Irrigation Modernization and Design of Pipe Distribution Networks

EXPERIENCE AROUND THE WORLD AND A CLASSIFICATION OF PIPE SYSTEMS

nhc
northwest hydraulic consultants
water resource specialists

Reasons to modernise with buried pipes

For water efficiency gains and improved equity of distribution

For much higher crop yields and to enable crop choice

To better connect to farmer investments (dug-wells, drip, etc)

To meet challenge of climate change/ uncertainty

For greater efficacy of fertiliser use

For reduced labour costs

To help break the cycle of rehabilitation and neglect

Irrigation Modernisation with Pipes - Experience from around the world

- USA and Australia – pipe systems have been part of modernisation (last 30 years)
- Vietnam – pump pressure pipe irrigation adopted following drought
- Central Asia – has many old pump & gravity pipe systems
- Bangladesh – low-cost low head pipe distribution for paddy, with pre-paid metering
- India – last 10 years many states have constructed PDN systems, and supportive domestic industry is developing fast.

USA

Sunnyside Irrigation Division
Washington State, USA, August 2015
ENCLOSED LATERAL IMPROVEMENT PROJECT (ELIP)

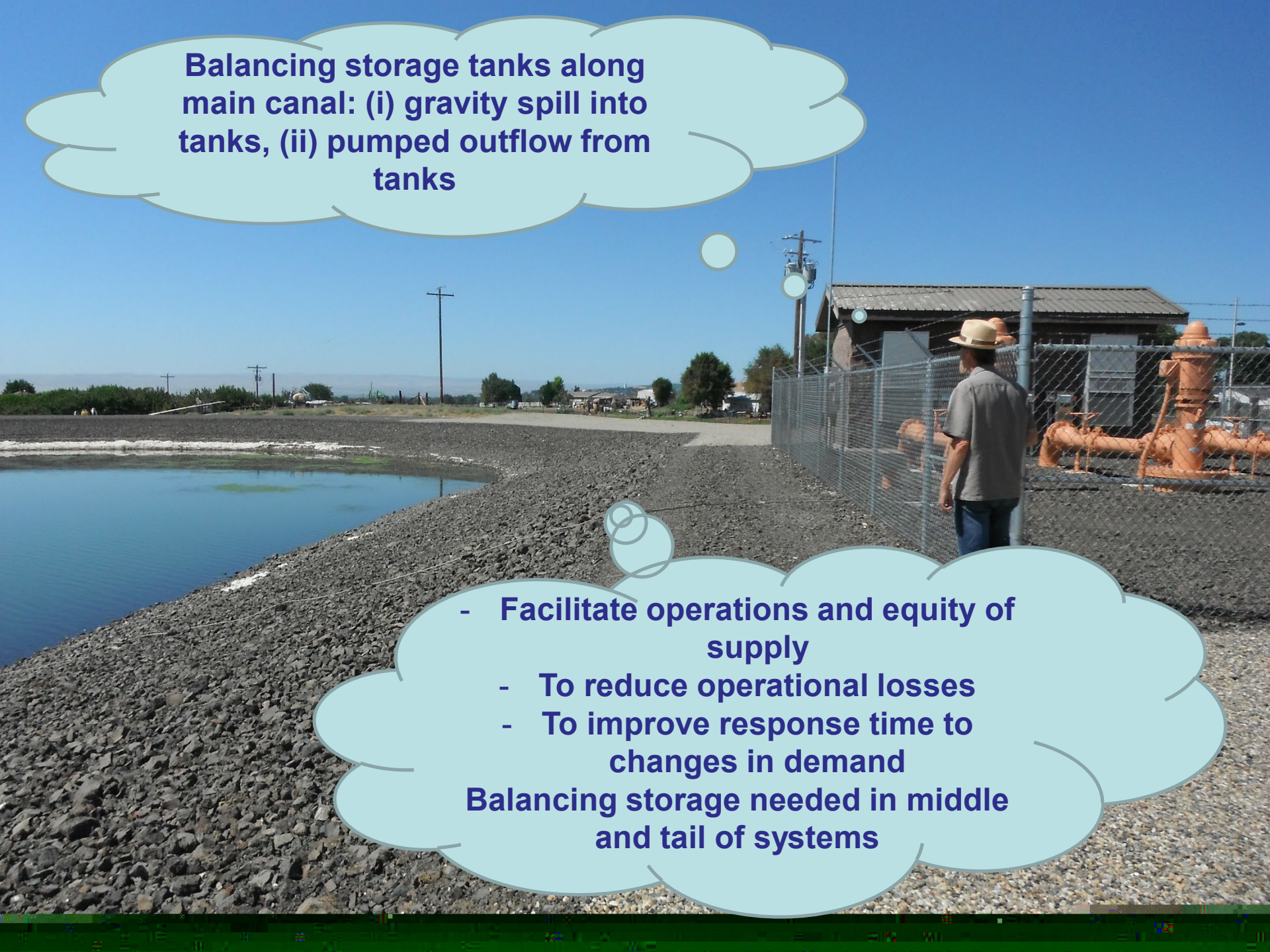
Salient features:

- 38,290 ha net command area
- River diversion and gravity main canal about 96.6 km (60 mile) long with 30 check structures (ie every 3.2 km)
- Off-taking secondary laterals supplying farms (tertiary units) about 40 to 80 ha in size. Gravity and pumped supply.
- Irrigation application methods- drip/ sprinkler
- 65 O&M staff answerable to Cooperative Board (elected farmers/ stakeholders)

