ADB ASIAN DEVELOPMENT BANK

WATER EFFICIENCY IMPROVEMENT IN DROUGHT-AFFECTED PROVINCES PROJECT

GUIDELINES FOR DETAILED ENGINEERING DESIGN

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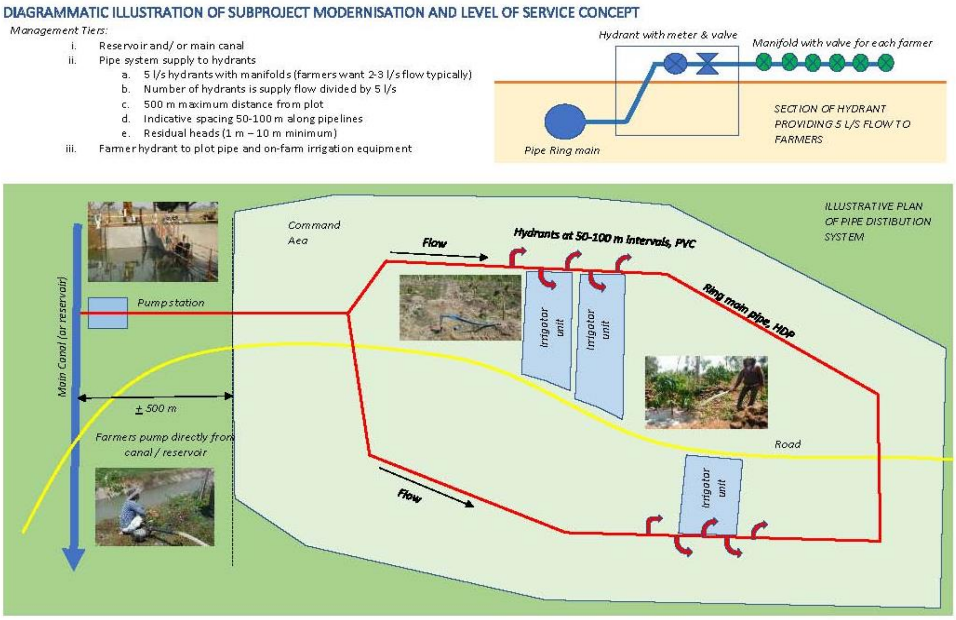

HANOI, August 2019

GUIDELINES FOR DETAILED ENGINEERING DESIGN

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I. INTRODUCTION

1. Under the Water Efficiency Improvement in Drought-Affected Provinces (WEIDAP) Project, climate resilient modernized irrigation will be developed providing farmers with efficient, affordable and flexible irrigation water.
2. Feasibility level designs have already been prepared for each subproject, and approved by the Provincial People's Committees (PPCs). These have largely fixed service areas, (pipeline) layouts and design discharges. Design options have been evaluated and recommendations made for detailed engineering designs.
3. This document is prepared to guide the detailed design process, for use by the Ministry of Agriculture and Rural Development (MARD), the Departments of Agriculture and Rural Development (DARDs) and the Specialized Provincial Project Management Units (SPPMUs) involved in the WEIDAP Project, the Provincial Project Management Units (PPMUs), and the Asian Development Bank (ADB), and will be included as appropriate in or attached to the Terms of Reference for the procurement of services for detailed engineering design. The detailed designs will be prepared by national consultants recruited by the DARDs/SPPMUs/PPMUs involved in the WEIDAP Project with support from MARD (the Central Project Office (CPO)/ the Central Project Management Unit (CPMU)).
4. MARD (CPO/CPMU) assisted by the ADB and the Australian Water Partnership (AWP) will review detailed design process which will include the following milestone (MS) discussions/ checks for each subproject:

   i. MS 1: MARD(CPO/CPMU)'s reviewing with the help of ADB and AWP the terms of reference of the detailed design consultants covering the detailed design scope and intent for each subproject, prepared by DARDs/SPPMUs/PPMUs.
   ii. MS 2: Design workshops/ Discussions on the proposed consulting services opportunities for detailed engineering designs to advise the design consultant firms special features of the required designs and receive feedbacks from the design consultant firms for possible modifications of the terms of references.
   iii. MS 3: DARDs/SPPMUs/PPMUs submission of detailed engineering design dossiers (draft detailed design drawings, reports and calculations) for review and comments by MARD (CPO/CPMU) with the help of ADB and AWP.
   iv. MS 4: Submission of final detailed engineering design dossiers including full reports, specialized reports, maps, detailed design drawings, calculations, quantities and cost estimates; technical instructions for constructions, operational procedures, etc., revised taking into any comments made in MS 3.

Note: the project implementation support consultants, if appointed in time, may also review the detailed designs.

5. The key design principles for detailed design are summarized below in Section II. These supplement national design standards and criteria by providing guidance particularly for pipeline layouts and designs of pipe systems with hydrant –

manifolds, ring main piped distribution systems, Supervisory Control And Data Acquisition (SCADA) systems, with metering and flow control devices, etc.

6. Detailed engineering designs shall be aligned with those in the approved FSs and shall observe current design standards/ regulations. Specifically, designs of pressured pipe systems shall/ should observe the design standard: Water supply - Distribution pipeline system and facilities (TCXDVN 33:2006).

7. In Section III, design improvements building on the work completed at feasibility are summarized for each subproject. In cases of (any) further option/ solution changes, there shall be technical and economic arguments/ evaluations to support them and approval shall be requested and given by DARD and ADB.

II. KEY DESIGN PRINCIPLES FOR SUBPROJECTS

A. Existing Farmer Practices and Adopted Level of Service and Layouts

8. Farmers in all the subprojects cultivate high-value crops, with irrigator flows usually between 1.7 and 4 l/s. Indicative irrigation times, stream flows and irrigation periods are tabulated below for the main high value crops. Water is usually conveyed to and within the farm by hose. Some farmers have installed buried uPVC pipe within the farm to connect drag hoses. Irrigation maybe directly onto the plant (dragon fruit), or into basins (mango, coffee, pepper) as on Figure 1. Furrow irrigation is practiced for some vegetables, while small areas of drip (grape) or sprinkler (dragon fruit, coffee, pepper) have been installed.

Table 1: Irrigation time, flow, interval and application

	Units	Mango	Dragon Fruit	Coffee	Pepper
Irrigation time per plant	minutes	5-20	½ to 1	1 - 2	1 – 2
Application method	-	Basin	Onto plant	Basin / sprinkler	
Number of trees/ vines	no./ ha	200-210	±1,000	±1,100	±2,200
Irrigator flow	l/s	1.7 – 2.5	1.5 – 4.0	2 - 3	2 – 3
Irrigation application	mm	50 – 130	10 – 20	80 - 120	80 – 120
Time to irrigate 0.5 ha farm	hours	±21	5 – 8	20 - 26	20 – 26
Irrigation Interval	days	±10	2 - 5	10 - 15	10 - 15

Figure 1: Applied irrigation systems and basic types of irrigation methods

9. The focus for system modernization is buried piped distribution (gravity and pumped), taking water from canals and/ or reservoirs, and supplying hydrants, typically 63 mm diameter, with flows of $\pm$5 l/s to which farmers can connect. These hydrants are to be within 500 m of farmers' fields. The required level of service is illustrated on Figure 2 below.
10. The flow at each hydrant will ensure that all hydrants can operate at the same time supplying 5l/s. There will be several farmers connecting to each hydrant taking water in turns and as per their requirements. Sufficient flexibility shall be provided so that, generally, all farmers can irrigate within daylight hours.
11. Basic SCADA systems will facilitate operations, for example enabling remote monitoring of flows at hydrants, pressures at key points in pipelines, and linking pump operation to water levels in a controlling header tank, and so on.
12. The design guidance given below covers pipe systems, pumping and SCADA for schemes to be developed under the project. There will of course be other hydraulic structures, canals systems and service roads to be constructed/ upgraded under the project but no additional guidance is needed for these.

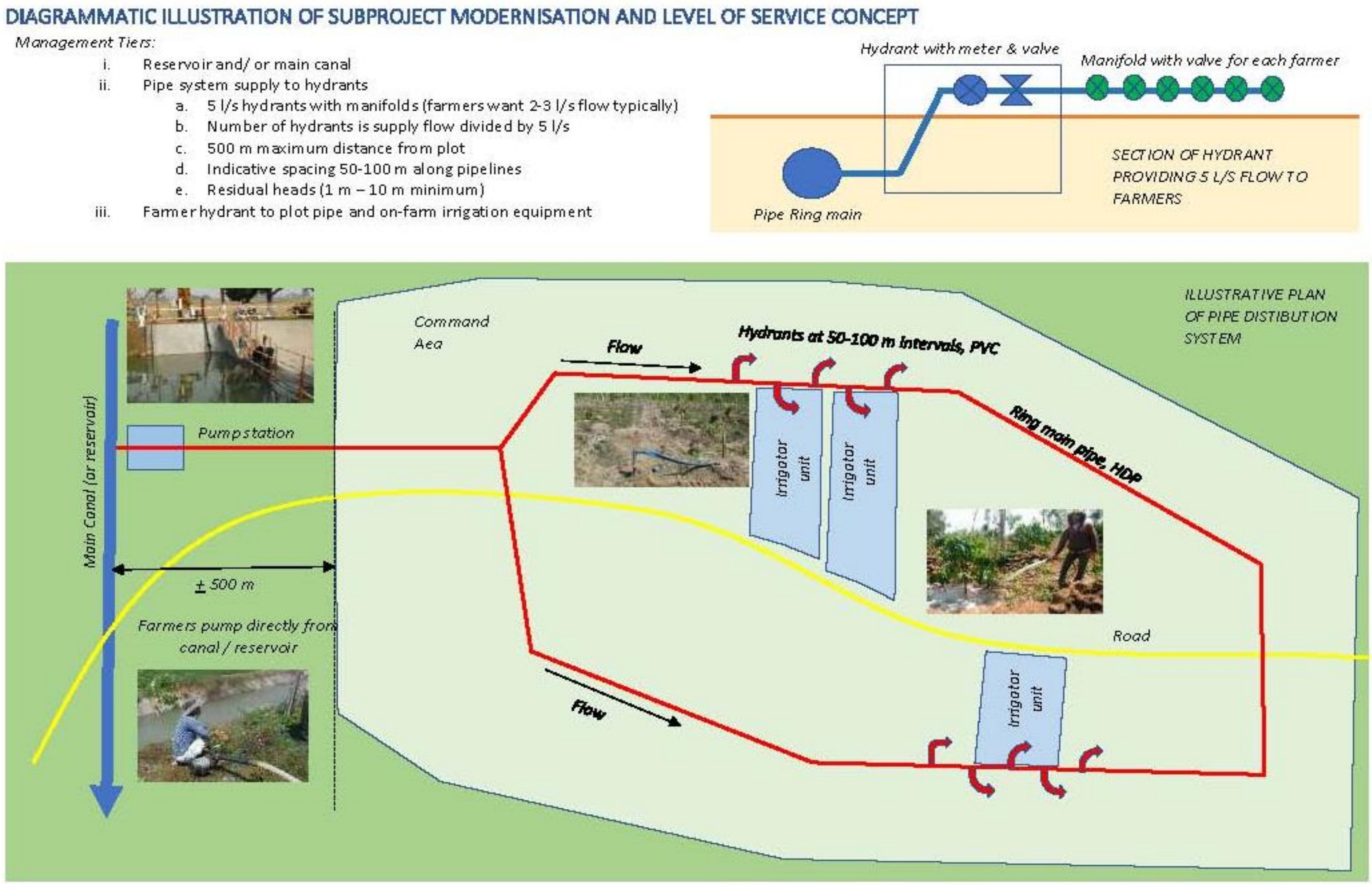

Figure 2: Diagrammatic illustration of subproject modernization and level of service concept

B. Design of Pipe Systems

1. Design Duties and Flows

13. The flow per ha is specific for each system and is/ will be provided and should not be changed except as approved by MARD/ DARDs and ADB.

14. The net area served is for each scheme is/ will be provided and should not change more than ± 5%. Any variation of the scheme boundary should have prior approval from DARDs/SPPMUs/PPMUs involved in the WEIDAP.

2. Design of Pipelines and Layout

15. Pipe systems should be designed using EPANET or WaterGEMS unless otherwise approved. Pipe drawings must include a long section showing HGL and available head under full flow.

16. Maximum velocity limits shall depend on pipe type and class, but will typically be 1.5 (1.7) m/s for uPVC pipes and 2.0 (2.5) m/s for HDPE pipes at full flow. Minimum velocity at design flows will be 0.3 m/s to ensure against sedimentation in the pipe. For pumped systems, the optimum flow velocity, from capital and energy cost considerations, is likely to be 0.7-1.2 m/s.

17. Adopt a hydrant flow of 5 l/s in pipeline design.

18. Design (residual) head at the hydrants should be a minimum of 2.5 m for gravity systems where constant flow valves are not required, and a minimum of 10.0 m for pipe pressured systems, for each hydrant operating at 5 l/s for the system operating at full flow. The operating and residual heads will be higher when the overall system flow is less than design maximum.

19. The maximum static head must not exceed the pressure rating for the pipe type and class used, and is not likely to be relevant.

20. Pipes shall be either HDPE or uPVC of appropriate class. HDPE pipes are likely to be adopted for all pipes due to ease of connections, and certainly for larger flows and pipe diameters.

21. Pipe layouts shall observe the level of service adopted for the project (see Figure 2). For example, a single pipeline is sufficient for service areas < 1.0 km wide. For larger areas, ring (loop) systems may be adopted. Combination of ring and branch (dead end) pipe systems may be appropriate.

22. The main advantage of ring (loop) designs is that they keep more even pressure and operating conditions under various demand/ supply conditions, as flow may occur to a hydrant from both directions. They also have redundancy in that flow may be maintained in one arm while the other is under repair. Ring designs shall be adopted unless shown to be significantly (>5-10%) more expensive.

23. Where ring designs are adopted, each arm of the ring would usually have a similar range of pipe diameters.

3. Hydrant - Manifold

a. Hydrant flow

24. Hydrant flows shall be 5 l/s ± 10% at full flow in the pipeline. To achieve this either:

i. Adjust the hydrant pipe diameter that connects to the main line according to the available (residual) head under full design flow conditions – this enables farmers at one hydrant to exceed the flow if others are not using their hydrants, BUT it works by burning off residual head[1]. This option is cheap and it may be adopted for gravity designs;

ii. Also for gravity flow systems, consider pressure control valves in the mains pipeline so that pressures at each hydrant under full flow conditions are similar. Any further residual head may be burnt off at hydrants. This option could be considered for systems where there are very large head losses to be burnt off[2]; or

iii. Install a constant flow valve to each hydrant – this option will ensure all hydrants receive the design flow, though it limits the ability of one hydrant to use more water when others are shut, AND it may not burn off (all the) residual head, thereby potentially allowing farmers to convey water from the hydrant-manifold to their farms without pumping. This option is suggested for all the pump-pipe systems. It could also be adopted for the gravity systems.

25. Number of hydrants = total flow (l/s) divided by 5 l/s. Under no circumstances can the number of hydrants be increased, not shall the design flow per hydrant be changed.

26. Cost effective hydrant - manifolds designs shall be identified/ agreed between the design consultants and DARDs/SPPMUs/PPMUs. MARD (CPO/CPMU) will review the designs as necessary with the help of ADB and AWP. Note: direct fuse connections are envisaged between the main pipeline and the off taking pipe where HDPE pipes are adopted. If uPVC pipes are adopted, then T fittings shall be used.

