Table C.II-06 Comparison of Alternative Block Plan

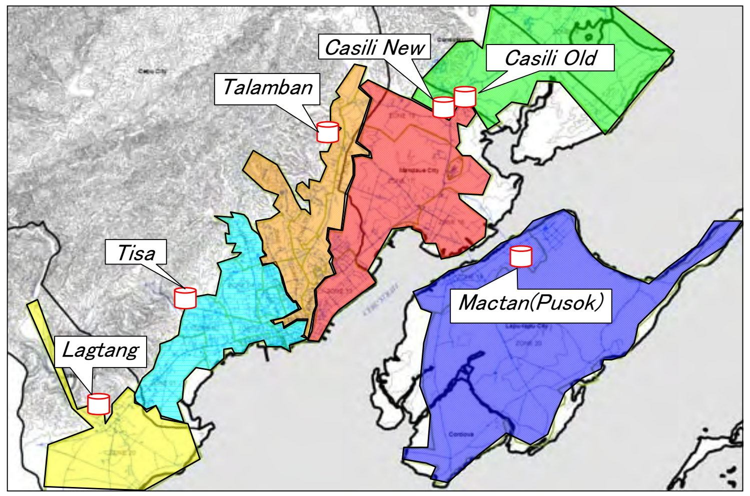
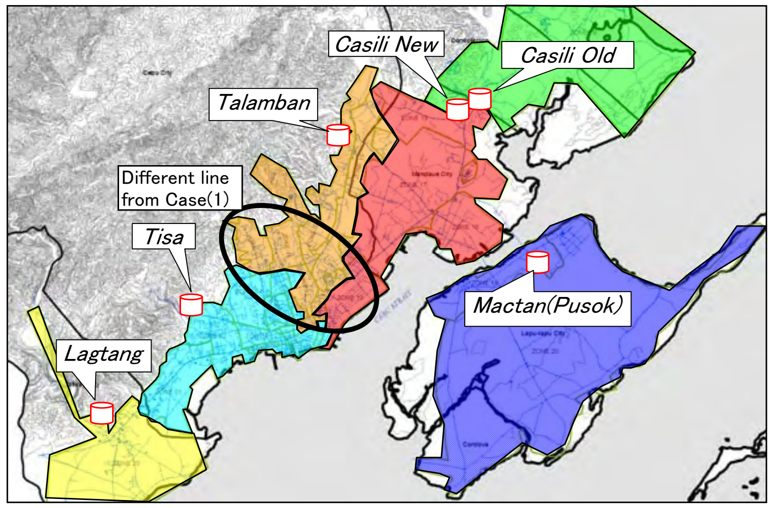
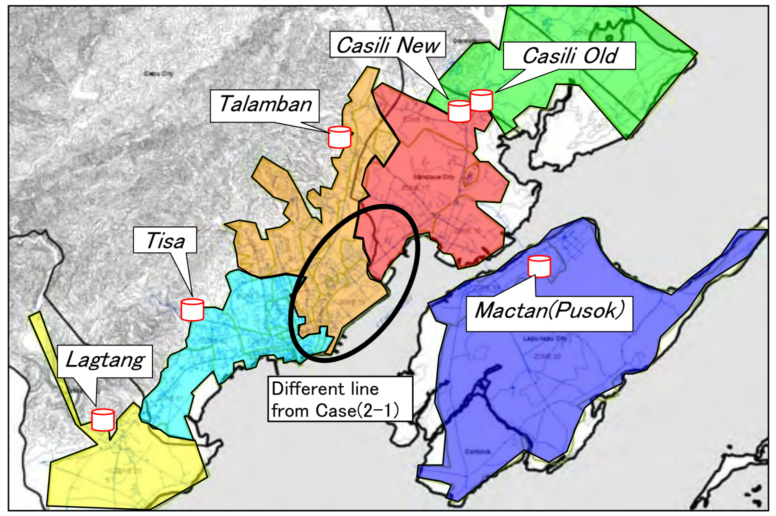
Item	Case (1)	Case (2-1)	Case (2-2)
Outline	Lagtang reservoir covers Talisay City in Lagtang D.B. Casili old reservoir covers Consolacion, Lilo-an and Compostela in C.L.C D.B. Mactan D.B is composed of Lapu-lapu City and Cordova covering with its own water and also imported water from Cebu Island. Boundary line among Tisa D.B, Talamban D.B and Casili D.B is principally based on the zone boundary so that consumed volume summed up by each zone is easily compared with the distributed volume from the reservoir. To detect the NRW ration of each distribution block. Demand balance among three major distribution block, Tisa, Talamban and Casili is **39: 28: 33**	Lagtang D.B, C.L.L D.B and Mactan D.B are under same conditions as Case (1). Boundary line among Tisa D.B, Talamban D.B and Casili D.B is principally based on the location of existing valves so that fabrication of the block is easily made by shutting the existing valves. Rough demarcation line is similar to the Case (1). Demand balance of Tisa, Talamban and Casili is almost same as Case (1) **38: 29: 32**	Lagtang D.B, C.L.L D.B, Mactan D.B and Tisa D.B are under same conditions as Case (2-2). Boundary line between Talamban D.B and Casili D.B is revised to lessen the supply-demand gap of each distribution block. Demand of Talamban goes up, while that of Casili is down. Tisa: Talamban: Casili = **38: 37: 25** Cebu City is almost equally divided into 2 distribution area and other City/Municipality belong to certain distribution block without dividing its coverage into some blocks.
Figure			
Additional block shutting valve	Without any valve insert construction work, block is easily fabricated ×	Without any valve insert construction work, block is easily fabricated ○	Easier than Case(2-1) ◎
NRW detection	Comparing with the consumption data compiled by zone, NRW ratio by distribution block is easily accessible. ◎	To grasp NRW of each distribution block, additional re-compiling work of billing data based on the boundary demarcation is necessary △	Better than Case (2-1) since only Cebu City concessionaire is divided into two distribution block ○
Demand-Supply balance	Promising ground water source is located mainly near Tisa and Talamban Block, so demand distribution is not so suitable in view of demand-supply balance. △	Almost same as Case(1) △	Demand is comparatively concentrated to Tisa and Talamban D.B. So, from the point of area-wise supply balance, this plan is superior to the others ○
Evaluation	△	○	◎