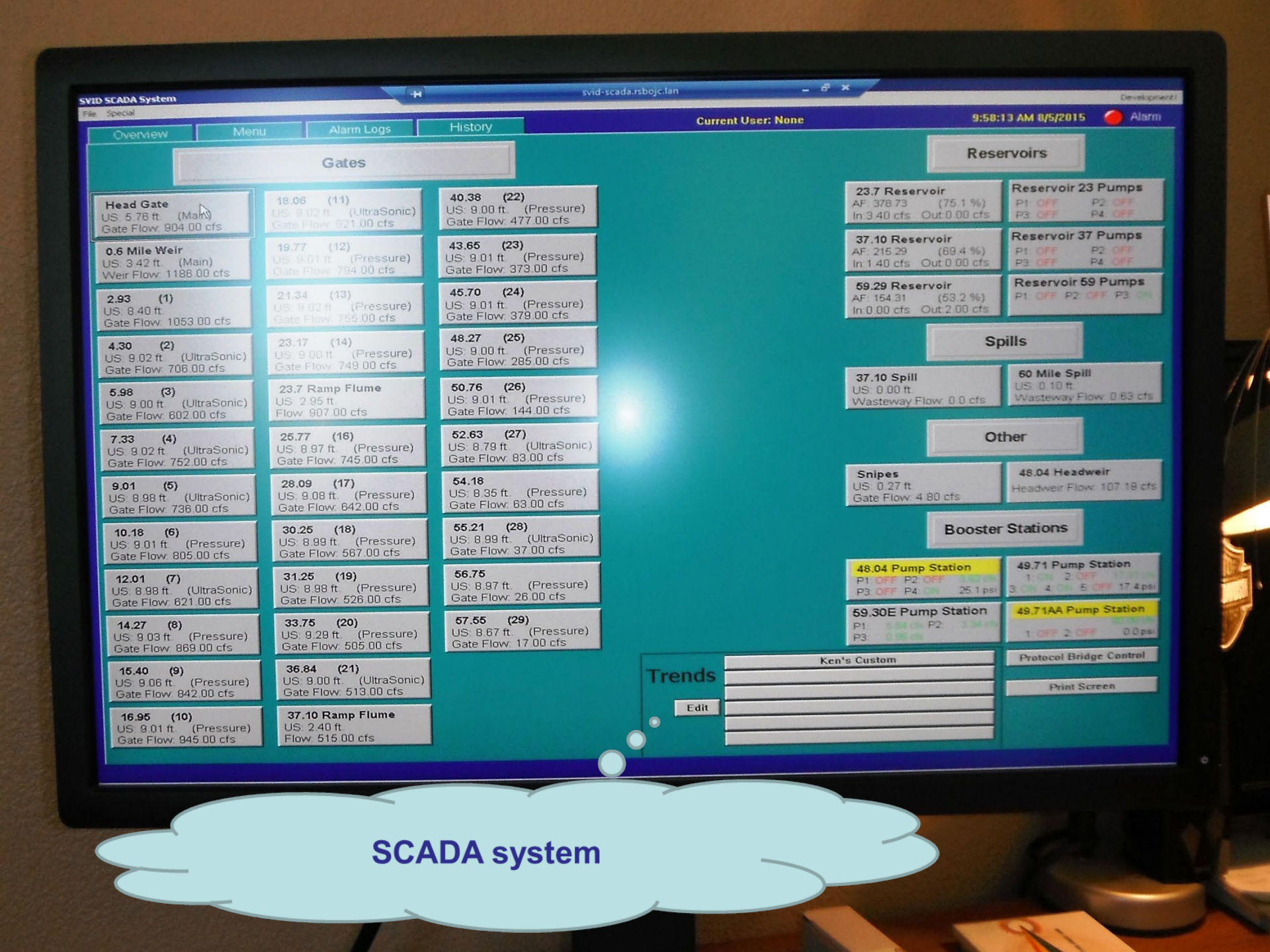
- Modernization entailed:
  - Fully automated electrically powered gates to the 30 X-regulators along main canal
  - Supervisory Control & Data Acquisition System (SCADA) for main canal – water levels/ flows/ gate adjustments
  - Construction of three storage (flow balancing) reservoirs
  - Enclosed lateral program: all secondary canal systems converted to uPVC pipe distribution systems, both gravity and pumped


CHECK
37.10
Overshot (hinged) cross regulators: (i) automatic water level and flow monitoring, (ii) gate actuators locally/ remotely operated


THE
PROBE


Balancing storage tanks along main canal: (i) gravity spill into tanks, (ii) pumped outflow from tanks
- Facilitate operations and equity of supply
- To reduce operational losses
- To improve response time to changes in demand
Balancing storage needed in middle and tail of systems


Flow measurement structure:
remote water level monitoring



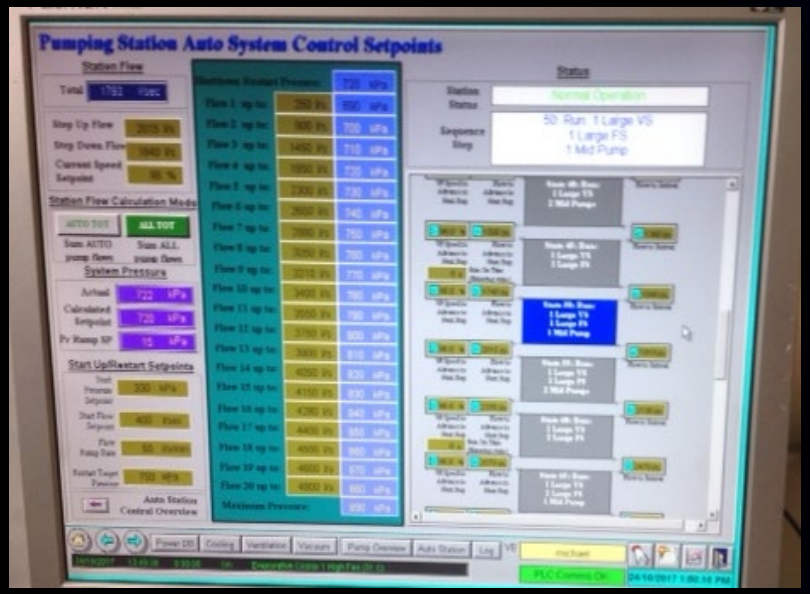
SCADA system


Piped distribution systems laterals – intake to pumping station and PDN system


Hydrant with filter – supply to tertiary units (farms)