27. Hydrant-manifold head loss for 5 l/s flow due to bends, on-off valve and flow meter(s) would be about 13.1 m for 40 mm pipe, 5.5 m for 50 mm pipe, and 2.5 m for 63 mm pipe.

28. Head loss through a constant flow valve is typically 2-4 m depending on the make and model. Typically, 63 mm pipe hydrants are proposed and total head loss through the hydrant – manifold will be about 6.5 m, assuming 4.0 m for the constant flow valve. A general arrangement sketch for a hydrant - manifold is shown on Figure 3) with indicative head losses as in Table 2.

b. Hydrant location/ spacing

29. The hydrants spacing is to be adjusted proportionally to the area served, so that each hydrant commands the same area.

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[1] If residual head is burnt off, then it may be advised for pipeline alignments to follow high land to extent deemed practical.

[2] None of the WEIDAP subprojects have very large head losses, so this option is not expected to be adopted.

30. The hydrants shall connect directly to the main pipeline. There is no need for any intermediate linking pipeline, or introduction of a distribution hierarchy with parallel running pipelines (as sometime recommended for canal systems) to control water distribution. For large systems, if additional flow control/ measurement is required, it will be introduced into the main pipeline at intervals.

c. Manifold

31. The manifold is supplied from the hydrant and allows each farmer who uses the hydrant to have his own hose connection which may be metered for water charging purposes (see Figure 3). Each farmer would usually take the full flow in turn, or may choose to split the flow with another farmer.

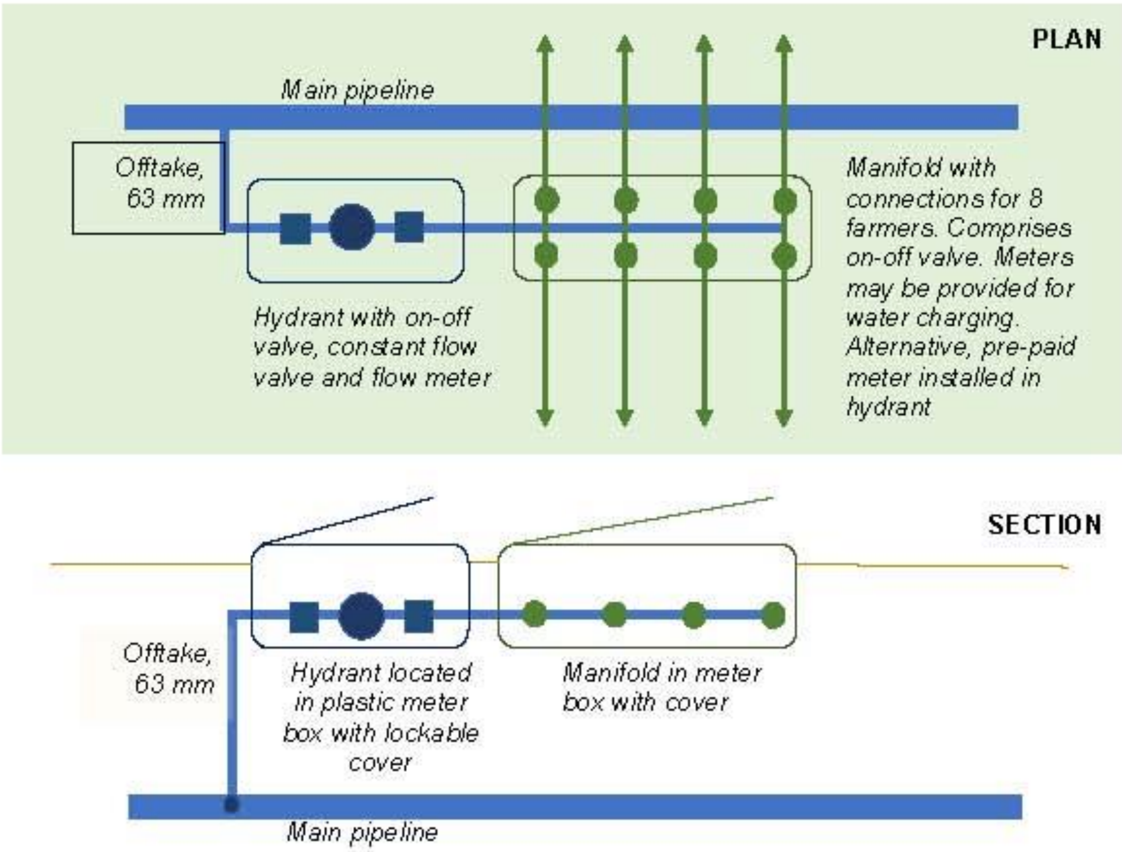


Figure 3: General arrangement sketch for a Hydrant - Manifold

Table 2: Indicative head losses through pipe Hydrant - Manifold

Losses through Pipe Hydrant - Manifolds					
Flow l/s:	5.00	5.00	5.00	5.00	5.00
Flow m3/hr:	18.00	18.00	18.00	18.00	18.00
Pipe OD, mm:	40.0	50.0	63.0	75.0	90.0
Min. Pipe thickness, DSDR 21, mm:	2.0	2.4	3.0	3.8	4.3
Pipe ID, mm:	36.0	45.2	57.0	67.4	81.4
Pipe area, m2:	0.0010	0.0016	0.0026	0.0036	0.0052
Pipe velocity, m/s:	4.91	3.12	1.96	1.40	0.96
		Pipe Dia.	**63.0**		
Fitting	**K value**	**V2/2g**	**Headloss per fitting, m**	**Nr. of fittings**	**Headloss, m**
90^0 bend	0.30	0.62	0.18	3	0.55
45^0 bend	0.15	0.62	0.09	0	0.00
90^0 in line Tee	0.10	0.62	0.06	0	0.00
90^0 Tee side outlet	1.60	0.62	0.98	1	0.98
Gate or ball valve (open)	0.17	0.62	0.10	2	0.21
Flow Meter (2 inch, nominal 25 m3/hr):	0.2 m		0.20	2	0.40
Misc other losses at 15%:					0.32
Constant flow valve (limiter)	2 - 4 m		4.00	1	4.00
				Total loss, m:	**6.47**
Ref. K values from Smount, pipeline design					

32. Hydrants and manifolds are typically constructed from HDPE welded to main line and uPVC standard pipe connected with standard fittings. There is no need for steel fittings, except perhaps flanges for valve and meter connections.

33. Technologies and procedures for welding and joining HDPE plastics/ pipes shall observe guidelines provided by manufactories. The options for welding the HDPE (wet or dry) is demonstrated in the video at https://www.youtube.com/watch?v=03CGrcImzLc produced by USA Plasson company in USA, and also in the training video at https://www.youtube.com/watch?v=q_GO4l75Ev4 produced by Georg Fischer Piping Systems in Australia.

34. Farmers may connect pumps to the manifolds, in which case suction heads up to about 5 m may be developed by these pumps. If residual heads are lower than 5 m, then measures may be necessary to ensure each hydrant still receives $\pm$5 l/s under full flow. This could be accomplished by flow limiting valves at the hydrants.

4. Pipe Alignment

35. The pipeline should be located to minimize the impact on private land, and avoid housing areas wherever possible.

36. Farmers will not be able to take their hose over major highways. Either pipelines (and hydrants) shall be provided both sides of the road (ring design), or branches provided.

37. All farm land shall be within 500 m of the pipeline, and the density of pipe shall typically be 15 - 20 m/ ha. Layouts given in this note may be adopted, and improved as necessary.

5. Control and measurement

38. The following is suggested for valves:

- Main flow control (on/off) valves should be located strategically, for example at head of pipeline, and separating out each part of a ring main.
- Air valves should be located at high points and at intervals along the pipeline.
- Flushing valves should be located at low points and/or gully or stream crossings.
- Non-return valves are not expected to be needed.
- Hydrants must have a flow control (on/ off) valve which opens/ closes quite slowly and are also likely to require a constant flow device/ limiter to limit flows to 5 l/s for a range of pressures.
- Each individual farmer should have a simple flow control (ball) valve at the manifold.

39. Pressure gauges may be located at branch pipeline offtakes, at the end of each pipeline, and other suitable locations and be:

- Connected to alarms for breaks or malfunctions.
- Connected to continuous read out.
- Connected to pumps where appropriate and required for automated pump operations.

40. Flow measurement requirements:

- For overall pipe system: continuous monitoring relayed to central office/ control at following points: (i) head of main pipeline, (ii) several strategic points around the system to enable monitoring of water use/ distribution and to identify any leaks.
- Hydrants: continuous monitoring relayed to central office is ideal, but if this is too expensive, a few of the remote reading type shall be installed, with locally read meters installed at other locations. This will enable operators to see if some areas are getting disproportionally more flow and can allow adjustments to be made.
- Individual farmer meters: local read for sharing purposes and post-paid charging if this is envisaged.

41. Metering options, indicated below, will be discussed and agreed between the design firms and DARDs/SPPMUs/PPMUs. MARD will review the proposed design options as necessary with the help of ADB and AWP. For example, if a prepaid meter were adopted and installed at a hydrant, additional meters would not be required in the manifold, as each farmer using his “smart card” would operate the meter and take the full flow in turn.

Water meter with vane for flow measurement, local read US$ 30-50 (50 – 60 mm)

Ultrasonic clamp on for wide range of pipe sizes – local and remote read (wireless). US$ 150-250

Ultrasonic meter connected to valve for pre-paid operation, with local and remote read options (wireless). US$ 500 – 1,200

C. Pumping Considerations

1. Pump/ Gravity/ Tank scheme distinctive response

42. The delivery schemes will comprise one (or more) of the following alternatives: (i) direct pumping with pumping controlled by pressure sensors or by water level in a header (pressure) tank at some high point, (ii) pumping into a header tank with subsequent gravity supply, or (iii) gravity supply.

43. The options discussed below each have quite different specific requirements.

a. Direct pumping into a pipeline

44. These include: (i) the pump-pipe schemes in Dak Lak, (ii) the first scheme, Thanh Son, in Ninh Thuan, and (iii) the two adjacent schemes in Khanh Hoa, Suoi Dau and Cam Ranh. Key features of these schemes include:

- Control System options:
    - A small header tank located at a high point within the pipe system which provides feedback to pumps which turn on/ off depending on the water level in the tank.
    - Pressure sensor(s) in the pipeline, usually close to the pumping point, which control pumps.
- At least two pumps shall be provided, possible three, together with a standby pump. At least one of the pumps should be variable speed type able to meet very low demand.

45. If header tank option is selected, pressure sensors in the header tank will turn on the first pump when water level begins to fall, with additional pumps turning on if water level continues to fall to maintain the required pressure. Storage of tank shall be sufficient to avoid pumps turning on/ off too frequently; about 15-20 minutes storage for the full flow discharge is suggested.

46. If the required pressures together with flat terrain do not allow a cost effective header tank option (i.e. the height and cost of the header tank would be unacceptable high), then pressure sensor(s) should be adopted to control the pump. A controller would turn on/ off the pumps according to the pressures in the pipeline.

47. Pipeline pressures (HGL) should be calculated under several operating conditions:

- Full flow conditions, i.e. with all hydrants open – this is the most important condition and used to size the pipes.
- Partial flow conditions, i.e. with some of the hydrants open and some closed – this allows evaluation of pressures (and flows) within the pipeline under actual operating conditions to be assessed.

48. If pumps are controlled by a header tank, it is also appropriate to check pressures at all hydrants when the pumps are all off, i.e. check flow from a full header tank can reach all the hydrants.

b. Pump to header tank for subsequent gravity supply

49. Pumping into a header tank with subsequent gravity supply is suited if there is a high hill quite close to the supply point (reservoir/ canal), and is adopted for the Tra Tan scheme in Binh Thuan.

50. The combined capacity of the pumps/ rising main and header tank are interrelated:

- If the pumps/ rising main capacity equals the peak design flow then 1 hour of storage at peak flow shall be adopted.
- If a smaller capacity is adopted (saving on pump and rising main cost), then a larger storage is required. The maximum storage considered shall be 8 hours.

51. At least two pumps shall be provided, possible three, together with a standby pump. Sensors in the header tank will turn on the first pump when water level begins to fall, with additional pumps turning on if water level continues to fall.

c. Gravity supply

52. There are two gravity schemes, Du Du in Binh Thuan and Nhon Hai in Ninh Thuan. The source of water for Du Du is an intake from a reservoir, while Nhon Hai takes water from a large pipeline supplied from a river diversion.

2. Water hammer and surge

53. Providing flow velocity limits are adopted along with appropriate pressure classes of pipe water hammer is unlikely to be a problem. Nonetheless, consideration of water hammer/ surge is advised for each of the different options and the need is quite different[3]. In every case it is speed of control (open/ shutting) of valves and the speed of starting and stopping pumps that requires attention.

a. Direct pumping

54. If a header tank is incorporated into the pipeline it will takes out some of the water hammer.

55. Adoption of valves that cannot be opened or closed too rapidly is suggested.

56. Starting and stopping of the pumps is critical and this designer should specify and check with pump manufacturers for the need for additional devices and operating procedures. It may be sufficient to only provide a opening/ closing check valve which is gradually opened/ closed, but sometimes a surge suppression device may be needed.

[3] AWWA C906 defines two types of surge pressure, recurring and occasional. The safe peak pressure for HDPE pipe is 1.5 times the pipe's pressure rating for recurring surge and 2.0 times the pipe's pressure rating for occasional surge

b. Pump to header tank for subsequent gravity supply

57. There are two sections:

- Generally downstream of the header tank water hammer depends upon the speed of opening and closing pipeline valves which would be for maintenance only. No devices required.
- Upstream of the header tank requires slow opening of valves and a standard for start up and stopping of pumps. The designer shall check with pump manufacturers for the need for any additional devices.

c. Gravity supply

58. This is relatively straightforward and just needs that pipeline valves are shut/ opened slowly during operation and for maintenance.

3. Pump stations

59. The feasibility design consultants adopted on-shore pumping structures. For reservoirs with large water level fluctuations these are expensive. Moreover, removing sediment from the intake so that supply is maintained at low reservoir levels requires annual maintenance. Floating pumping stations need more careful consideration.

4. Pump types

60. Where suction head remains less than about 5-6 m, then centrifugal pumps are likely to be appropriate, for example as proposed for Tra Tan, Suoi Dau and Cam Ranh.

61. Variable speed pumps provide energy savings and increased flexibility. Where two or more pumps are provided for operations, one of them (the smallest if more than one size is provided) should be a variable speed pump, with the others fixed speed. The speed of the variable speed pump would be linked to pressure in the pipeline. Variable speed pumps typically cost 50-100% more than constant speed pumps.

62. Where suction heads are too high (as in some Dak Lak reservoirs), then submersible or turbine pumps are required. The preference is for submersible pumps for the following reasons: (i) close coupled pump-motor with no long shaft, (ii) usually cheaper pump house, (iii) factory assembly, avoiding difficult on-site assembly with accurate alignment between motor-shaft-pump to avoid vibration, (iv) low noise, (v) slightly lower maintenance and operation/ energy costs, and (vi) quicker erection.