Table C.II-07 Cover Area by each Distribution Block

Distribution Block	Main Reservoir	Supply Zone Number		
		Case(1)	Proposed case-Case (2-1)	Proposed case-Case (2-2)
Lagtang	Lagtang	Part of 20(20-1 Talisay)	Same as Case (1)	Same as Case (1)
Tisa	Tisa	1 to 8 and 10, plus 21 (Government)	1,2,4,5,6,7, 10, part of (8,9,12 and 13)	Same as Case (2-2)
Talamban	Talamban	9, 11, 12 and 14 to 16	3,11,15,16, Part of (8,9,12,13, 14 and 17)	3,11,14,15,16, Part of (8,9,12,13 and 17)
Casili	Casili New	13, 17, 18	18,part of (13, 14 and 17)	18, part of 17
C.L.C	Casili Old	Part of 19(19-1 Consolacion) Part of 19(19-2 Lilo-an) and Part of 20(20-2 Compostela)	Same as Case (1)	Same as Case (1)
Mactan	Casili New	Part of 19(19-3 Lapu-lapu Cebu Strait side) Part of 20(20-3 Lapu-lapu Bohol Strait side) Part of 20(20-4 Cordova)	Same as Case (1)	Same as Case (1)

Zone vs. Block Matrix of Case (2-1)

zone	Distribution Block					
	Lagtang	Tisa	Talamban	Casili	CLC	Lapu-lapu/ Cordova
1		100				
2		100				
3			100			
4		100				
5		100				
6		100				
7		100				
8		80	20			
9		50	50			
10		100				
11			100			
12		15	85			
13		10	5	85		
14			90	10		
15			100			
16			100			
17				100		
18				100		
19-1					100	
19-2					100	
19-3						100
20-1	100					
20-2					100	
20-3						100
20-4						100
21		100				

Zone vs. Block Matrix of Case (2-2)

zone	Distribution Block					
	Lagtang	Tisa	Talamban	Casili	CLC	Lapu-lapu/ Cordova
1		100				
2		100				
3			100			
4		100				
5		100				
6		100				
7		100				
8		80	20			
9		50	50			
10		100				
11			100			
12		15	85			
13		10	90			
14			100			
15			100			
16			100			
17			5	95		
18				100		
19-1					100	
19-2					100	
19-3						100
20-1	100					
20-2					100	
20-3						100
20-4						100
21		100				