Store – irrigation authority keeps
a good stock of spare parts

Australia



Australia – adoption of pipes is part of coping with water scarcity (drought)

nhc

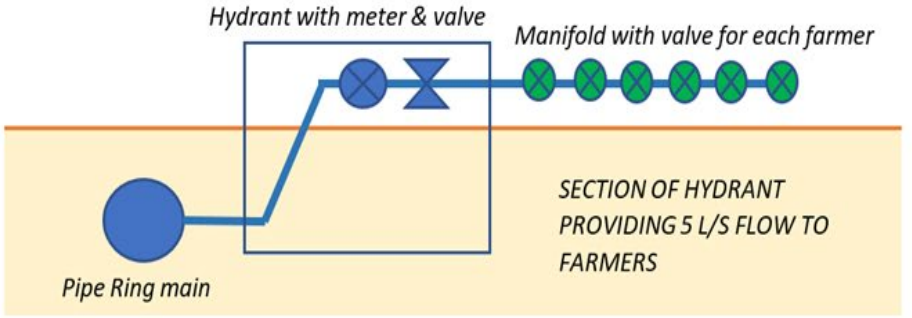
water resource specialists

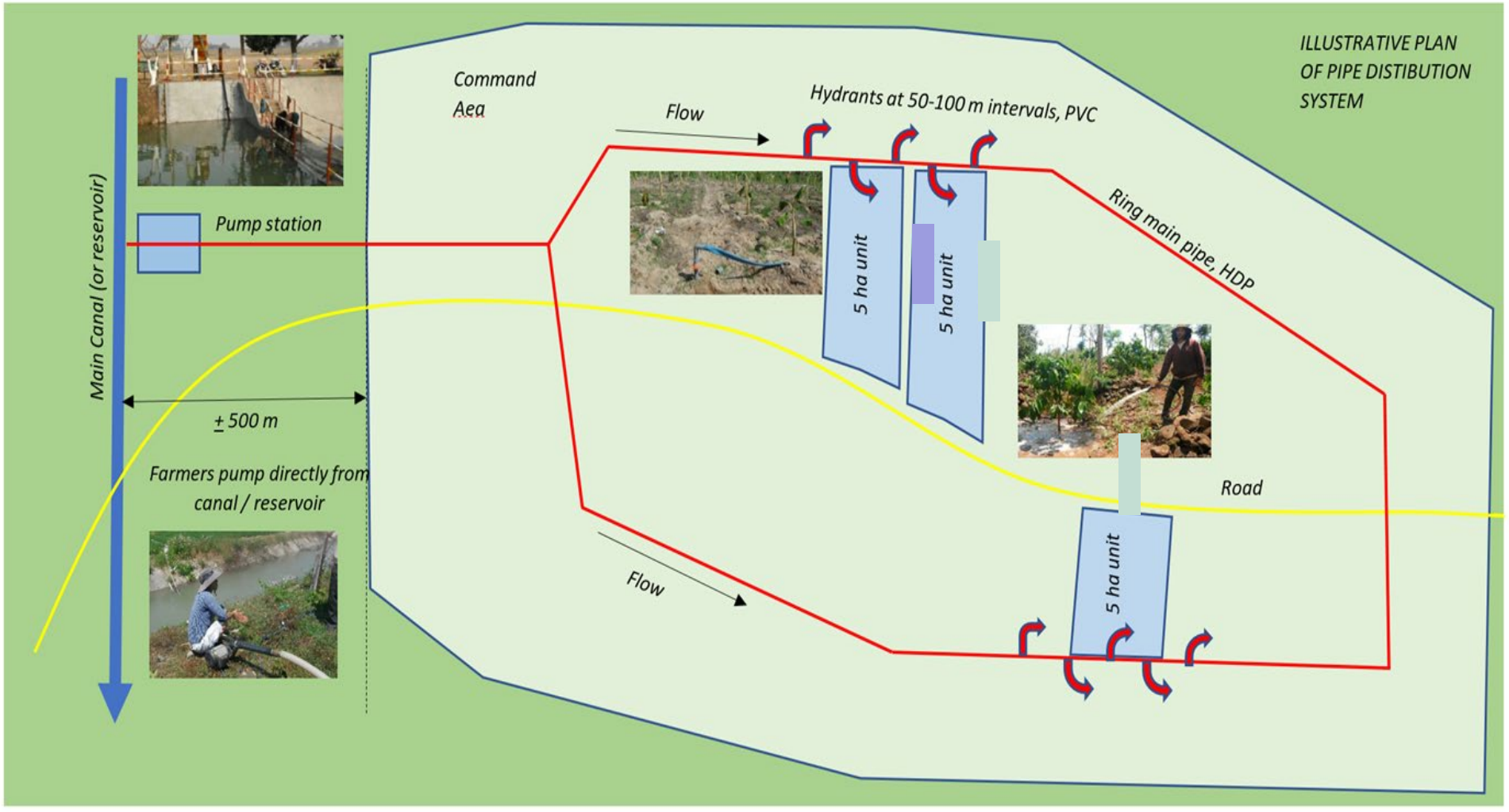
Vietnam

Vietnam – crop diversification in central highlands/ coping with drought (WEIDAP)