D. Inspection Roads

63. In Vietnam land for buried pipe systems is acquired and compensation paid, so that the Operator has the right of inspection at any time to check pipeline structures, associated valves and fittings as well as for any leaks. Paved inspection roads, typically 3.0 – 5.0 m wide, are ideally provided along the

pipelines. For the WEIDAP subprojects, as funds are limiting, the following guidance is given for paved inspection roads:

- If the pipeline is aligned along an existing paved road/ highway, no additional parallel inspection road is required.
- For pipelines less than 400 mm in diameter, paved inspection roads need not be provided, unless than are also justified to improve farm-market access
- Inspection roads shall be 3.0 m wide (pavement width) if the sole/ major purpose is for inspection. If significant other traffic use is expected, the width may be 5.0 m, or as appropriate.

E. Balancing Storage for Canal Systems

64. For improved canal operations and water accounting, balancing (regulating) storage should be provided at the end of canal systems, usually at the end of the main canal and sometimes at the end of long branch canals. Balancing storage should be provided for Tra Tan.

65. Balancing storage is not required where rice is the predominant crop at the end of the canal system as in Cam Ranh, or for very flat (contour) canals as in Ea Kuang, Dak Lak.

66. Releases from main upstream reservoir would be informed by water level sensors in balancing storage and/ or from sensors at intakes at pump offtakes (see SCADA below).

F. SCADA Systems

67. For each scheme, a basic supervisory control and data acquisition (SCADA) system will be installed to monitor operations for both pipe and canal systems.

68. For pipe systems remote monitoring of pump operations, pressures and flows is proposed. The decision concerning local or remote read of flows at hydrants will be made following consultations between central and provincial authorities.

69. For canal systems water levels and flows will be monitored at a few selected points: reservoir, head of main canal, and balancing storage in tail of system.

70. Adoption of two sensors for important data is recommended, including data that inform reservoir releases and pump operations. Also, the sensor types should be different; e.g. piezometric (pressure) and ultrasonic sensors. An alarm signal shall be transmitted if the level or pressure readings are significantly different from each other.

71. Except for pump stations remote operation (automation) is not proposed.

72. It is expected that transmission of data/ coded signals from sensors – loggers/ remote terminal units (RTUs) to central control rooms (offices) and vice versa will use the Internet and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology.

73. Indicative requirements are given for each subproject in Section III.

Concerning design flows and areas, the guidance has been given in the Project preparatory technical assistance (PPTA) documents, and will be provided in the design workshops.

III. DETAILED DESIGN OF SUBPROJECTS

A. TRA TAN SUBPROJECT, BINH THUAN

74. The scheme comprises an existing canal system to be rehabilitated and modernized, and a new pumped pipe system, see figures attached.

1. Canal System

75. Design parameters include:

- Gross and net command areas of about 920 ha and 854 ha respectively. Net command crop areas comprise 140 ha of rice, and 714 of pepper and cashew.
- Design duty to be is 1.4 l/s/ha (, giving a design flow at the head of the system of about 1.2 m^3/s.

76. At detailed design the following is proposed:

- Reduce the extent of secondary canal lining. For example, the length of secondary canals might be further reduced by lining only three with a total length of 3.18 km (0.54 km, 0.98 km and 1.66 km).
- Provision of balancing storage tanks at the end of the main canal, and possibly at the end of the longer of the secondary canals in the tail of the system. This would facilitate operation, allow feedback from tank water levels to inform reservoir flow releases and reducing operational losses. Small farmer ponds would not perform this function.
- Consider if a bridge crossing for the service road over the Tra Tan river would be cheaper than the proposed culvert – causeway design.
- Provision of a flume structure with water level sensor for flow measurement at the head of the canal, or equivalent flow measurement device such as an ultrasonic velocity – flow depth equipment.
- If funds allow, consider gravel surfacing of the inspection road along the main canal to allow wet season access.
- Confirmation that canal cross-drainage structures and drainage channels are adequate.

2. Pumped Pipe System

77. At detailed design the following will be considered further:

- Size of rising main and capacity of storage tank
- Design of pump station and choice of pumps
- Distribution pipe, residual heads and hydrant design
- Pipe service road

- Electric connection

78. The feasibility design includes for a rising main designed for 0.222 m^3/s, the full required flow, and a header tank with eight hours of storage. This is unnecessary. Either the header tank capacity may be reduced, or the rising main designed for a smaller flow. The two options should also be compared and the cheaper option adopted.

79. The feasibility design adopted an on-shore reinforced concrete pumping station with centrifugal pumps. Consideration shall be given to alternative pump station designs, together with possible adoption of submersible pumps.

80. The residual heads at the hydrants vary from 10 - 23 m. It may be appropriate to slightly reduce sizes of the distribution pipeline to reduce costs, subject to maximum velocity limits. If not, residual heads will remain quite high, and flow through some hydrants could be significantly higher than 5 l/s. Alternatively, the head could be burnt off at the hydrants by adopting different hydrant sizes – smaller diameters would burn off more head – or by including a flow limiter for each hydrant in the design (see Section II).

81. The concrete service road follows high land and cross drainage will probably not be required. However, the land is steep approaching the storage tank on the hill, and the road may not be able to follow the pipeline, but traverse across the slope.

82. The electric power requirements of the pumping station shall be firmed up, and cost determined including cabling for 3-phase connection, poles, transformers, electric meter, and so on.

3. SCADA System

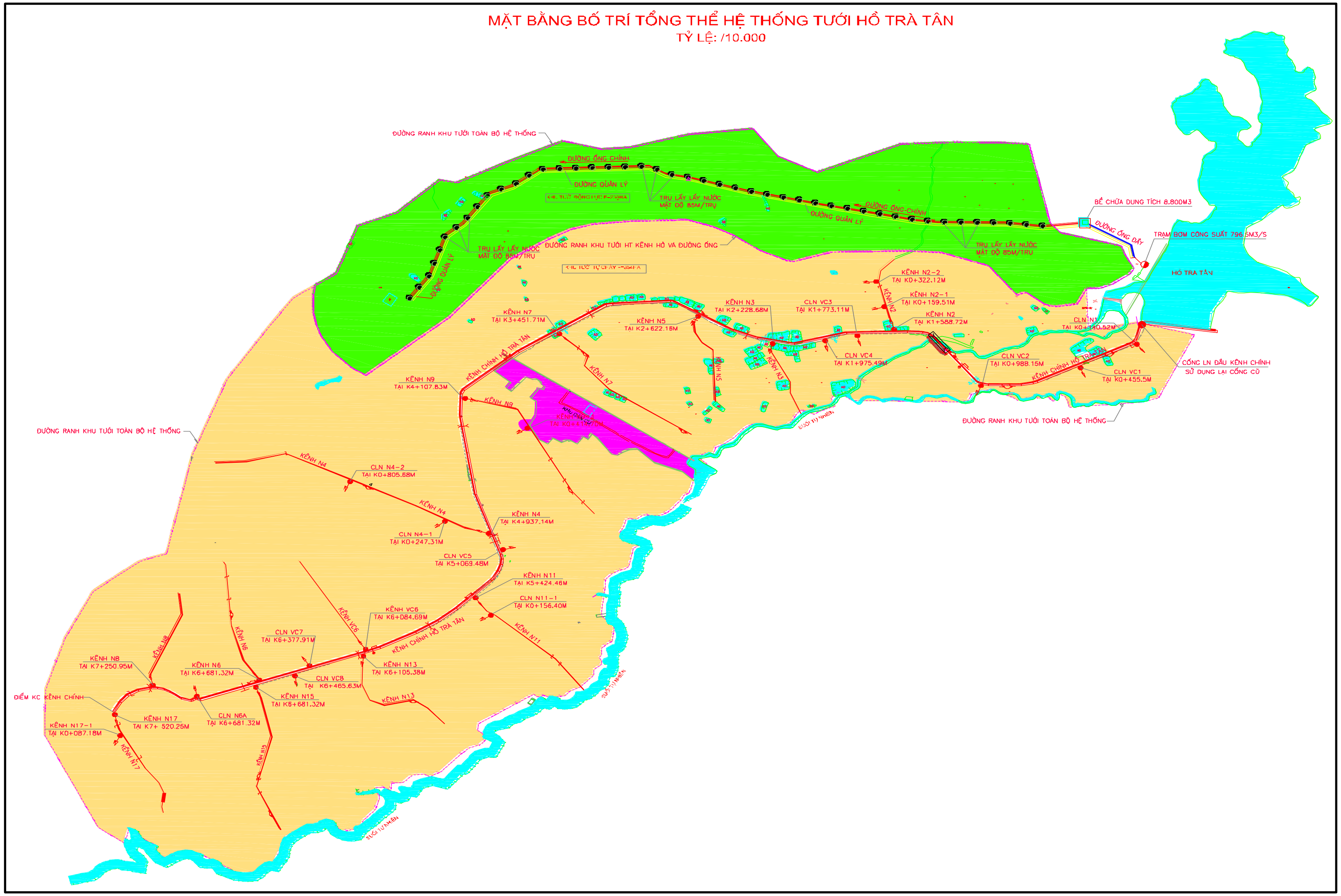
83. Design including identification of sensors, meters, loggers, remote terminal units (RTUs), communication media (the Internet and the 4G/ 5G universal mobile telecommunication systems or the latest mobile technology), databases and software, and costing of a basic supervisory control and data acquisition (SCADA) system for the canal and pipe system, including the following elements:

- Canal system operations: remote monitoring of water levels at key locations with data transmitted to a central office: tail of the canal in tail end storage tanks, in the Tra Tan reservoir, and in the head of the main canal at the measuring structure.

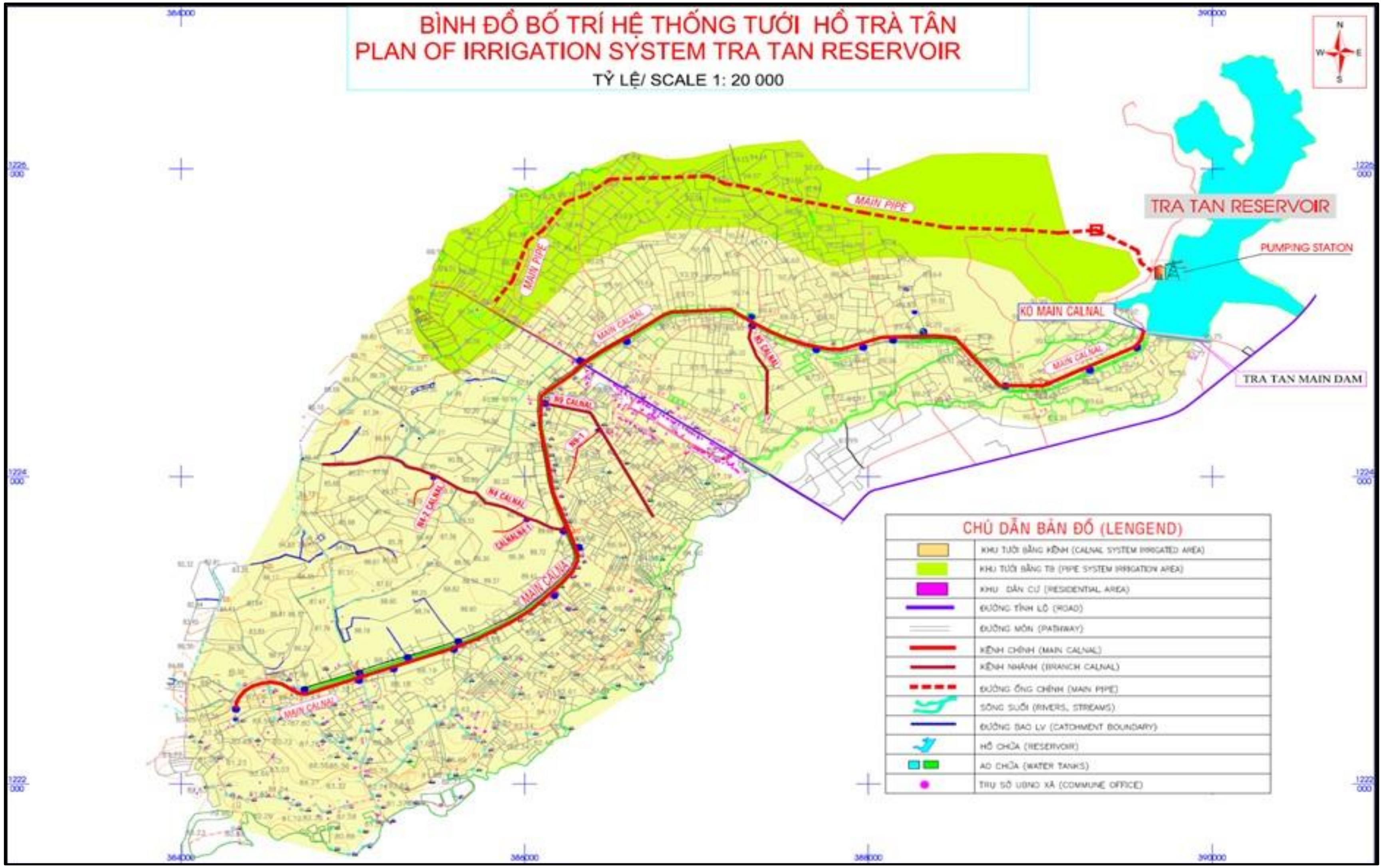
- Pump-pipe system operations:
  - System so that pumps operations are linked to water levels in the header tank.
  - System for remote monitoring of pumping and for safety of pumps.
  - System for remote monitoring of flows from the head tank and from the hydrants

- Central control room (office) shall be located, rehabilitated and equipped as required with computer/ devices/ Internet connection and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology, software, database and so on.

