop water requirement of two days is to be satiated. So, the irrigation time will also be double. E.g. for current design , it is suggested to have eight shifts with 2.67 Hr shift duration to satiate crop water requirement of 3.2 mm* for daily irrigation. For same area, with alternate day irrigation, amount of water to be discharged will be 6.4 mm and so the time of irrigation will be 5.34 Hrs and maximum of 4 shifts/day. The operational schedule for both daily as well as alternate day irrigation is as below;

iii. **Schedule of operation (see fig 5)**

OPERATIONAL SCHEDULE FOR 50 Ha Module – Daily irrigation							
Shift Valve No	**Individual Valve**				**Shift**		
	No.	**No of valves**	**Area (Ha)**	**Flow (m3/hr)**	**Area (Ha)**	**Flow (m3/hr)**	**Duration (Hr)**
		a	b	c =b x AR(1.2) x 10	a x b	a x c	As in irrigation data
S1	V1-V6	6	1.04	12.5	6.25	75	2.67
S2	V7-V12	6	1.04	12.5	6.25	75	2.67
S3	V13-V18	6	1.04	12.5	6.25	75	2.67
S4	NV19-V24	6	1.04	12.5	6.25	75	2.67
S5	V25-V30	6	1.04	12.5	6.25	75	2.67
S6	V31-V36	6	1.04	12.5	6.25	75	2.67
S7	V37-V42	6	1.04	12.5	6.25	75	2.67
S8	V43-V48	6	1.04	12.5	6.25	75	2.67
Total					50		21.36

OPERATIONAL SCHEDULE FOR 50 Ha Module - alternate day irrigation								
Day	**Shift Valve No**	**Individual Valve**				**Shift**		
		No.	**No of valves**	**Area (Ha)**	**Flow (m3/hr)**	**Area (Ha)**	**Flow (m3/hr)**	**Duration (Hr)**
			a	b	c =b x AR(1.2) x 10	a x b	a x c	As in irrigation data
1	S1	V1-V6	6	1.04	12.5	6.25	75	5.34
	S2	V7-V12	6	1.04	12.5	6.25	75	5.34
	S3	V13-V18	6	1.04	12.5	6.25	75	5.34
	S4	NV19-V24	6	1.04	12.5	6.25	75	5.34
Day one total						**25**		**21.36**
2	S5	V25-V30	6	1.04	12.5	6.25	75	5.34
	S6	V31-V36	6	1.04	12.5	6.25	75	5.34
	S7	V37-V42	6	1.04	12.5	6.25	75	5.34
	S8	V43-V48	6	1.04	12.5	6.25	75	5.34
Day two total						**25**		**21.36**

iv.Crop water requirements

The approved cropping pattern for khariff season under the ICA of Chitradurga Branch Canal (1,07,265 Ha) comprises of semidry crops as shown below with 100% intensity of irrigation.

Ground nut	-	45% of the ICA
Ragi	-	15% of the ICA
Maize	-	10% of the ICA
Pulses	-	10% of the ICA
Sunflower	-	20% of the ICA

The crop water requirements have been worked out as per Modified Penman method considering effective rainfall contribution, evapo-transpiration values and crop coefficients for surface irrigation method (overall efficiency 50%). Considering overall efficiency of 81% under drip irrigation, the fortnightly discharges and the quantum of water required under CBC are tabulated below. The Peak Water Requirement (PWR) for crops in project area is worked out as 3.2 mm.

v.Design of LPS drip system for Block 1 of CBC

From a contour map of the area, it is observed that enough elevation difference is not available in irrigation area to operate the Low Pressure Drip irrigation system. So, entire 250 ha area is designed with low head pump ofabout 50 HP power for operation. Block 1 is divided into 5 nos of zones with an average area of about 50 Ha. The size of each block is kept at about average 50 ha which will have separate head control unit i.e. secondary filters, pressure regulators, pressure relief valves, non return valves, air release cum vacuum release valves etc.

The Block 1 details are

Design details for Block 1		
a	GCA (Ha)	280
b	ICA (Ha) (GCA x 90%)	250
c	Application rate for selected emitter specifications (mm/hr)(as in irrigation data)	1.2
d	No. Of shifts/day (as in irrigation data)	8
e	Shift area (Ha) (b/d)	31.25
f	Shift flow (m3/hr) (e x c x 10 i.e. constant)	375
g	Shift flow (cumec) (f / 3600)	0.104