Management Tiers:

i. Reservoir and/ or main canal
ii. Pipe system supply to hydrants
    a. 5 l/s hydrants with manifolds (farmers want 2-3 l/s flow typically)
    b. Number of hydrants is supply flow divided by 5 l/s
    c. 500 m maximum distance from plot
    d. 5 ha (50-100 m along pipelines)
    e. Residual heads (1 m – 10 m minimum)
iii. Farmer hydrant to plot pipe and on-farm irrigation equipment





Central Asia

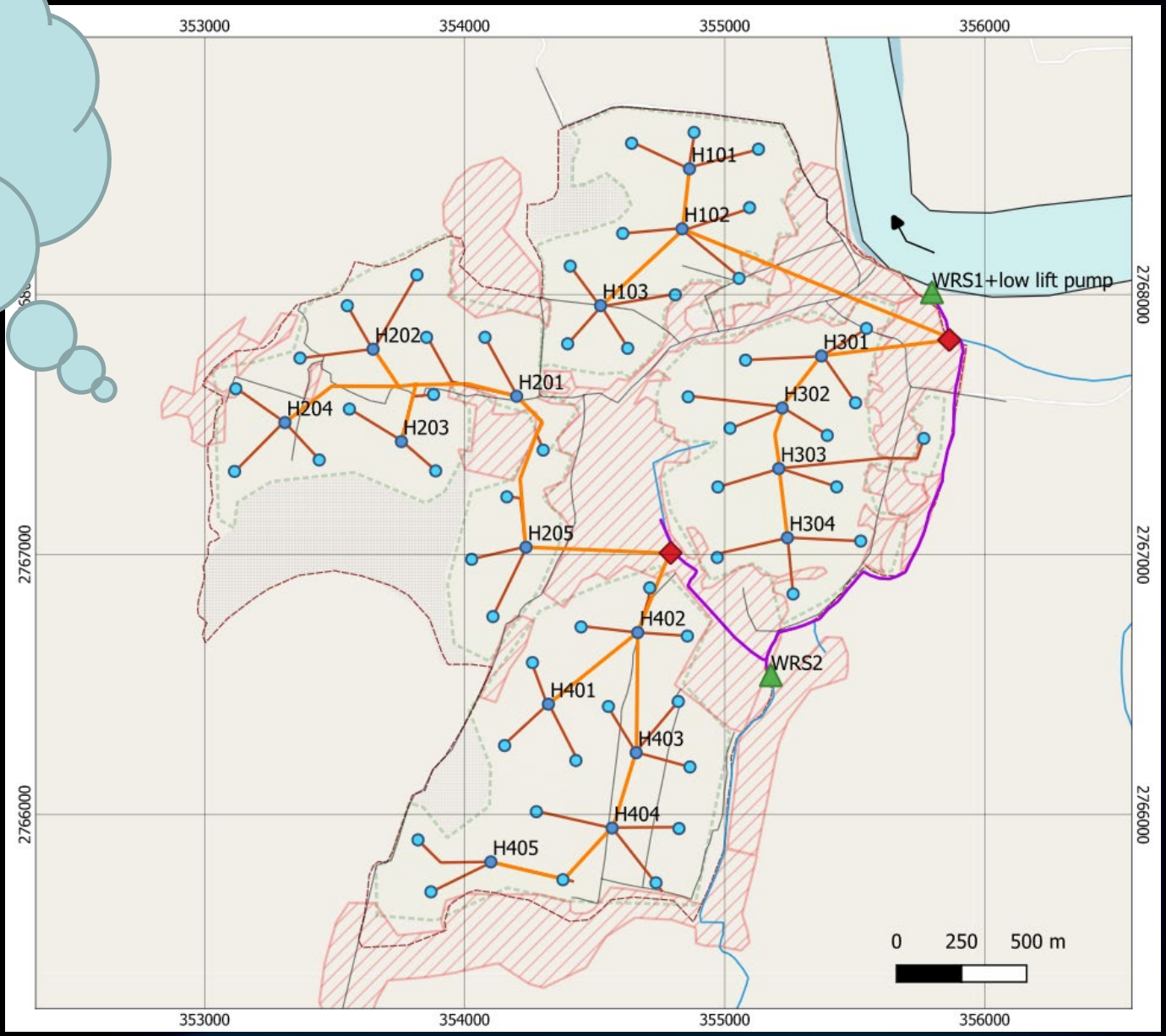
Central Asia – modern pipe distribution with drip and furrow irrigation is replacing old systems

Bangladesh

Bangladesh – low-cost uPVC pipe systems for rice

water resource specialists

Typical Layout for low-cost, low pressure, buried pipe systems (hub and field layout)



nhc

water resource specialists

Bangladesh – use of trencher machines is fast and provides uniform trench bed

India

Tajnapur LIS, Aurangabad district, Maharashtra, 6,605 ha

- Lift irrigation from Jaikwadi reservoir to distribution chambers in 3 blocks. From the DCs, water pumped to 8 Zones (avg. 825 ha), and supplied to 660 Chaks, each 8-12 ha. Each chak comprises 14 sub-chaks (0.7-0.8 ha).
- One WUA per Zone.
- Pipes: MS, HDPE, PVC
- Duty: 0.45 l/s/ha. Mixed cropping.
- SCADA, including OMS under consideration
- Lumpsum turnkey contract for with 2 years for construction (2021-23) and 5 years for O&M.

Tajnapur LIS, 6,605 ha

Pumping Station, HDPE Pipe laying, Circular Delivery Chamber at high points, 4-inch Outlet to 8-12 ha chaks. (temp?)