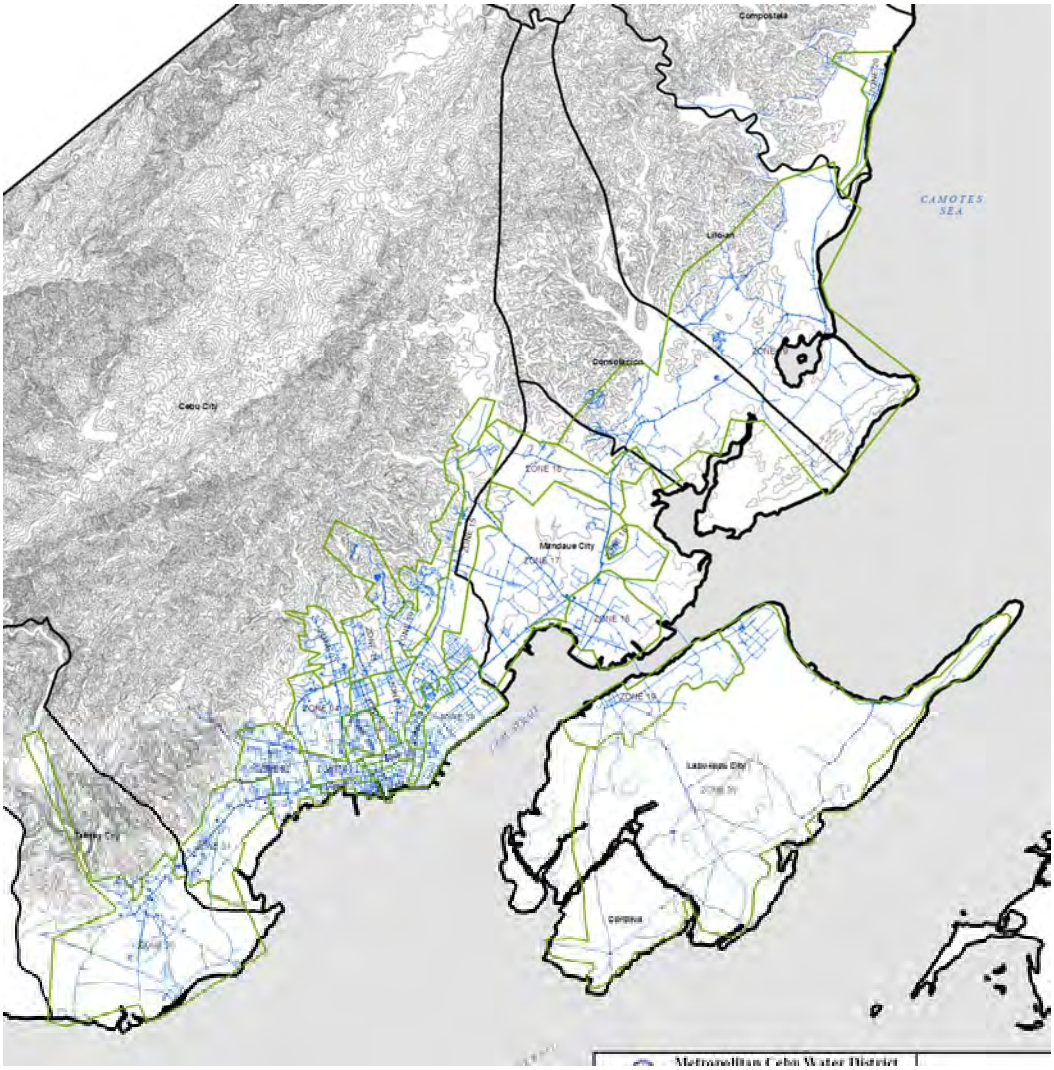


Figure C.II-07 MCDW billing zone map

- **Location and Number of Valves closed to form separate block**

Location of the closing valves are shown in the following figures

Number is summarized in the following table.