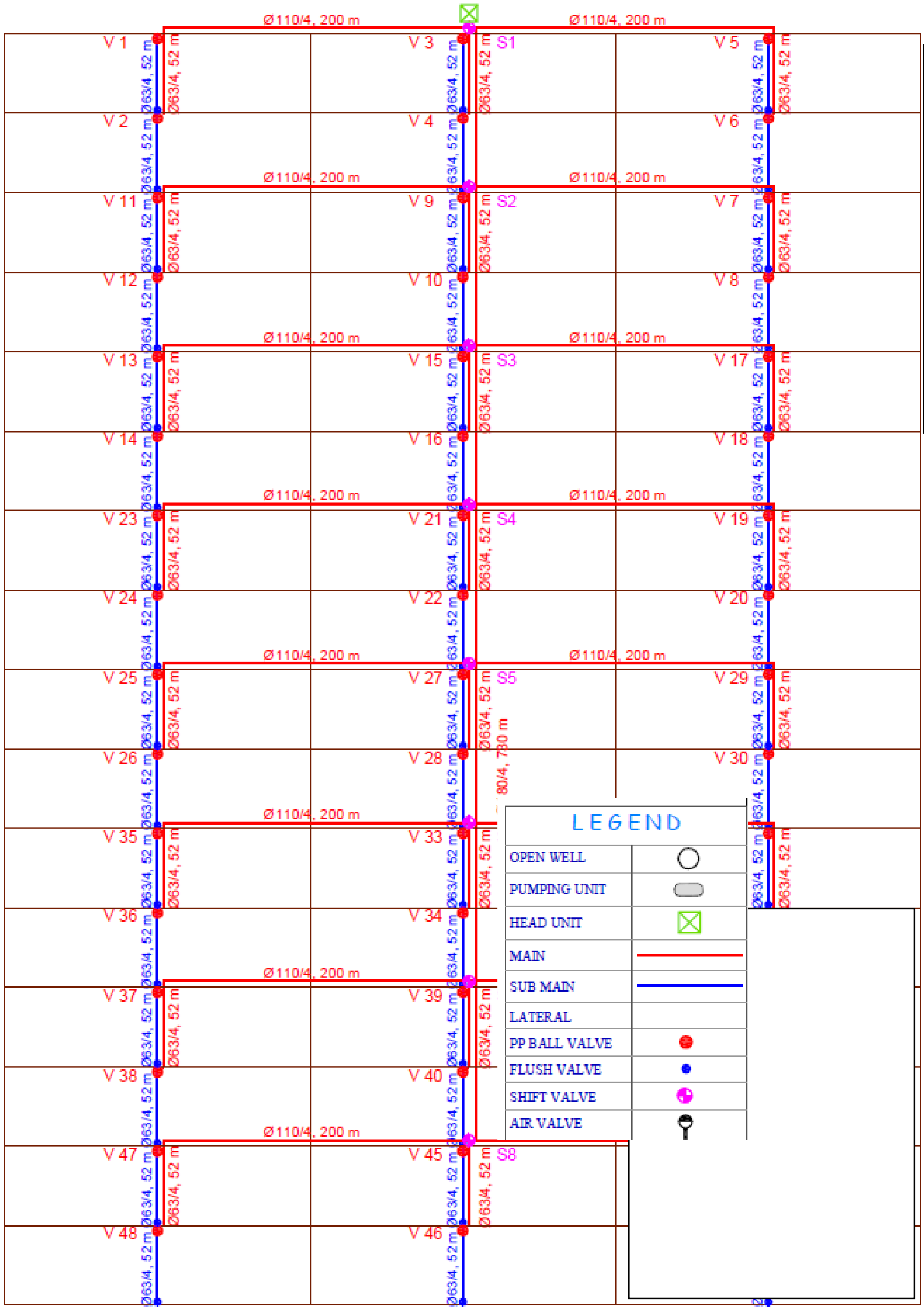

Fig 5 Drip module (50 ha)

vi.Power requirement

Power requirement for operating the drip system is worked out for the case of CBC with 1,07,265 ha ICA. The details are given below.

Power requirement under CBC			
Total area under CBC		**107265 ha**	
		Gravity Irrigation	**Low head pump irrigation**
Approximate area (%)		61	39
Area (Ha)	a	65028	42237
No of shifts	b	8	8
Average shift area (Ha)	c = a/b	8128.5	5279.6
Application rate (mm/hr)	d	1.2	1.2
Average shift flow (m3/hr)	e = c*d*10	97542	63355.5
Approximate pumping head required to operate Drip system	f	0	25
Approximate pump HP (Overall pumping efficiency is considered as 80%)	g =((e/3.6) * f)/ (75*80%)	0	7332.8
Approximate power requirement (MW)	h = (g * 746 / 1000000)	0	5.47

4. TECHNICAL BACKING BY FAO

KNNL has been in the forefront in India in adopting modern technology and tools for effective management of its irrigation systems with the active backing of Food and Agriculture Organization (FAO) of United Nations (UN). KNNL has the experience in construction and management of large irrigation system (45) having a vast command area of about a million hactares. FAO has been backing KNNL efforts in improving the performance of the large irrigation systems through the MASSCOTE (Mapping SYstem and Services for Canal Operation Techniques) approach. The six training workshops that are held since 2006 in irrigation projects in Karnataka have built the technical capability of over 250 key staff of KNNL in adopting modern methods of irrigation such as sprinkler/drip and modern tools of management.

KNNL is implementing the UBP as an 'Integrated Water Resources Management' project given its combined objectives of meeting irrigation, drinking and urban water supply. KNNL looks at this project as a pioneering pilot project which will set a model not only for its new projects but also for other projects in the State and the Country. This project will therefore bring about the desired transformation and reforms in the management of water resources which will have National relevance.