Kundalia LIS, Rajgarh dist, Madya Pradesh, 131,449 ha

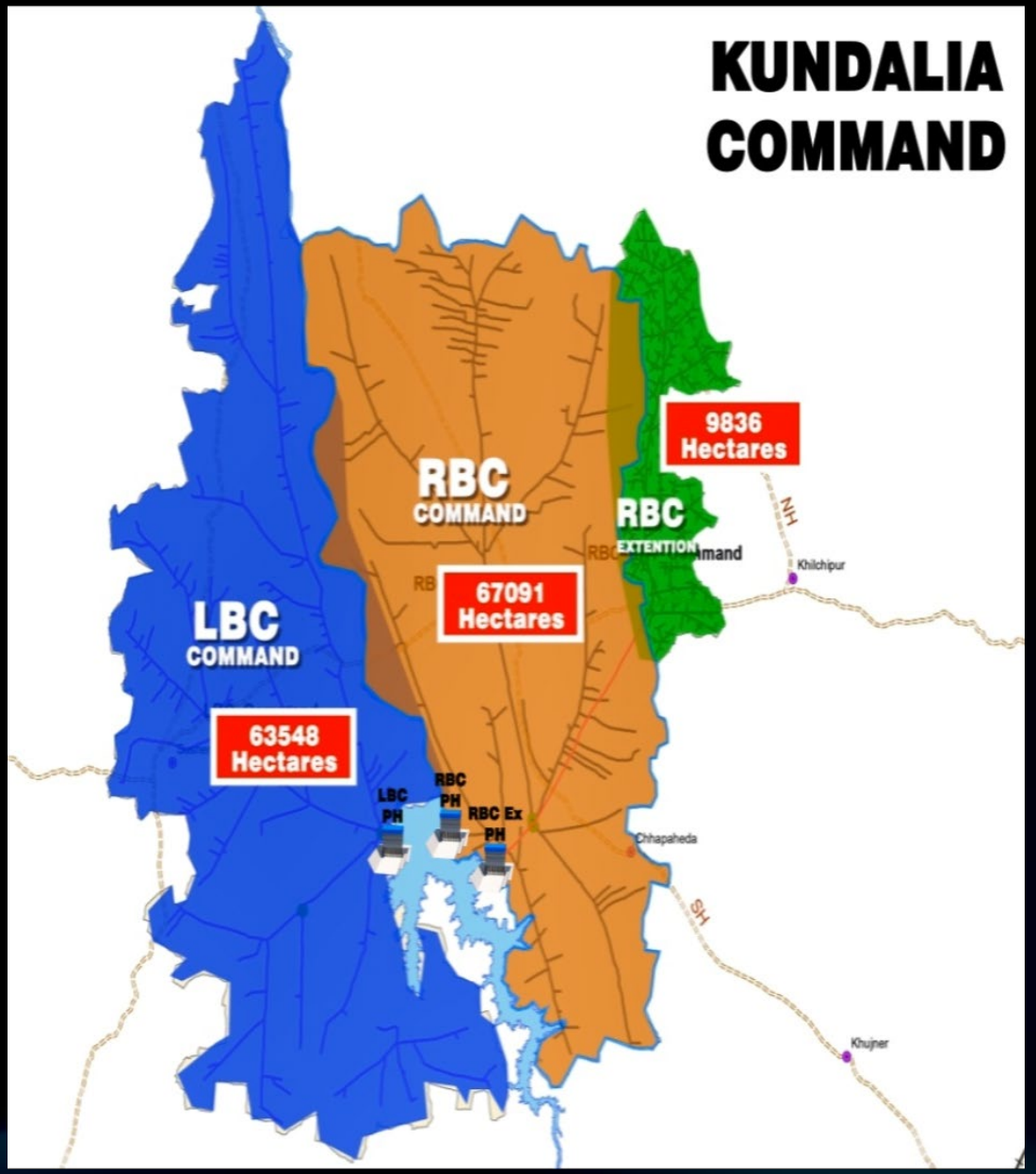
- Pumped LIS schemes supply water to Delivery Chambers for distribution by gravity pipelines.
- Tiered layout: Zones, Village Units, Chaks , Sub-chaks, farm units
- Pipes: MS, HDPE.
- Duty: 0.45 l/s/ha. Mixed cropping.
- Full SCADA with OMS with flow and pressure control. Also, RMS at Zones and Village Units.
- Operation: 24/7 flow of 13.5 l/s to 30 ha Chaks. Rotational supply of 4.5 l/s to 3 subchaks at a time.
- WUAs – each 3,000 to 4,000 ha

Constructed 2021-2025

Both RBC and LBC comprise of pumping stations lifting water to Delivery Chambers. From the DC water flows by gravity to the command area.

One zone is pressurized by direct pumping to pipeline

Layout Tiers:
- ~6,000 ha Zones
- 300 ha Village Units
- 30 ha Chaks (OMS)
- 5 ha Subchaks
- 1 ha Farms

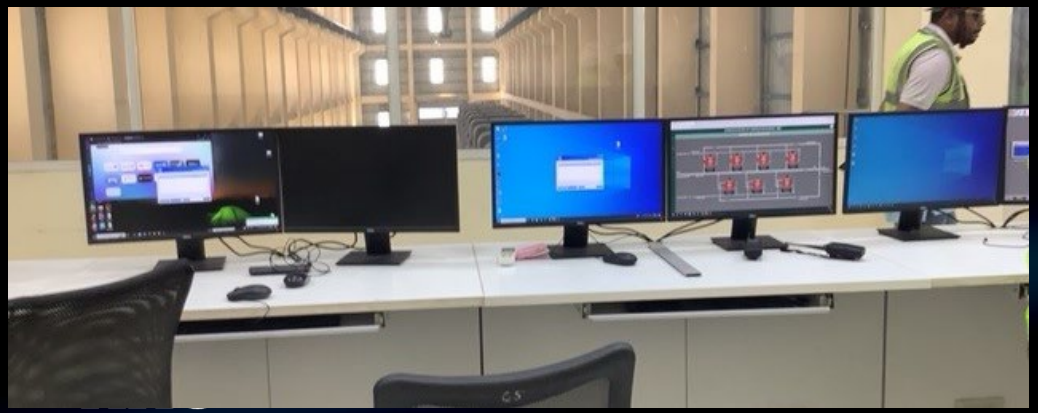


nhc

water resource specialists

Kundalia LIS, CCA 131,449 ha

RB Pumping Station, Discharge Chamber, Remote Management System, and 30 ha OMS



water resource specialists

Modernizing Existing Major & Medium Schemes

Consider:

1. Groundwater, Farmer Investments and Implications for Irrigation Modernization
2. Changing Command Areas and Implications
3. Scarcity of Water Resources and Implications

Groundwater, Farmer Investments and Implications for Irrigation Modernization

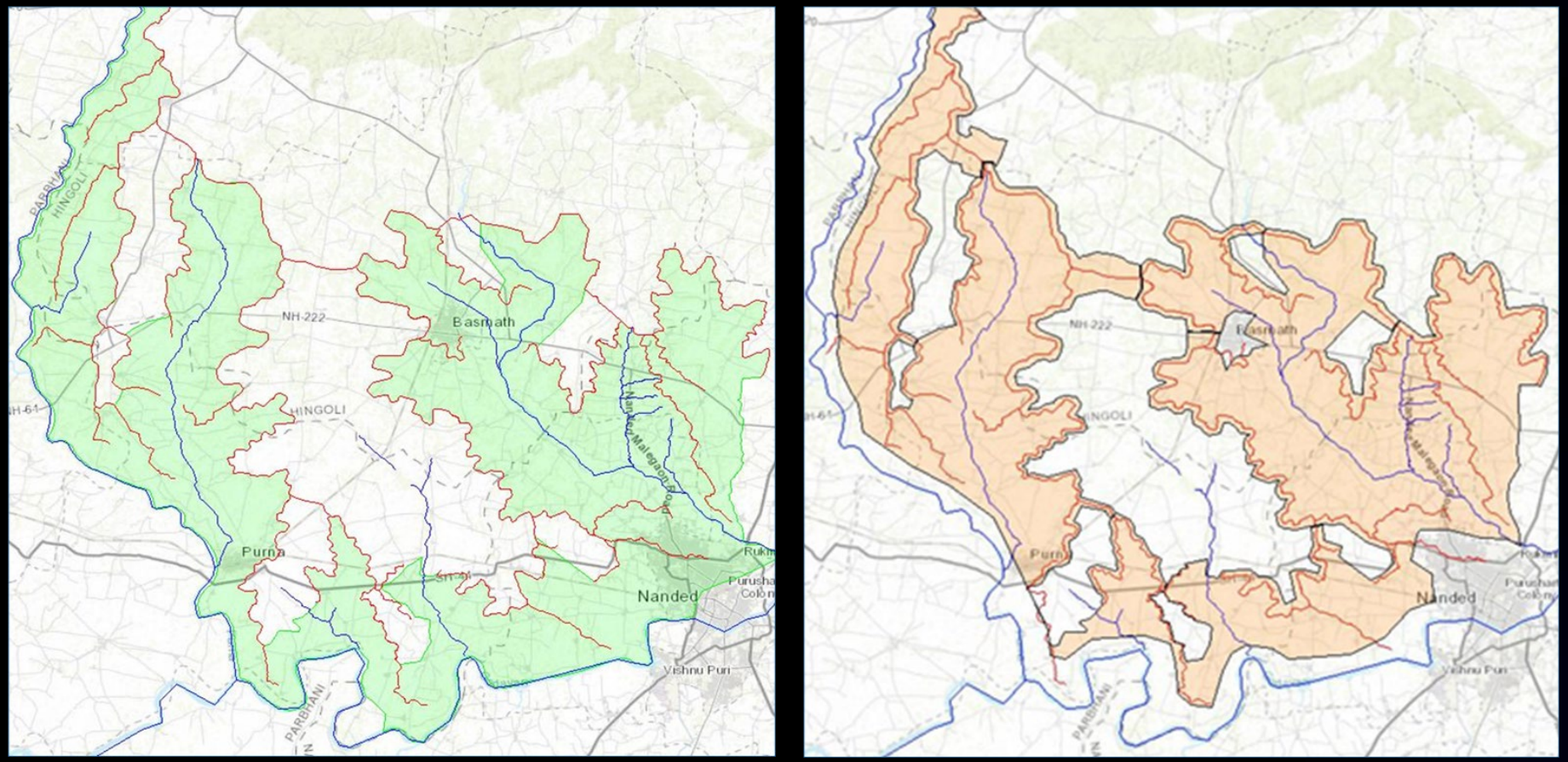
nhc

water resource specialists

nhc

water resource specialists

Changing Command Areas and Implications



Purna project, Nanded dist, Maharashtra

- ORIGINAL COMMAND AREA, 57,988 HA. 100% GRAVITY
- PROPOSED COMMAND AREA: 10,440 HA, 18% PERIPHERAL PLUS 47,548 HA, 82% GRAVITY

Scarcity of Water Resources (due to climate change, competing water demands, etc) and Implications

Competing Water Demand, Palkhed Scheme, Maharashtra

		Original Design		Avg. Last 10 years	
Irrigation	MCM	251.73	88.9%	87.26	57.2%
Domestic water supply	MCM	18.23	6.4%	83.68	54.8%
Industry	MCM	1.12	0.4%	4.11	2.7%
Hydropower	MCM	0.00	0.0%	0.00	0.0%
Other	MCM	11.97	4.2%	2.70	1.8%
Total	**MCM**	**283.05**	**100.0%**	**177.75**	**116.4%**

Works to modernize MM Schemes

- Headworks
- Main conveyance system
- Smaller canals and field channels
  - Gravity PDN systems
  - Pumped PDN systems – expand CCA to peripheral areas
- Drainage
- Roads

Main conveyance system

- Full and/ or selective lining of canals with geomembrane under hard surface (concrete) protection. For urban areas consider flume sections.
- Upgrade/replacement and modernization of canal structures – overshot hinged gates are recommended.
- Trash removal facilities.
- Sediment traps.
- Balancing storages.
- Groundwater recharge facilities (canal side recharge wells)
- Canal side pumping facilities.
- Real time water level and flow monitoring systems

Smaller canals and field channels – PDN Systems Adopted

- Where land slopes are sufficient, replacement of canals/ channels with gravity buried plastic pipe systems done. Turnouts exclude rubbish and coarse sediment from entering and blocking pipelines.
- If land slopes are not sufficient, pumped pipe systems adopted.