Layout Map of Tra Tan Subproject (Feasibility Stage)



Layout of Tra Tan Subproject (proposed for Detailed Design)



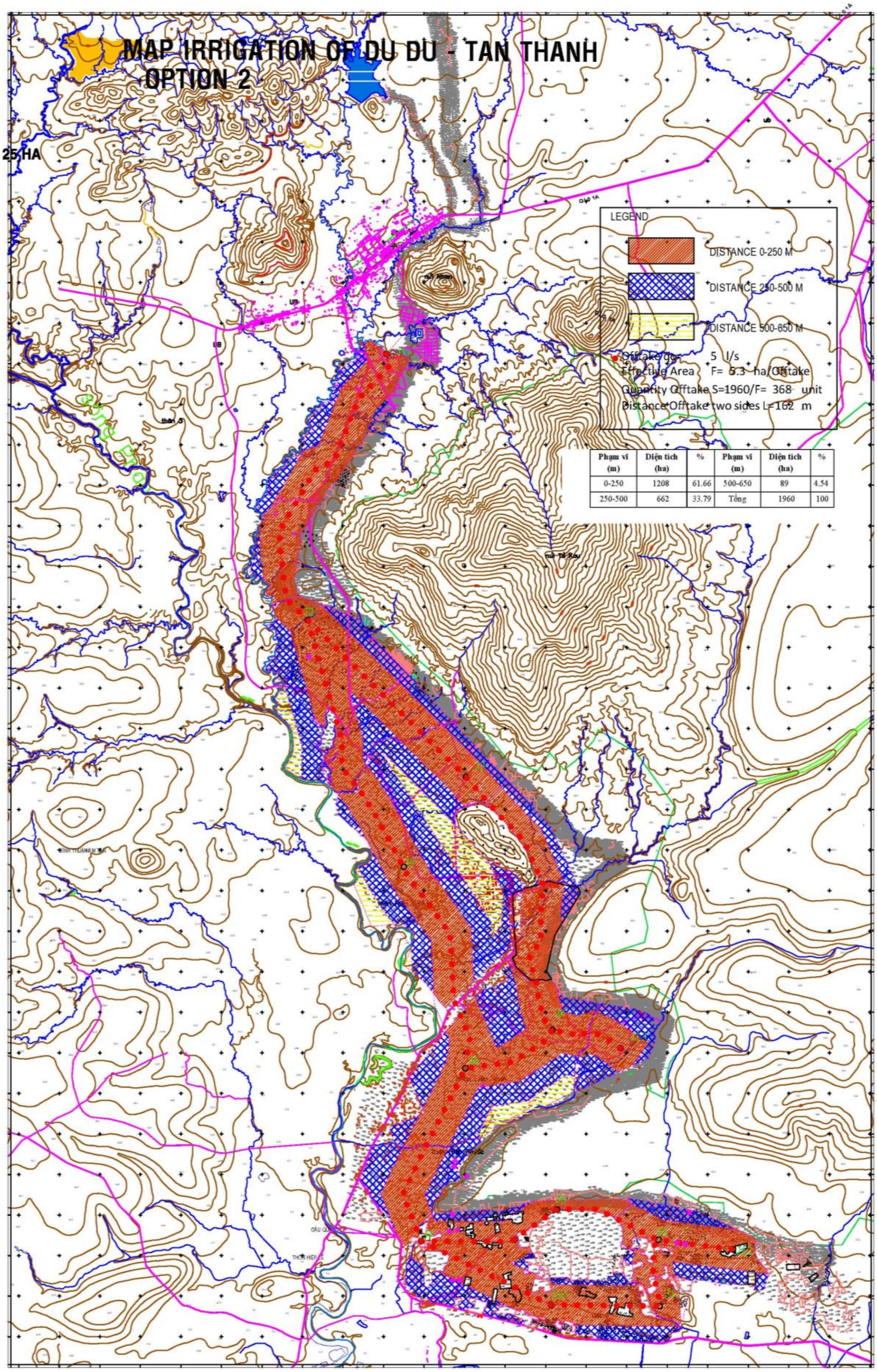
B. DU DU SUBPROJECT, BINH THUAN

84. For Du Du a new ring main piped distribution system is proposed to supply surface water to farmers growing dragon fruit, reducing reliance in umped groundwater. The layout proposed at feasibility is attached. With this layout, 62% of farms are within 250 m of the pipeline, 34% within 500 m and just 4% over 500 m.

85. Aspects to consider further at detailed engineering design shall include the following:

- Refine the pipe layout for further improvement to the LoS without significantly increasing costs, for example, provide a spur so that no land > 500 m from hydrant, and/ or perhaps consider three ring mains and eliminate spurs.
- The pipelines will cross about 12 stream beds. Safe crossing arrangements shall be designed; this is likely to entail calculation of scour depths to ensure the pipeline is buried to a safe depth and/ or protected.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are $\pm$5 l/s for a range of residual heads at design flow with metering and flow control devices. Direct fuse connections are envisaged between the main HDPE pipeline and the off taking pipe. Adequate protection against tampering shall be considered (refer Section II).
- The requirement for valves shall be firmed up at detailed design, and will include air valves at intervals/ high points along the pipeline, washout valves at one or more of the creek crossings, and flow control valves to allow parts of the pipeline to be isolated, for example for repair.
- The SCADA system shall allow remote monitoring of pressures and flows in the pipe system and also flows at all/ selected hydrants.
- Central control room (office) shall be located, rehabilitated and equipped as required with computer/ devices/ internet connection and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology, software, database and so on.
- Provision of spare parts/ hydrants/ valves and meters, etc.
- Confirmation of extent that paved inspection roads are provided along the pipelines – currently about 17 km of paved road is proposed for 34 km of pipeline.

Layout of Tra Tan Subproject



Phạm vi (m)	Diện tích (ha)	%	Phạm vi (m)	Diện tích (ha)	%
0-250	1208	61.66	500-650	89	4.54
250-500	662	33.79	Tổng	1960	100

C. THANH SON-PHUOC NHON SUBPROJECT, NINH THUAN

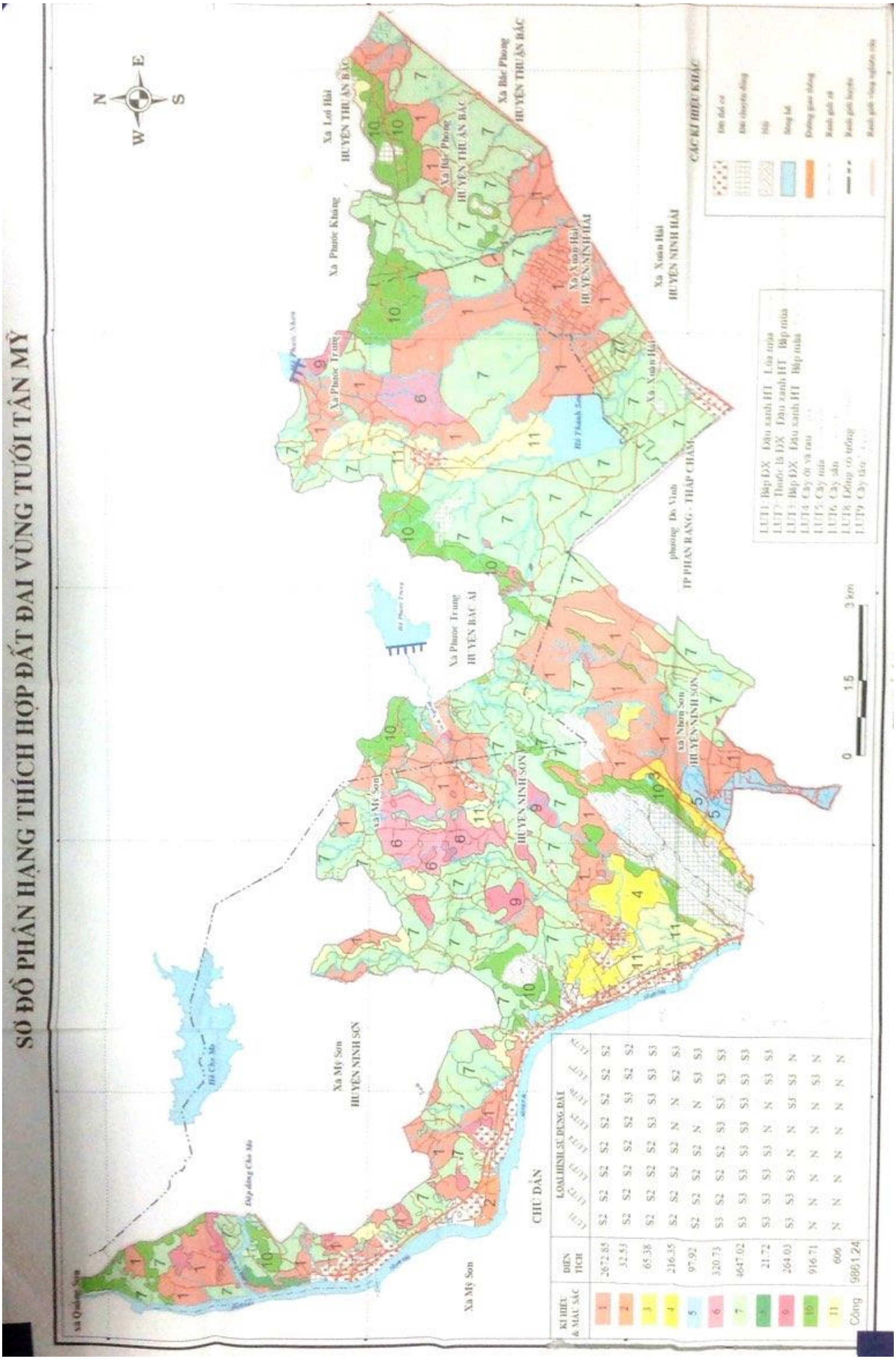
86. The water allocation for this subproject is 1.8 m3/s and the net irrigable area to be developed under WEIDAP is set at 1,800ha. The gross area available is 3,043 ha, but much of this comprises very poor soils (see sketch below). The layout adopted at feasibility is shown below, and priorities supply to the better soils. The sub-systems designs require 28.66 km of HDPE pipe, ranging in diameter from 160 mm to 500 mm, and giving average density of 15.9 m/ha. About 1,219 ha (68%) of fields will have access to water within 250 m, 446ha (25%) from 250 m to 500 m and only 135 ha (7%) beyond 500 m.

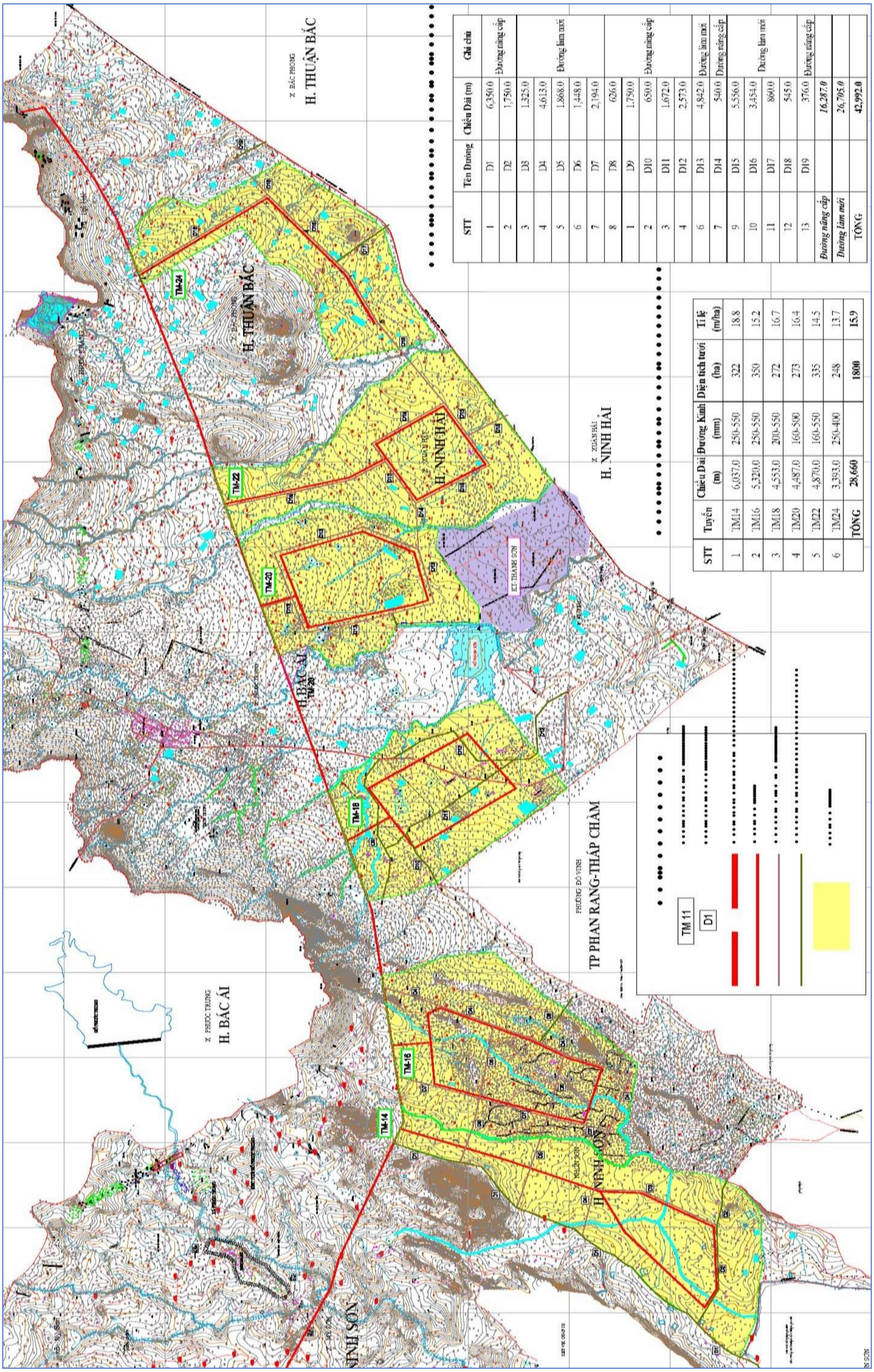
No.	Name	Type	Net Area (ha)	Diameters (mm)	Length (m)	Density (m/ha)
1	TM14	Ring	322	250 - 500	6,037	18.8
2	TM16	Ring	350	250 - 500	5,320	15.2
3	TM18	Ring	272	200 - 500	4,553	16.7
4	TM20	Ring	273	160 - 500	4,487	16.4
5	TM22	Ring	335	160 - 500	4,870	14.5
6	TM24	Branch	248	250 - 400	3,393	13.7
Total			**1,800**		**28,660**	**15.9**

87. Aspects to consider further at detailed engineering design shall include the following:

- Carry out soil field checks to confirm the best soil areas, and refine the pipe layout to include the best soils.
- Confirm the location of the proposed high-tech zone, which is to be on the best possible soils, with road access and good electricity supply.
- The road upgrading and construction shall be carefully considered, especially roads within the proposed high-tech zone.
- Carry out a drainage study with topographic survey of natural drainage system, estimation of capacity, required capacity of a design (5 year) storm and design of a surface drainage system. This is especially important for the high-tech zone.
- Reassess the net irrigable area within the gross areas, based on soils, topographic features (e.g. exclude gullies and buffer strips along gullies), and infrastructure (i.e. excluding roads, housing, etc.).
- Confirm/ check pressures available along the main steel pipeline – the pipe systems are not expected to require additional pumping (except perhaps by farmers downstream of hydrant-manifolds).
- Refine pipe layouts for further improvement to the LoS without significantly increasing costs.
- The requirement for road improvement/ construction, at least for the high tech. zone, and of electric supply for the high tech. zone shall be firmed up.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are ±5 l/s for the range of residual heads at design flow, with metering and flow control devices. Direct fuse connections are envisaged between the main HDPE pipeline and the off taking pipe. Adequate protection against tampering shall be considered (refer Section II).

- The requirement for valves shall be firmed up at detailed design, and will include air valves at intervals/ high points along the pipeline, washout valves at selected creek crossings, and flow control valves to allow parts of the pipeline to be isolated, for example for repair.
- The SCADA system shall allow remote monitoring of pressures and flows in the pipe system and also flows at all/ selected hydrants.
- Central control room (office) shall be located, rehabilitated and equipped as required with computer/ devices/ internet connection and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology, software, database and so on.