5. STATUS OF PROJECT

The implementation of the UBP was taken up in the year 2008. The key components of the infrastructure viz. the lifting arrangements and tunnel that delivers water to Chitradurga Branch Canal and Tumkur Branch Canal are taken up and are in progress.The work of 6.9 km long tunnel near Ajjampura village in Tarikere taluk is a critical work that would convey water from Bhadra reservoir to CBC and TBC. The project had to face stiff resitance from the farmers of tunnel region who depended heavily on limited groundwater potential for supporting agriculture. Detailed hydrogeological study along tunnel alignment was conducted. From the study, it became clear that it would be possible to conserve and sustain groundwater in the tunnel region during and after construction by appropriate strategies which broadly include precautions to be taken during tunneling operations and augment limited groundwater reserves by providing additional surface water and by rainwater harvesting tehniques/structures. Another important initiative is to extend irrigation by LPS system of drip above tunnel region to support agriculture over a large area of about 7500 ha.

Other than the above, the project had to overcome many impediments in its implementation after entrustment of the three package works; two lifts and tunnel on EPC turn key contract basis such as delays in land acquisition, power sanction, forest clearance etc. Now, with substantial progress achieved over the last three years, the UBP is poised to become a flagship project of KNNL and would benefit the farmers and the State in the years to come. Few photographs of works in progress are presented (Fig 6-9).

Fig 6: Raising main near Muttenkoppa (NR Pura Tq.)

Fig 7: CC lining in canal (Km 20)

Fig 8 : Pump house near Shantipura (Tarikere Tq.)

Fig 9 : Jambadahalla aqueduct in km 17

6. CONCLUSION

The implementation of LPS drip system of irrigation in UBP is found to be feasible on a large scale to bring in an area of over 2.14 lakh hactares under irrigation with a very high project efficiency of 81% by virtue of advantages over conventional surface irrigation (efficiency 51%). In view of limited availability of water for irrigation, the only way to extend irrigation benefits under Tumkur Branch Canal is by effecting water savings under Chitradurga Branch Canal by adopting modern drip irrigation. There would be considerable savings in water, thereby increasing the water use efficiency from 50% to 81%. This is in line with the State Water Policy which promotes drip and sprinkler irrigation to improve water use efficiency. The initiative of drip system in UBP is also in line with the National Water Mission of the Ministry of Water Resources, Govt. of India which promotes the integrated management of water resources and increase water use efficiency by 20 %.

REFERENCES

1. **A. Phocaides, FAO Consultant** 2007" Technical handbook on pressurized irrigation techniques"
2. **Acharyna, M.S.; Singh, J; Gupta, A.P and Singh, A.K. (1993)**, "Economic Analysis of Sprinkler Irrigation in Southern Rajasthan", in CBIP (1993), *Sprinkler and Drip Irrigation Systems*, Central Board of Irrigation and Power, New Delhi, pp. 74-76.
3. **A. Narayanamoorthy-** "POTENTIAL FOR DRIP AND SPRINKLER IRRIGATION IN INDIA" downloadable from link; http://nrlp.iwmi.org/PDocs/DReports/Phase_01/12.%20Water%20Savings%20Technologies%20-%20Narayanmoorthy.pdf
4. Rajagopal, A. (1998), "Sprinkler System of Irrigation for Water Economy in Scarcity Areas", in Verma C V.J and Rao, ARG (eds.), Micro Irrigation and Sprinkler Irrigation Systems, Central Board of Irrigation and Power, New Delhi, pp. IV1-IV7.
5. NETAFIM IRRIGATION INDIA PVT.LTD- 'Project Proposal for Upper Bhadra Project'

"M G Shivakumar graduated in Civil Engineering from University of Mysore in 1981, obtained post-graduation from Indian Institute of Science, Bangalore in 1983. Joined Karnataka Government service in 1983. He specializes in irrigation. He visited Thailand and Malaysia in 2006 on a study tour of irrigation modernization programmes and policies of FAO, Uzbekistan in 2009 as FAO faculty in a training workshop on irrigation modernization in Central Asia, Philippines in 2012 as a resource speaker in a training workshop of ADB staff. Presently, he is holding the position of Superintending Engineer, Karnataka Neeravari Nigam Limited (KNNL), pursuing Ph.D. at VTU, Belgaum."

"R. Cheluvaraju graduated in Civil Engineering from Bangalore University in the year 1982, Studied at Indian Institute of Science, Bangalore, joined Karanataka Government service in the year 1992. Has experience in planning, construction and management of large irrigation systems. Has been involved in execution of important irrigation projects/structures like dam, canal net work, lift schemes and tunnel"

"M. Satish graduated in Civil Engineering from Mysore University in 1988, obtained post-graduation in 1991 from Bangalore University in the year 1991.He has been serving the Government of Karnataka since 1992 and is working in the water resources sector since 2007. He has wide experience in planning and implementation of large irrigation schemes- flow and lift"