Components for Pipe System

Components for Pipe System

Components of Typical Pipe System:

- uPVC/ HDPE pipe for gravity systems
- NDPE for pump pipe systems

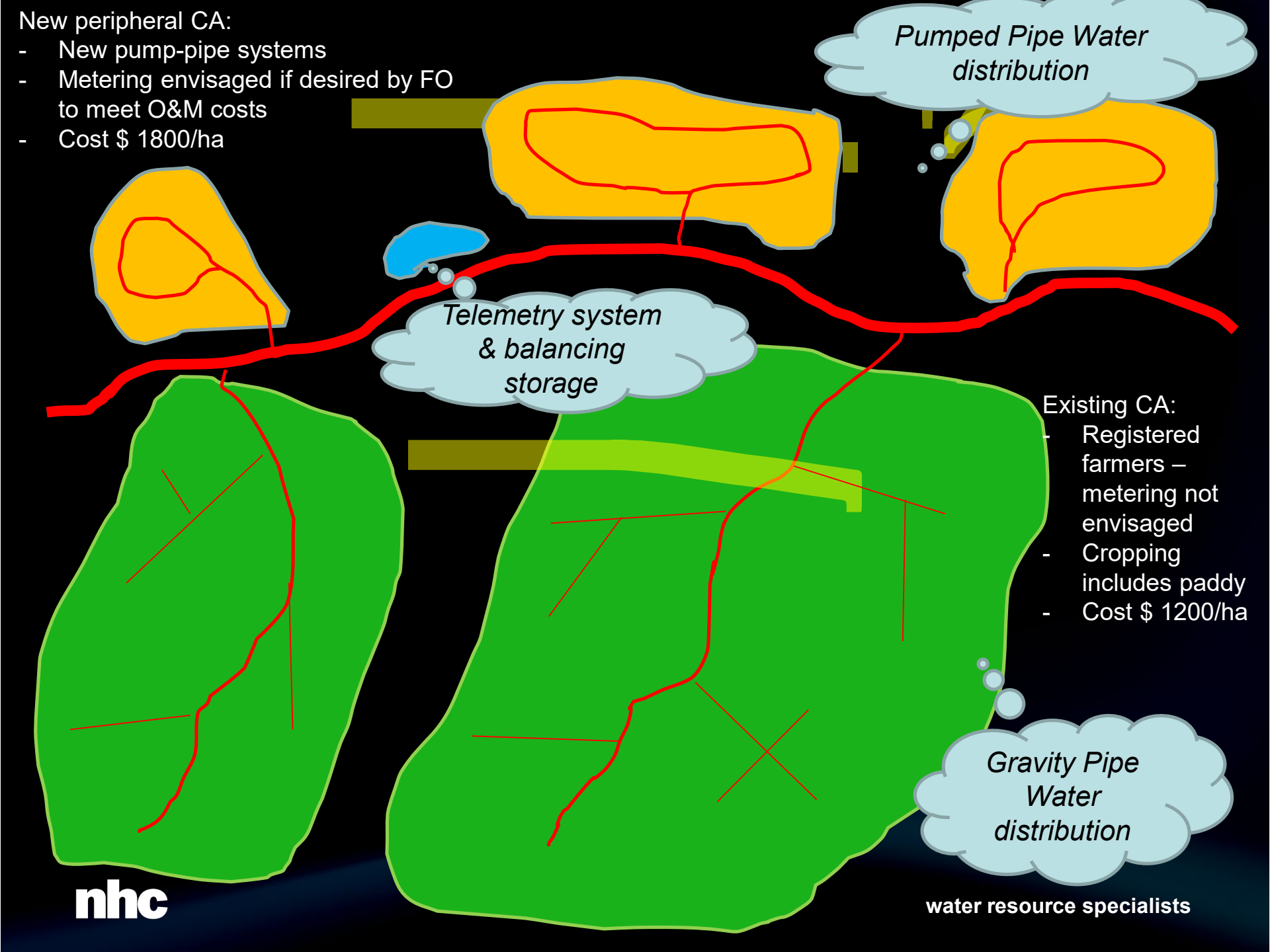
Sand Bedding placed under (and around pipeline) to ensure proper support