SƠ ĐỒ PHÂN HẠNG THÍCH HỢP ĐẤT ĐAI VÙNG TƯỚI TÂN MỸ
CHÚ DẪN
HUYỆN NINH SƠN
TP PHAN RANG - THÁP CHÀM



STT	Tên Đường	Chiều Dài (m)	Ghi chú
1	D1	6,350.0	Đường nâng cấp
2	D2	1,750.0	
3	D3	1,325.0	Đường làm mới
4	D4	4,613.0	
5	D5	1,868.0	
6	D6	1,448.0	
7	D7	2,194.0	
8	D8	626.0	
1	D9	1,750.0	Đường nâng cấp
2	D10	650.0	
3	D11	1,672.0	
4	D12	2,573.0	
6	D13	4,842.0	Đường làm mới
7	D14	540.0	Đường nâng cấp
9	D15	5,556.0	Đường làm mới
10	D16	3,454.0	
11	D17	860.0	
12	D18	545.0	
13	D19	376.0	Đường nâng cấp
Đường nâng cấp		*16,287.0*	
Đường làm mới		*26,705.0*	
TỔNG		**42,992.0**	

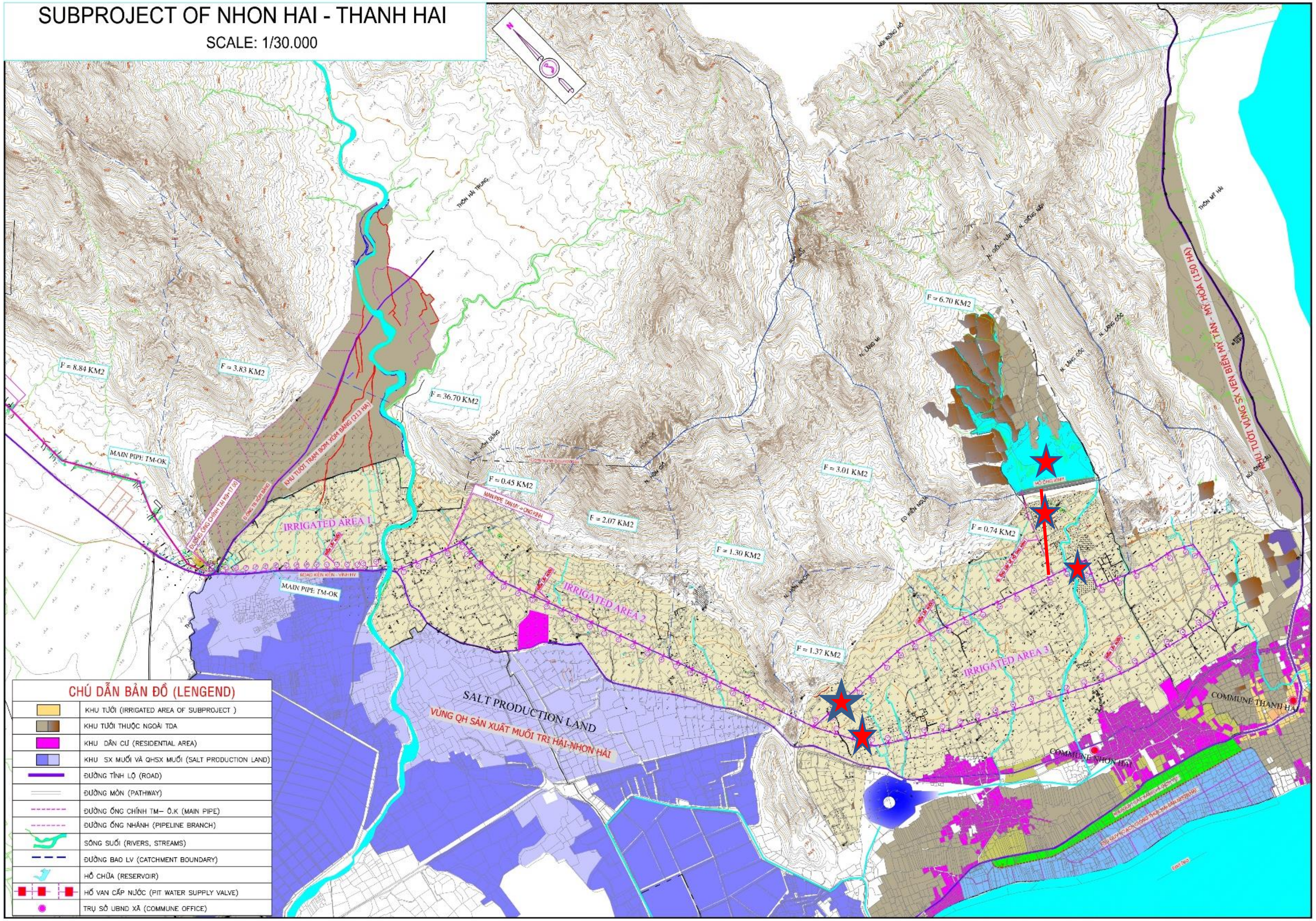
STT	Tuyến	Chiều Dài (m)	Đường Kính (mm)	Diện tích tưới (ha)	Tỉ lệ (m/ha)
1	TM14	6,037.0	250-550	322	18.8
2	TM16	5,320.0	250-550	350	15.2
3	TM18	4,553.0	200-550	272	16.7
4	TM20	4,487.0	160-500	273	16.4
5	TM22	4,870.0	160-550	335	14.5
6	TM24	3,393.0	250-400	248	13.7
	TỔNG	**28,660**		**1800**	**15.9**

D. NHON HAI-THANH HAI SUBPROJECT, NINH THUAN

88. The water allocation for this subproject is 1.0 m^3/s and the net irrigable area is set at 1,000ha. The layout adopted at feasibility is given below. The total length of pipe required is 24.09 km, including for the 9.12 km feeder pipeline from the end of the Tan My pipeline to the command area. HDPE pipe ranging in diameter from 1000 mm to 550 mm is proposed. Considering only the pipeline within the command area the average density is 15.0 m/ha. 532 ha (53%) will have access to water within 250 m, 350 ha (34%) from 250 m to 500 m and 118 ha (12%) beyond 500 m.

89. Aspects to consider further at detailed engineering design shall include the following:

- Confirm/ check pressures available along the main steel pipeline – the pipe systems are not expected to require additional pumping (except perhaps by farmers downstream of hydrant-manifolds).
- Whether a branch from the ring main is provided to allow surplus flow to be directed to the Ong Kinh reservoir, (full storage level = 31.00m).
- Reassess the net irrigable area within the gross areas, based on soils, topographic features (e.g. exclude gullies and buffer strips along gullies), and infrastructures (i.e. excluding roads, housing, etc.).
- Refine the pipe layout for further improvement to the LoS without significantly increasing costs. For example, the LoS pipeline generally follows the road in the upper part of the command area for convenience and to minimize resettlement impact. However, this means than significant land is > 500 m from the pipeline. Reconsider options, including a more central single pipe through farm land, or a ring main design. Note: an option with 7 (secondary) pipelines and 72 hydrant – manifolds may be considered. The 3rd ring (loop) system should be compared with a single pipeline option along the northern border.
- The pipelines cross several stream beds. Safe crossing arrangements shall be designed; this is likely to entail calculation of scour depths to ensure the pipeline is buried to a safe depth and/ or protected.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are +5 l/s for the range of residual heads at design flow, with metering and flow control devices. Direct fuse connections are envisaged between the main HDPE pipeline and the off taking pipe. No parallel pipes shall be adopted. Adequate protection against tampering shall be considered (refer Section II).
- The requirement for valves shall be firmed up at detailed design, and will include air valves at intervals/ high points along the pipeline, washout valves at selected creek crossings, and flow control valves to allow parts of the pipeline to be isolated, for example for repair, as well as to direct flow to the Ong Kinh reservoir if this is required.
- The SCADA system shall allow remote monitoring of pressures and flows in the pipe system, and also flows at all/ selected hydrants.
- A central control room (office) shall be located, rehabilitated and equipped as required with computer/ devices/ internet connection and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology, software, database and so on.


SUBPROJECT OF NHON HAI - THANH HAI
SCALE: 1/30.000
F = 8.84 KM2
F = 3.83 KM2
F = 36.70 KM2
F = 0.45 KM2
F = 2.07 KM2
F = 1.30 KM2
F = 3.01 KM2
F = 6.70 KM2
F = 0.74 KM2
F = 1.37 KM2
MAIN PIPE TM-OK
IRRIGATED AREA 1
IRRIGATED AREA 2
IRRIGATED AREA 3
SALT PRODUCTION LAND
VÙNG QH SẢN XUẤT MUỐI TRI HẢI-NHƠN HẢI
COMMUNE NHON HAI
COMMUNE THANH HAI
CHÚ DẪN BẢN ĐỒ (LENGEND)
KHU TƯỚI (IRRIGATED AREA OF SUBPROJECT)
KHU TƯỚI THUỘC NGOÀI TDA
KHU DÂN CƯ (RESIDENTIAL AREA)
KHU SX MUỐI VÀ QHSX MUỐI (SALT PRODUCTION LAND)
ĐƯỜNG TỈNH LỘ (ROAD)
ĐƯỜNG MÒN (PATHWAY)
ĐƯỜNG ỐNG CHÍNH TM– Ô.K (MAIN PIPE)
ĐƯỜNG ỐNG NHÁNH (PIPELINE BRANCH)
SÔNG SUỐI (RIVERS, STREAMS)
ĐƯỜNG BAO LV (CATCHMENT BOUNDARY)
HỒ CHỨA (RESERVOIR)
HỐ VAN CẤP NƯỚC (PIT WATER SUPPLY VALVE)
TRỤ SỞ UBND XÃ (COMMUNE OFFICE)

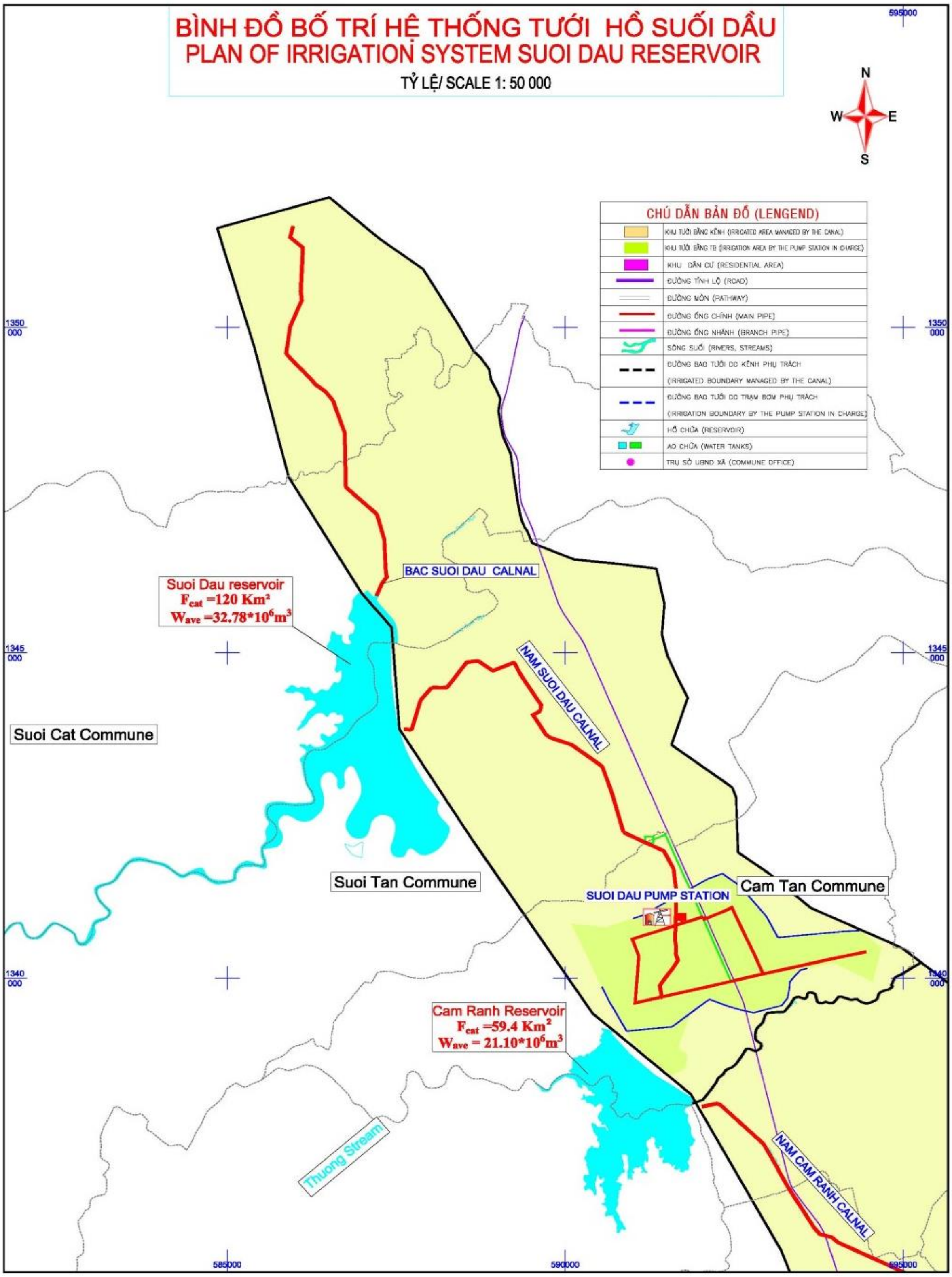
E. SUOI DAU AND CAM RANH SUBPROJECTS, KHANH HOA

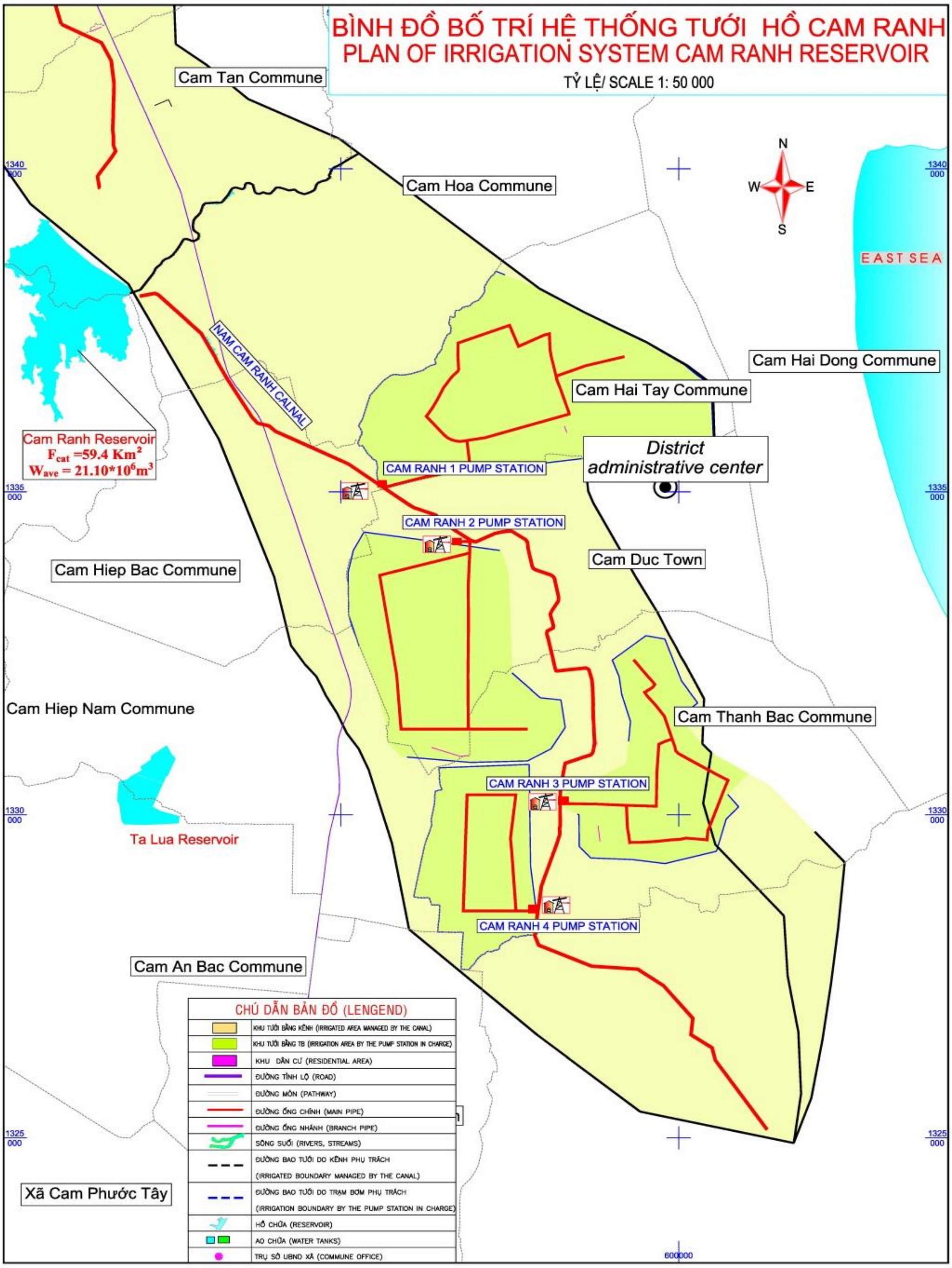
90. The subproject consists of two separate reservoir storage irrigation systems supplied from the Suoi Dau and Cam Ranh reservoirs. Works include rehabilitation of existing gravity canal systems and new pumped piped systems. The existing gravity canal systems will supply rice and mango areas and the new pumped pipe systems will supply established and expanded mango areas. Layout maps are attached.

91. Aspects to consider further at detailed engineering design shall include the following:

- Reconsider the feasibility study recommendation to demolish all the trapezoidal concrete lined sections and replace with new reinforced concrete flume sections. This is expensive, requires that bridges are also demolished and replaced, and probably unnecessary where the existing lining is in good condition. Use of geotextile liners protected with concrete should be considered. Overlarge sections that are retained provide useful buffer storage against pumped abstractions.
- The main canal banks are largely unpaved sandy tracks. Inspection/ patrols would benefit from a paved road along one side of main canals. These may be funded if less is spent on canal lining.
- The pumped pipe system service (command) areas and layouts should be further assessed and refined to ensure that they address inequities in standard of service.
- The design flows for each of the five pumped systems are based on 0.98 l/s/ha with adjustments for desirable flexibility, and likely farmer take up (willingness to connect and pay for water). The required capacity may be reassessed/ confirmed at detailed design.
- The proposed intake and pumping arrangements are rather more expensive that necessary, as well as taking up considerable land providing building for stores and an office. Adopting a more modest layout and design is suggested. Also, cost saving may accrue if a single pumping station/ intake serves two pumped pipe schemes.
- Adoption of centrifugal pumps and/ or a variable flow pump may be considered.
- Electrical works to provide necessary 3-phase power to each pump house need more accurate design and costing.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are ±5 l/s for a range of residual heads at design flow with metering and flow control devices. Direct fuse connections are envisaged between the main HDPE pipeline and the off taking pipe. Adequate protection against tampering shall be considered (refer Section II).
- The requirement for valves shall be firmed up at detailed design, and will include air valves at intervals/ high points along the pipelines, washout valves at gully crossings, and flow control valves to allow parts of the pipeline to be isolated. For each (ring) pipe system a header tank may be located at the highest point along the pipeline. In case of no positions high enough for constructing header tanks, there shall be technical and economic arguments/ evaluations for other options, including direct pumping into pipelines with pumping controlled by pressure sensors in the pipelines.
- The SCADA system shall allow remote monitoring of water levels, pressures and flows as appropriate in the reservoir, canal and pipe systems, i.e. in the two reservoirs, in the intakes to the pumping stations, in pipeline header tanks, in main pipeline leading from the pumping stations, at all/ selected hydrants. Pumping operations shall also be monitored and controlled. Pumps operation shall be linked to pipe pressures.

- The SCADA system shall link the pumping stations, field monitoring stations, and the central control room (office) via the Internet and the 3G/ 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology. The central office shall be located, rehabilitated and equipped as required with computer/ devices/ internet connection, software, database and so on.


BÌNH ĐỒ BỐ TRÍ HỆ THỐNG TƯỚI HỒ SUỐI DẦU
PLAN OF IRRIGATION SYSTEM SUOI DAU RESERVOIR
TỶ LỆ/ SCALE 1: 50 000
N
W
E
S
CHÚ DẪN BẢN ĐỒ (LENGEND)
ĐƯỜNG TỈNH LỘ (ROAD)
ĐƯỜNG MÒN (PATHWAY)
ĐƯỜNG ỐNG CHÍNH (MAIN PIPE)
ĐƯỜNG ỐNG NHÁNH (BRANCH PIPE)
SÔNG SUỐI (RIVERS, STREAMS)
ĐƯỜNG BAO TƯỚI DO KÊNH PHỤ TRÁCH (IRRIGATED BOUNDARY MANAGED BY THE CANAL)
ĐƯỜNG BAO TƯỚI DO TRẠM BƠM PHỤ TRÁCH (IRRIGATION BOUNDARY BY THE PUMP STATION IN CHARGE)
HỒ CHỨA (RESERVOIR)
AO CHỨA (WATER TANKS)
TRỤ SỞ UBND XÃ (COMMUNE OFFICE)
BAC SUOI DAU CALNAL
Suoi Dau reservoir
F_{cat} =120 Km²
W_{ave} =32.78*10^6m³
NAM SUOI DAU CALNAL
Suoi Cat Commune
Suoi Tan Commune
SUOI DAU PUMP STATION
Cam Tan Commune
Cam Ranh Reservoir
F_{cat} =59.4 Km²
W_{ave} = 21.10*10^6m³
Thuong Stream
NAM CAM RANH CALNAL
1350 000
1345 000
1340 000
585000
590000
595000


BÌNH ĐỒ BỐ TRÍ HỆ THỐNG TƯỚI HỒ CAM RANH
PLAN OF IRRIGATION SYSTEM CAM RANH RESERVOIR
TỶ LỆ/ SCALE 1: 50 000
N
W
E
S
EAST SEA
Cam Tan Commune
Cam Hoa Commune
Cam Hai Dong Commune
Cam Hai Tay Commune
NAM CAM RANH CALNAL
Cam Ranh Reservoir
F_{cat} =59.4 Km²
W_{ave} = 21.10*10⁶m³
CAM RANH 1 PUMP STATION
District administrative center
CAM RANH 2 PUMP STATION
Cam Duc Town
Cam Hiep Bac Commune
Cam Hiep Nam Commune
Cam Thanh Bac Commune
CAM RANH 3 PUMP STATION
Ta Lua Reservoir
CAM RANH 4 PUMP STATION
Cam An Bac Commune
Xã Cam Phước Tây
1340 000
1335 000
1330 000
1325 000
600000
CHÚ DẪN BẢN ĐỒ (LENGEND)
KHU TƯỚI BẰNG KÊNH (IRRIGATED AREA MANAGED BY THE CANAL)
KHU TƯỚI BẰNG TB (IRRIGATION AREA BY THE PUMP STATION IN CHARGE)
KHU DÂN CƯ (RESIDENTIAL AREA)
ĐƯỜNG TỈNH LỘ (ROAD)
ĐƯỜNG MÒN (PATHWAY)
ĐƯỜNG ỐNG CHÍNH (MAIN PIPE)
ĐƯỜNG ỐNG NHÁNH (BRANCH PIPE)
SÔNG SUỐI (RIVERS, STREAMS)
ĐƯỜNG BAO TƯỚI DO KÊNH PHỤ TRÁCH
(IRRIGATED BOUNDARY MANAGED BY THE CANAL)
ĐƯỜNG BAO TƯỚI DO TRẠM BƠM PHỤ TRÁCH
(IRRIGATION BOUNDARY BY THE PUMP STATION IN CHARGE)
HỒ CHỨA (RESERVOIR)
AO CHỨA (WATER TANKS)
TRỤ SỞ UBND XÃ (COMMUNE OFFICE)

F. DAK LAK SUBPROJECTS

92. In Dak Lak eight schemes are proposed, taking water from five reservoirs. Seven of the schemes are pump – piped systems. Engineering works include: (i) pumping stations (onshore or offshore) - if on-shore, submersible pumps have many advantages over vertical turbine pumps, (ii) access roads to pumping stations, (iii) pressurized pipe systems supplying hydrants, (iv) header tanks as required, and (v) control and monitoring systems. Layouts are attached.

Reservoir	Irrigation System		Area	Length	Density
	Supply	Distribution	(ha)	(km)	(m/ha)
Ea Drang	New pump station	New piped	150	2.70	18.0
Buon Yong	New pump station	New piped	451	8.51	18.9
Ea Kuang	New pump station	New piped	422	15.78	18.7
	Existing open canal	New piped	424		
Krong Buk Ha	New pump station*1	New piped	200	3.45	17.3
	New pump station*1	New piped	400	6.86	17.2
	New pump station	New piped	200	3.85	19.3
		New piped	200	3.31	16.5
Doi 500	New pump station	New piped	203	4.07	20.0
Total = 5		**7 Systems**	**2,650**	**48.53**	**18.3**

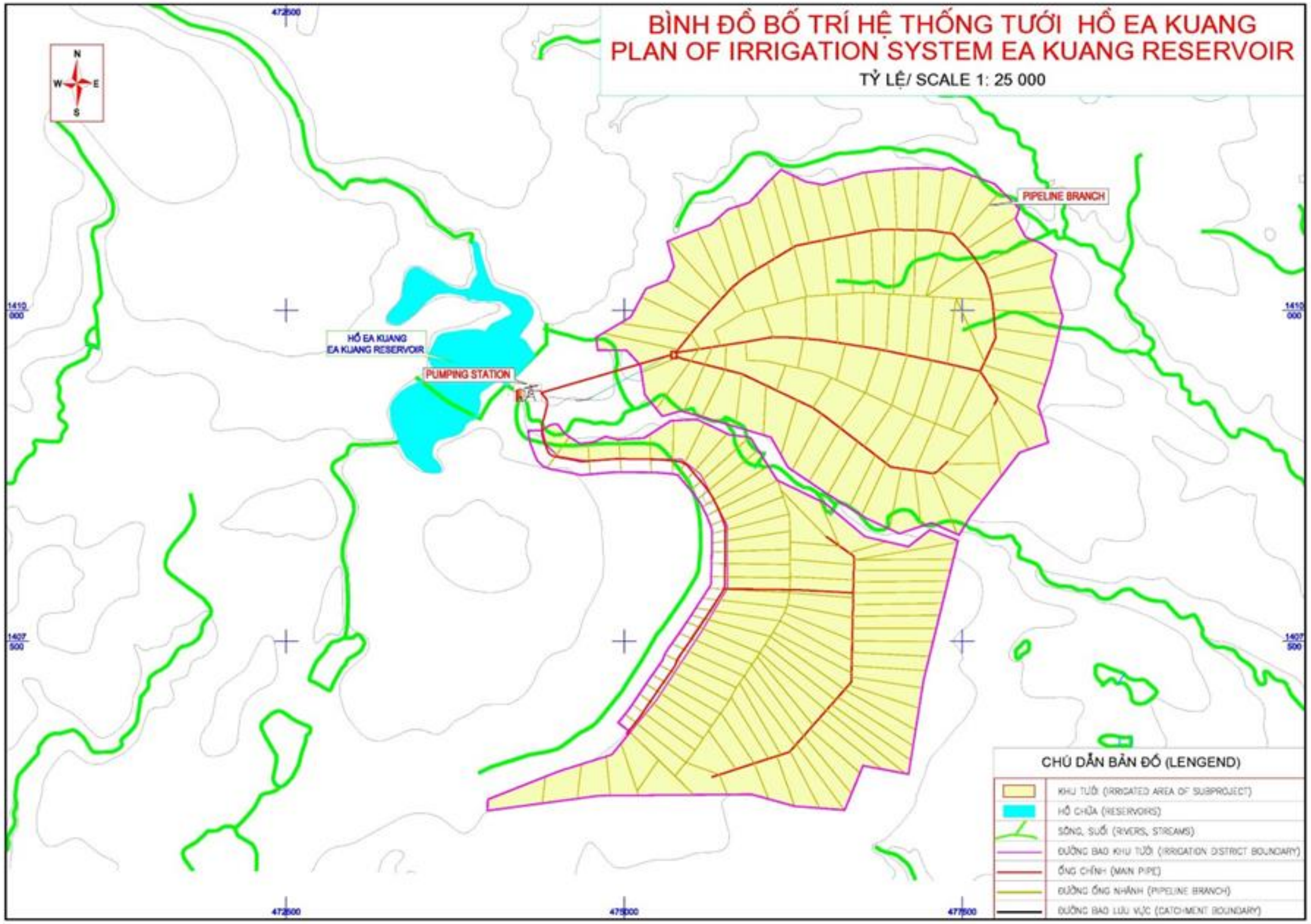
**1. Combing these systems with a single pumping station remains an option*

93. Aspects to consider further at detailed engineering design shall include the following:

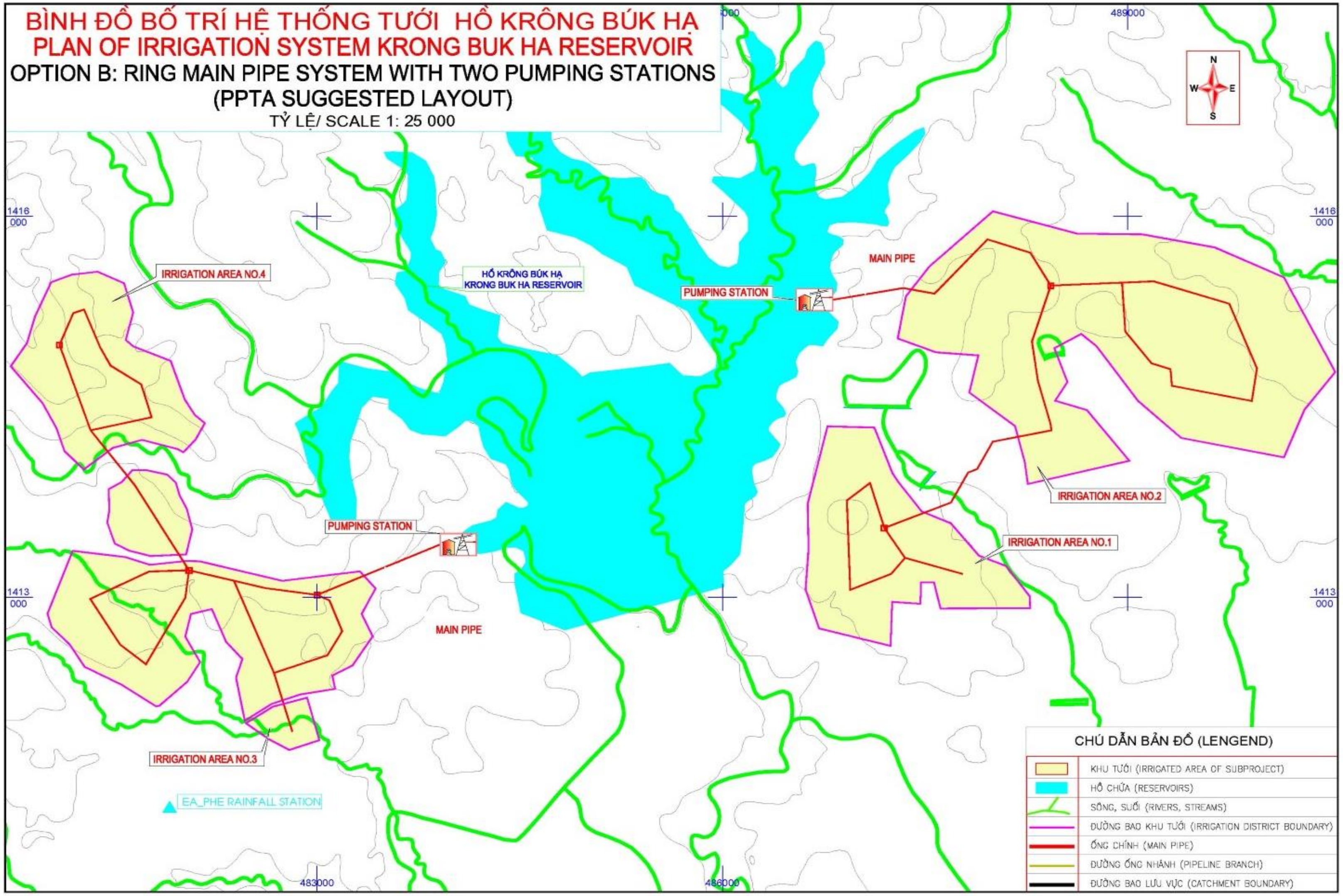
- For the pumped pipe systems, the pumped pipe system service (command) areas should be further refined to ensure that only high value (coffee and pepper) areas are included. Rice (valley) areas should be excluded.
- Pressure pipe (ring) systems shall be adopted (not pumping to a header tank with gravity distribution from the header tank). A single small header tank may be located at the highest (and furthest) location in each pipe system, with pressures (or water levels) triggering pump operations. Alternatively, pump operations may be controlled by pressure sensors in the pipeline.
- The design flows for each of the pumped pipe systems are based on 1.04 l/s/ha. The required capacity may be reassessed/ confirmed at detailed design.
- The feasibility designs propose on-shore pumping stations with vertical turbine pumps. Due to large reservoir water level fluctuations, these are expensive structures with long intake channels. As part of detailed design, the following additional options shall be costed and compared:
  - On-shore pumping station but with submersible pumps, as well as vertical turbine pumps.
  - Off-shore floating pumping station.
- At least one of the pumps provided shall be variable speed.
- For Krong Buk Ha – east, where two separate areas are supplied, the options of two pumping stations, or just one shall be costed and assessed.
- Access roads, at least to reach the pumping stations, shall be designed and costed.