Pumping for Pressure Pipe Systems

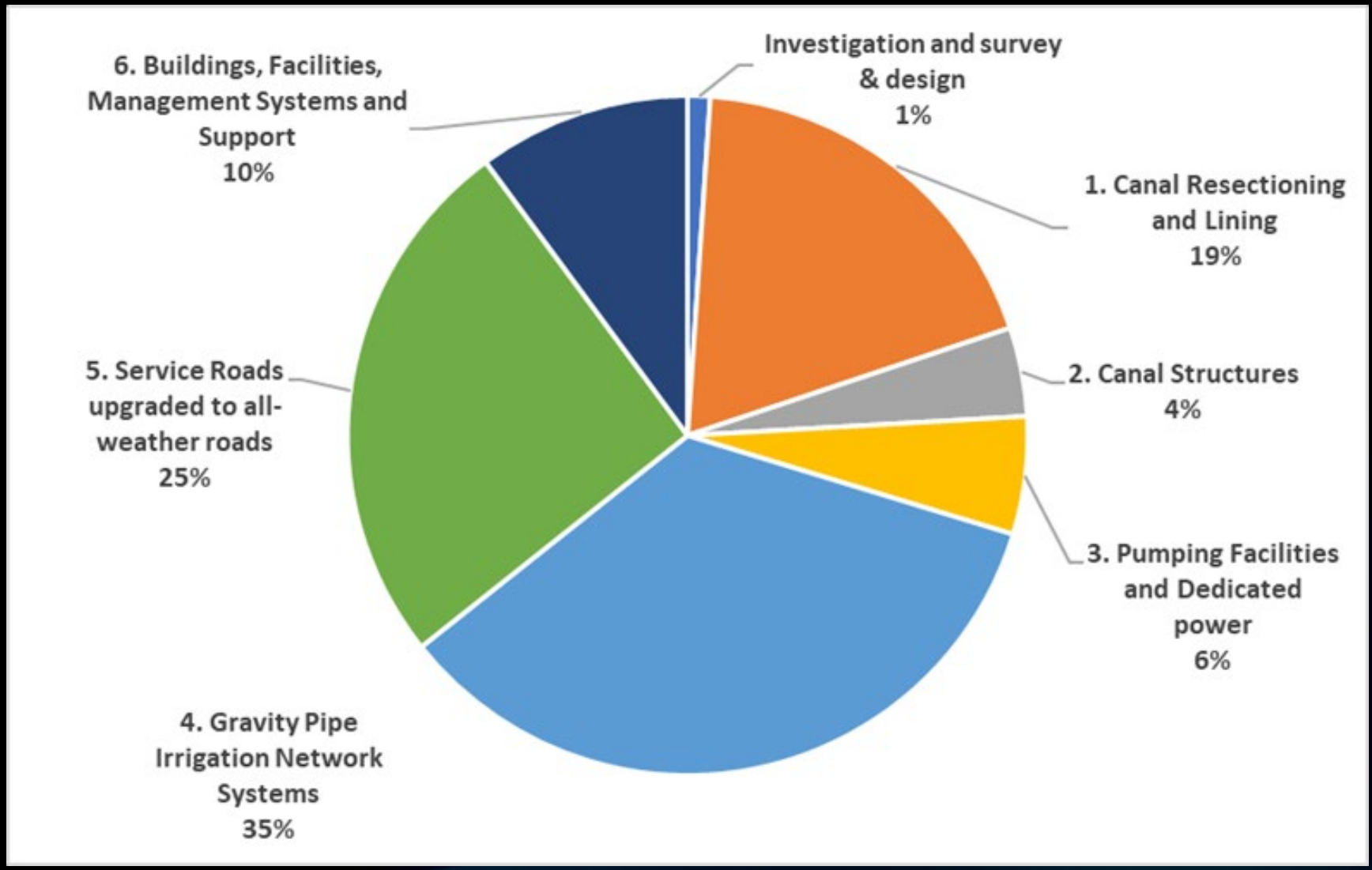
Pumping for Pressure Pump - Pipe System

nhc

water resource specialists


New peripheral CA:
- New pump-pipe systems
- Metering envisaged if desired by FO to meet O&M costs
- Cost $ 1800/ha
Pumped Pipe Water distribution
Telemetry system & balancing storage
Existing CA:
- Registered farmers – metering not envisaged
- Cropping includes paddy
- Cost $ 1200/ha
Gravity Pipe Water distribution
nhc
water resource specialists

Modernization of Purna Scheme, Maharashtra



Classification of Buried Pipe Systems

- **Size**
  - Large: > 3,000 ha
  - Medium: 500-3,000 ha
  - Small: < 300 ha
- **Pumped/ gravity system**
  - Gravity systems require an overall land slope of ~0.5%
  - For slopes of ~1-2.0%, flow velocities are likely to be close to the maximum allowed, ~2 m/s.
  - Energy for pumped systems is proportional to pumping head and discharge.
- **Pipe pressure, hydrants and water application method**
  - Very low pressure < 6 m: these are usually “open” systems with standpipe header tanks and air vents. Simple outlets for basin/ furrow irrigation are usually adopted with these systems (Bangladesh).
  - Low pressure, 6 to 20 m, hydrants allow for hose irrigation.
  - Medium pressure, 20 to 50 m, usually adopted for drip or low/ medium pressure sprinkler systems.
  - High pressure > 50 m, for sprinkler or gun, systems.

- **Pipe layout and pipe intensity (m/ha)**
  - Branching “dead end” systems are typically cheaper that ring systems but may have greater pressure variation.
  - Pipe intensity (m/ha) depends on maximum distance from hydrant to farmers field adopted, as well as on shape and fragmentation of the command area. For example, for 500 m (max.) from field to hydrant requires 15-20 m/ha of pipe, while 150 m requires 35-50 m/ha of pipe (see table below).
- **Pipe types**
  - Choice depends (i) size, (ii) pressure, (iii) design life under operating conditions, (iv) cost, and so on.

Indicative Engineering Costs US$/ha

Costs typically range from US$ 800 - 2,400 /ha

		Small Systems < 100 ha		Medium Systems, 100 – 400 ha	
		Pipe intensity < 25 m/ha	Pipe intensity 25-40 m/ha	Pipe intensity < 25 m/ha	Pipe intensity 25-40 m/ha
Very low pressure < 6 m, open system	Pipes	300	390	800	1,200
	Total	550	650	1,450	2,000
Low pressure 6-30 m, closed systems	Pipes	450	600	900	1,400
	Total	900	1,200	1,800	2,800


nhc
Thank you

nhc

water resource specialists