- Electrical works to provide necessary 3-phase power to each pump house need more accurate design and costing.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are ±5 l/s for a range of residual heads at design flow with metering and flow control devices. Direct fuse connections are envisaged between the main HDP pipeline and the off taking pipe. Adequate protection against tampering shall be considered. Further, constant flow valves shall be adopted at hydrants (refer Section II).
- The requirement for valves shall be firmed up at detailed design, and will include air valves at intervals/ high points along the pipelines, washout valves at gully crossings, and flow control valves to allow parts of the pipeline to be isolated.
- Relating to minimizing deposit in pipes and suspended materials in water for micro-irrigation systems, farmers may tank up micro-irrigation (drip/ sprinkler) from the pressure pipe hydrants (outlets), and appropriate arrangements need to be made to prevent ingress of sediment. This is likely to require screens at the pumping stations.
- The SCADA system shall allow remote monitoring of water levels, pressures and flows as appropriate in the reservoir, canal and pipe systems, i.e. in the reservoirs, in pipeline header tanks, in the main pipeline leading from the pumping stations, at all/ selected hydrants. Pumping operations shall also be monitored. Pumps operation shall be linked to pipe pressures.
- The SCADA system shall link the pumping stations, field monitoring stations, and the central control room (office) via the Internet and the 4G/ 5G universal mobile telecommunication system (UMTS) or the latest mobile technology. The central office shall be located, rehabilitated and equipped as required with computer/ devices/ internet connection, software, database and so on.

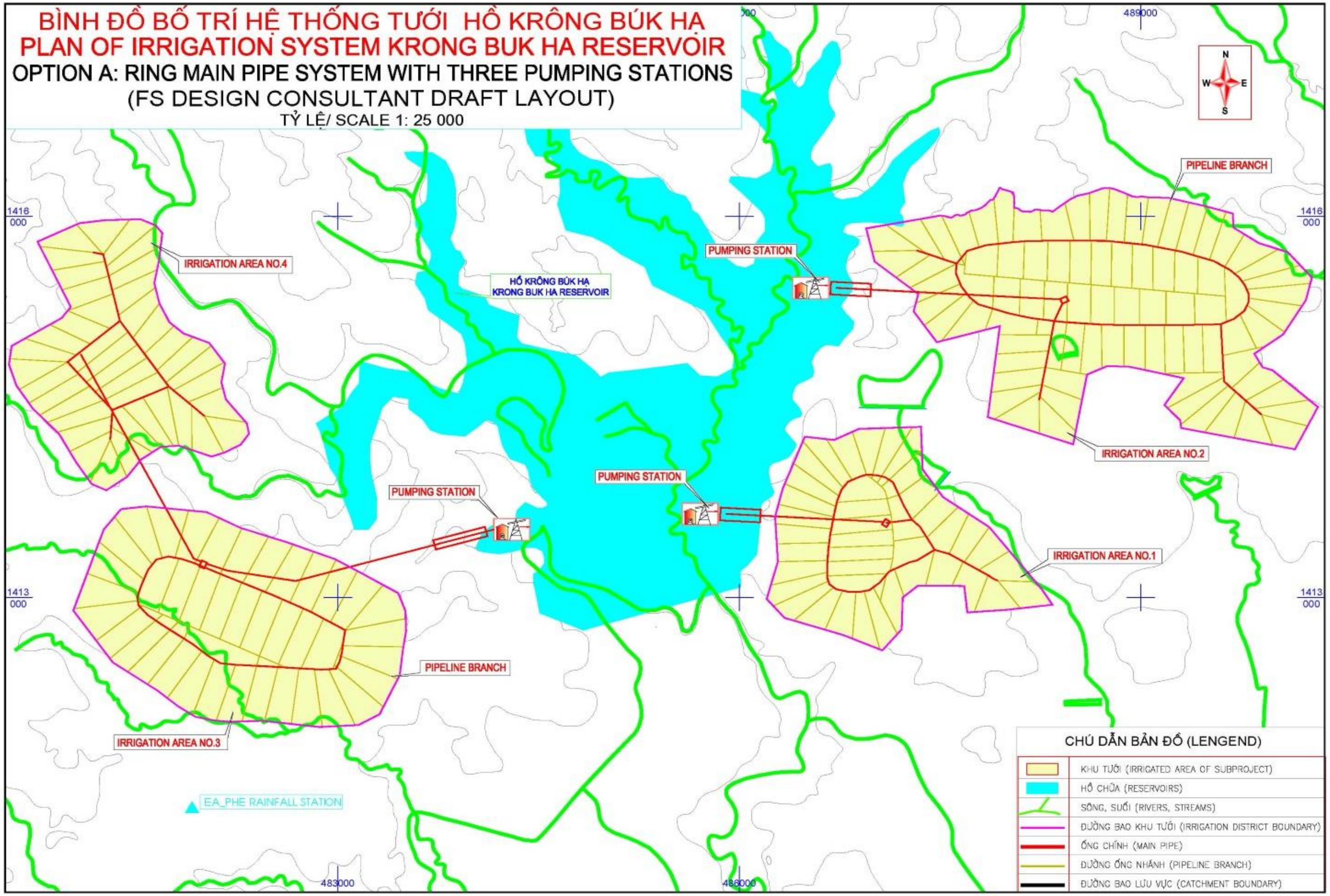
Scheme Layout for Ea Kuang Reservoir - Dak Lak



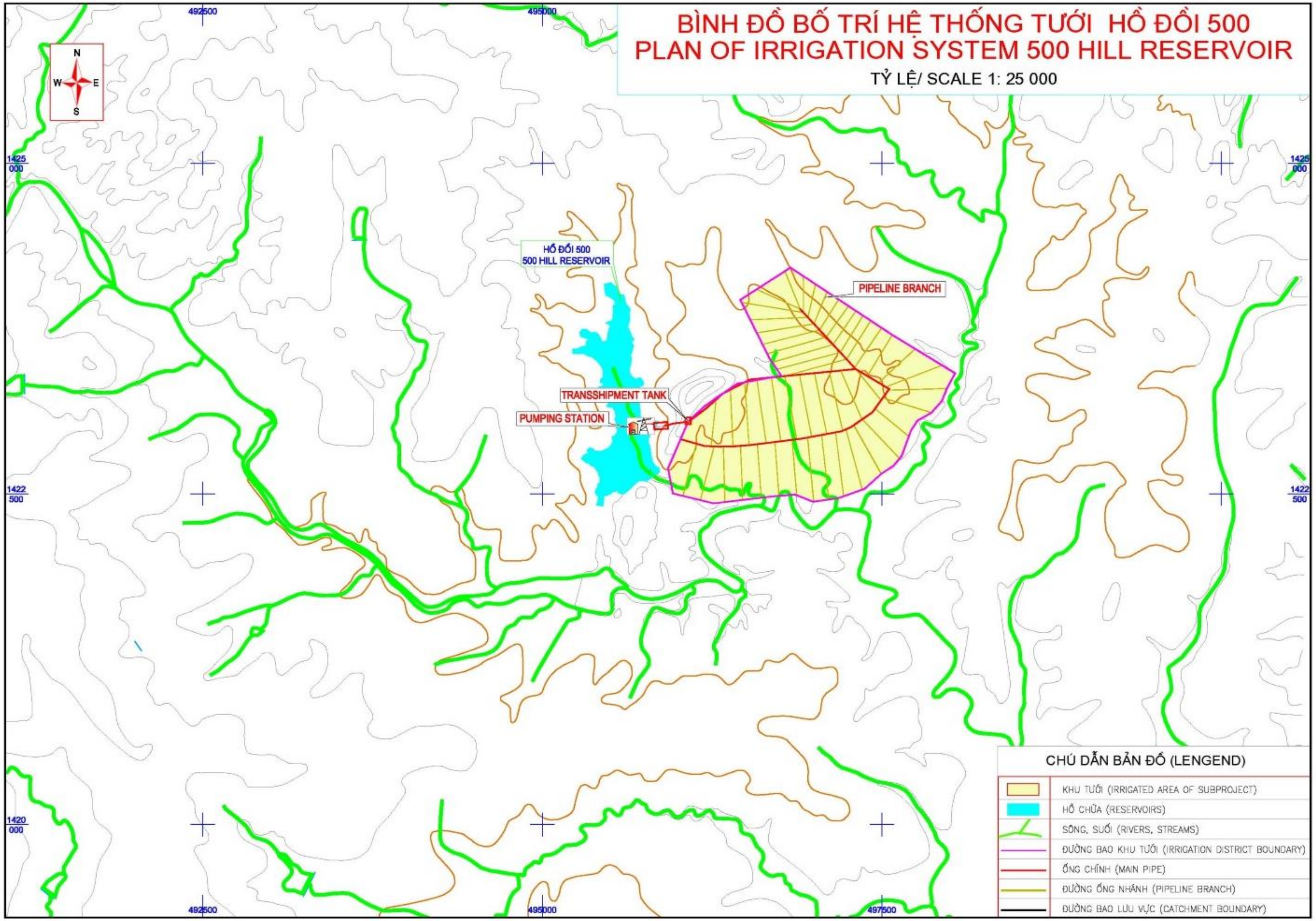
Scheme Layout for Krung Buk Ha - Dak Lak: Option A – 2 pumping stations



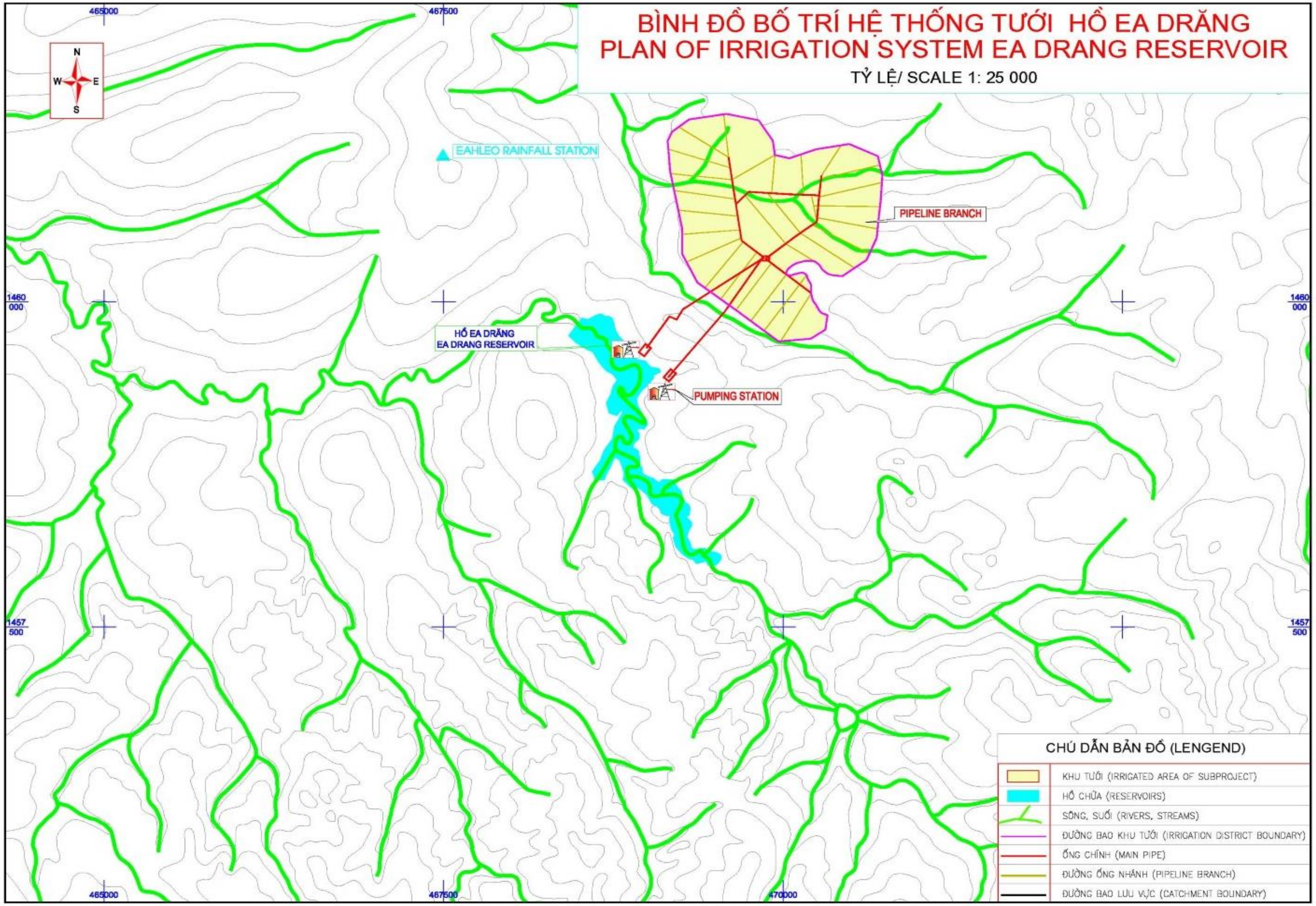
Scheme Layout for Krung Buk Ha - Dak Lak : Option B - 3 Pumping Stations



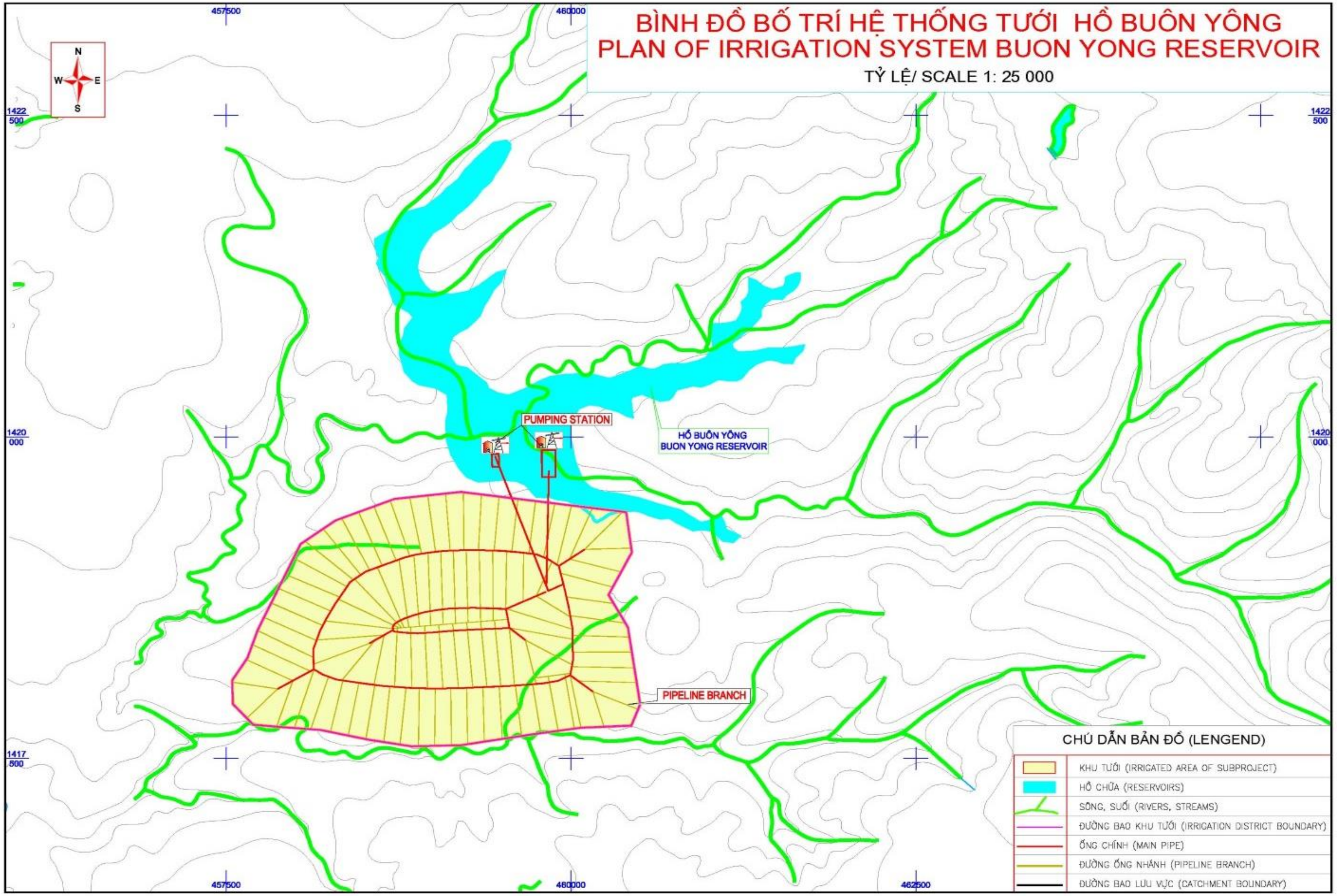
Scheme Layout for Doi 500 Hill Reservoir - Dak Lak



Scheme Layout for Trung Tam (Ea Drang Town) - Dak Lak



Scheme Layout for Buon Yong Reservoir - Dak Lak

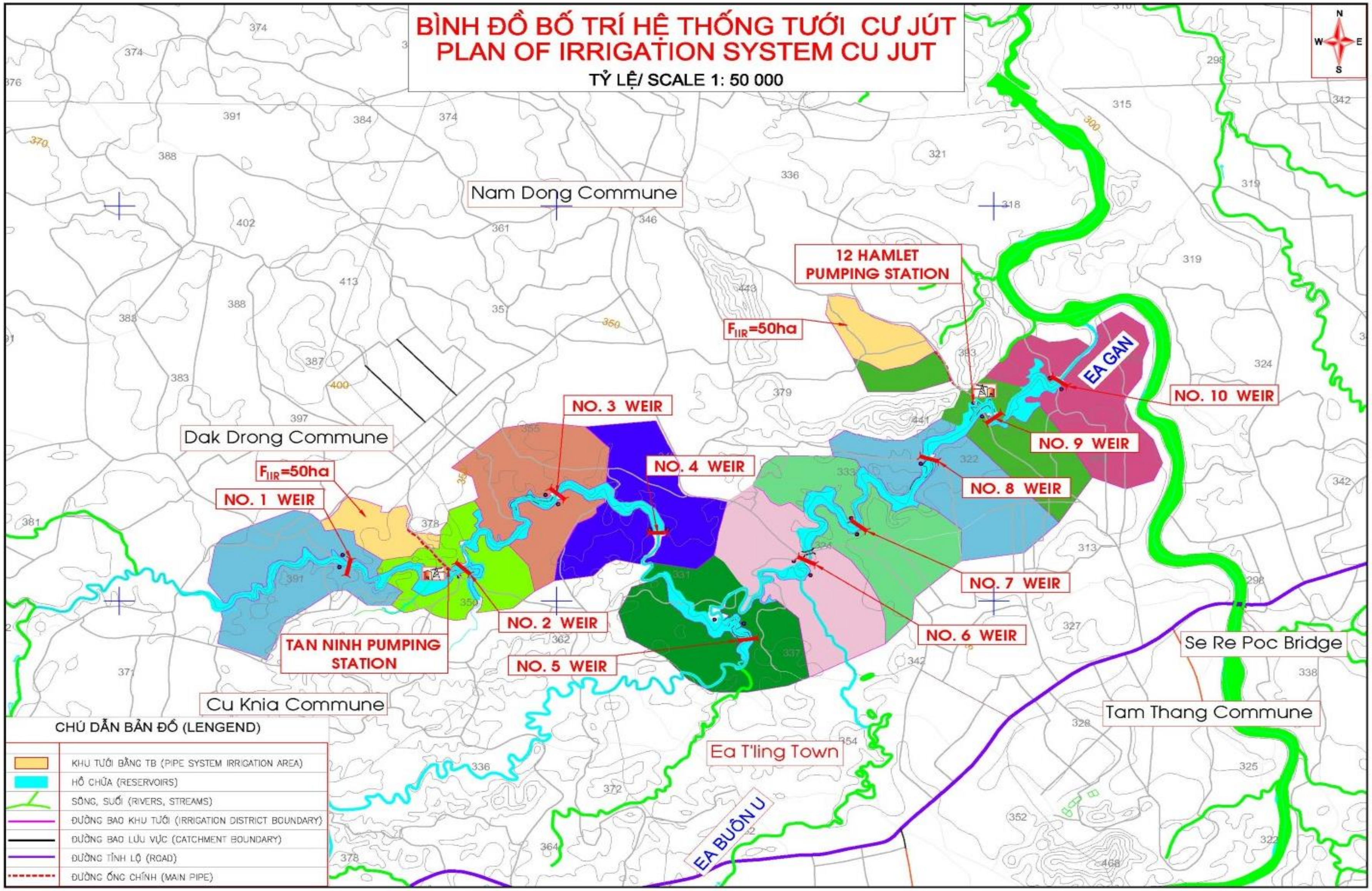


G. CU JUT SUBPROJECT, DAK NONG

94. The subproject comprises: (i) 10 permanent weirs to replace farmers' temporary weirs, supplied from the existing Dak Dier and Dak Drong reservoirs, (ii) two pumped-pipe demonstration irrigation systems, supplied from weirs 2 and 9, each serving about 50 ha, and (iii) upgrading of 10.95 km of access road. The layout of the 10 weirs and their service areas is attached.

95. Aspects to consider further at detailed engineering design shall include the following:

- Further refinement of the ungated weir designs, with measures to protect the concrete weirs in case of periodic outflanking – for example gabion protection could be placed at the same level as the weir floor to protect against scour of the structures abutments. Also, further consideration of flushing arrangements/ gates is required to ensure that river bed levels do not aggrade.
- Bridge crossings are proposed for two of the weirs. The need/ locations of bridge crossings shall be confirmed.
- The service area and pipe layout of the two pumped piped demonstrations systems shall be confirmed and revised as necessary following discussions with local stakeholders. Ideally, the pipe density of both schemes shall be closer to 20m/ ha.
- The design flows for each of the two pumped systems are based on 1.16 l/s/ha. The required capacity may be reassessed/ confirmed at detailed design.
- Adoption of at least one variable flow pump is suggested.
- Pressure pipe systems are suggested (not pumping to a header tank with gravity distribution from the header tank). A single small header tank may be located at the highest (and furthest) location in each pipe system, with pressures (or water levels) triggering pump operations. Alternatively, pump operations may be controlled by pressure sensors in the pipeline.
- Electrical works to provide necessary 3-phase power to each pump house need more accurate design and costing.
- Cost effective hydrant - manifolds designs shall be adopted so that hydrant flows are ±5 l/s for a range of residual heads at design flow with metering and flow control devices. Direct fuse connections are envisaged between the main HDPE pipeline and the off taking pipe. Adequate protection against tampering shall be considered (refer Section II).
- The requirement for valves shall be firmed up at detailed design, and may include air valves at intervals/ high points along the pipelines, washout valves at gully crossings, and flow control valves to allow parts of the pipeline to be isolated.
- The components and cost of a basic SCADA system shall be firmed up. This would include monitoring: (i) water levels in the reservoirs and in the last weir (No. 10) along the Ea Dier river; (ii) pump operations, pipe pressures and pipe and selected hydrant flows.


BÌNH ĐỒ BỐ TRÍ HỆ THỐNG TƯỚI CƯ JÚT
PLAN OF IRRIGATION SYSTEM CU JUT
TỶ LỆ/ SCALE 1: 50 000
Nam Dong Commune
Dak Drong Commune
Cu Knia Commune
Ea T'ling Town
Tam Thang Commune
Se Re Poc Bridge
12 HAMLET PUMPING STATION
TAN NINH PUMPING STATION
NO. 1 WEIR
NO. 2 WEIR
NO. 3 WEIR
NO. 4 WEIR
NO. 5 WEIR
NO. 6 WEIR
NO. 7 WEIR
NO. 8 WEIR
NO. 9 WEIR
NO. 10 WEIR
F_{IIR}=50ha
F_{IIR}=50ha
EA GAN
EA BUÔN U
CHÚ DẪN BẢN ĐỒ (LENGEND)
KHU TƯỚI BẰNG TB (PIPE SYSTEM IRRIGATION AREA)
HỒ CHỨA (RESERVOIRS)
SÔNG, SUỐI (RIVERS, STREAMS)
ĐƯỜNG BAO KHU TƯỚI (IRRIGATION DISTRICT BOUNDARY)
ĐƯỜNG BAO LƯU VỰC (CATCHMENT BOUNDARY)
ĐƯỜNG TỈNH LỘ (ROAD)
ĐƯỜNG ỐNG CHÍNH (MAIN PIPE)

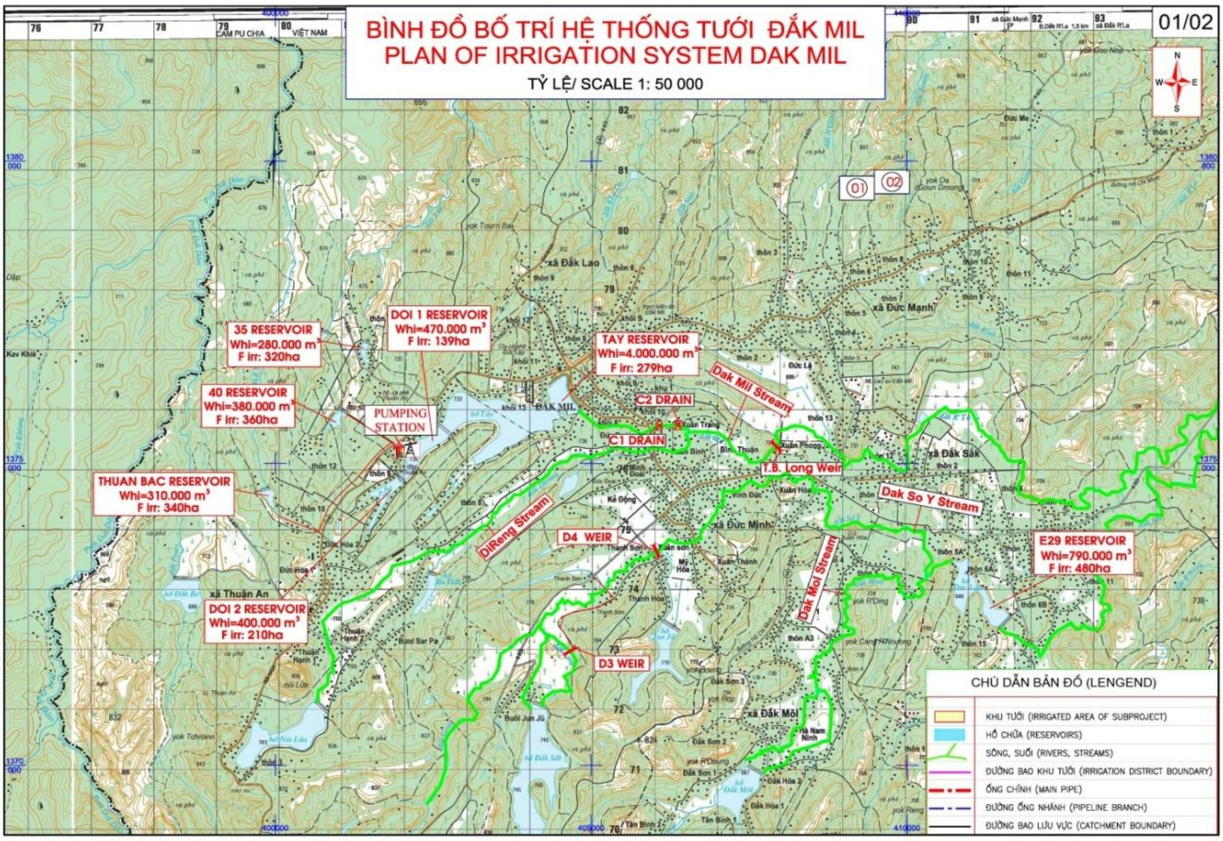
H. DAK MIL SUBPROJECT, DAK NONG

96. The subproject includes: (i) upstream works: rehabilitation of 24 existing structures including structures on four existing storage reservoirs, five existing diversion weirs, construction of 2.75 km of reinforced concrete box culvert, construction of a new pumping station, to replace a temporary one, on Reservoir #1; (ii) downstream works: replacement of farmers' temporary weirs with three permanent un-gated weir structures, and (iii) road upgrading together with bridge/ culvert crossings.

97. Aspects to consider further at detailed engineering design shall include the following:

- Confirmation of all works identified at feasibility.
- Further refinement of the ungated weir designs including measures to protect the concrete weirs in case of periodic outflanking.
- Basic SCADA system for effective system operation with efficient water use.

Dak Mil System Layout – sheet 1



Dak Mil System Layout – sheet 2