Table C.II-08 Nos. of Closing Valves

Boundary	Nos.	No. of Valve in Figure
CLC vs. Casili	3	No.1 to No.3
Casili vs. Talamban	9	No.4 to No.12
Talamban vs. Tisa	43	No.13 to No. 55
Tisa vs. Lagtang	2	No.56 and No.57
Casili vs. Mactan	2 booster pump station (one is existing, one is planned)	

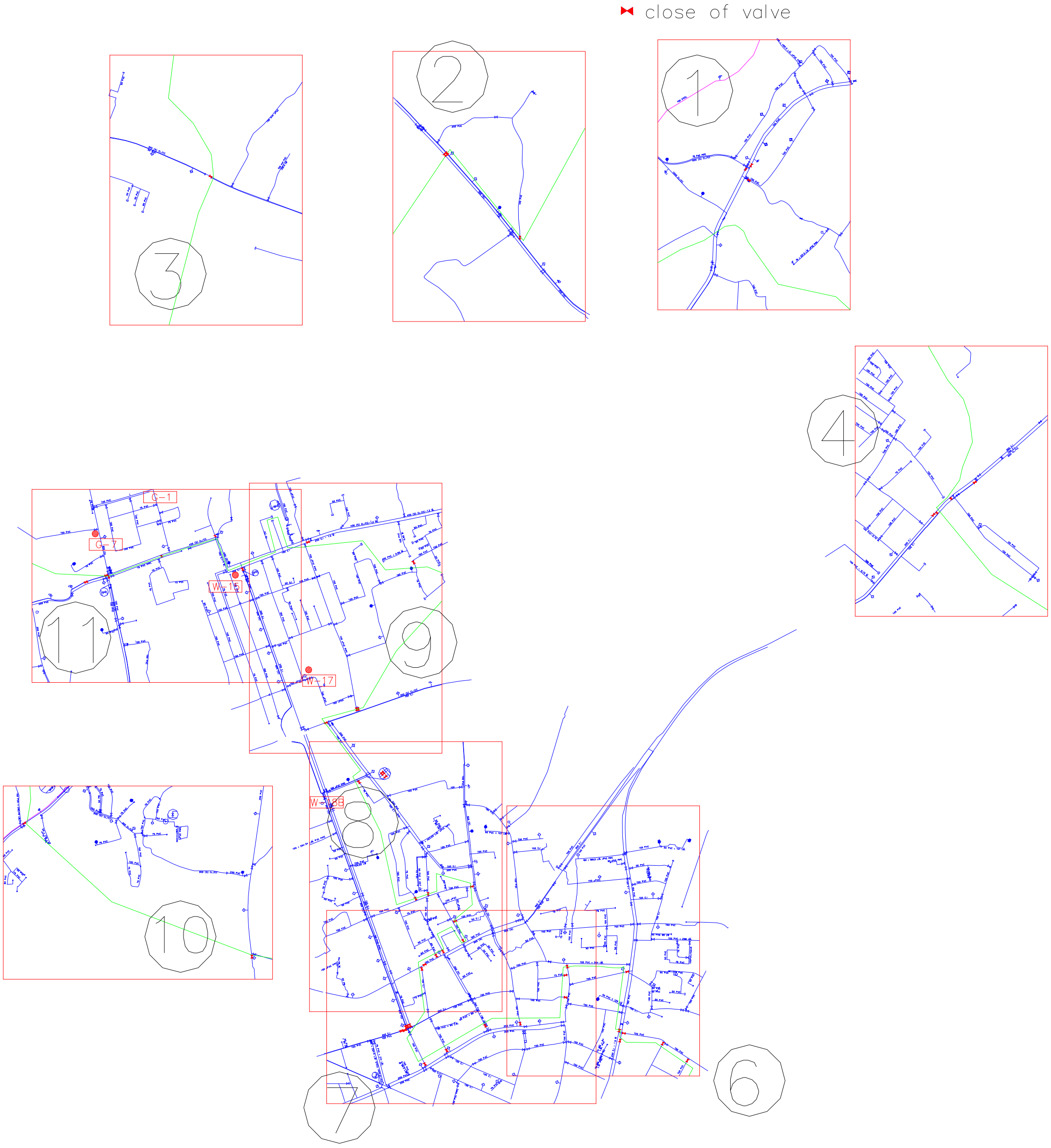
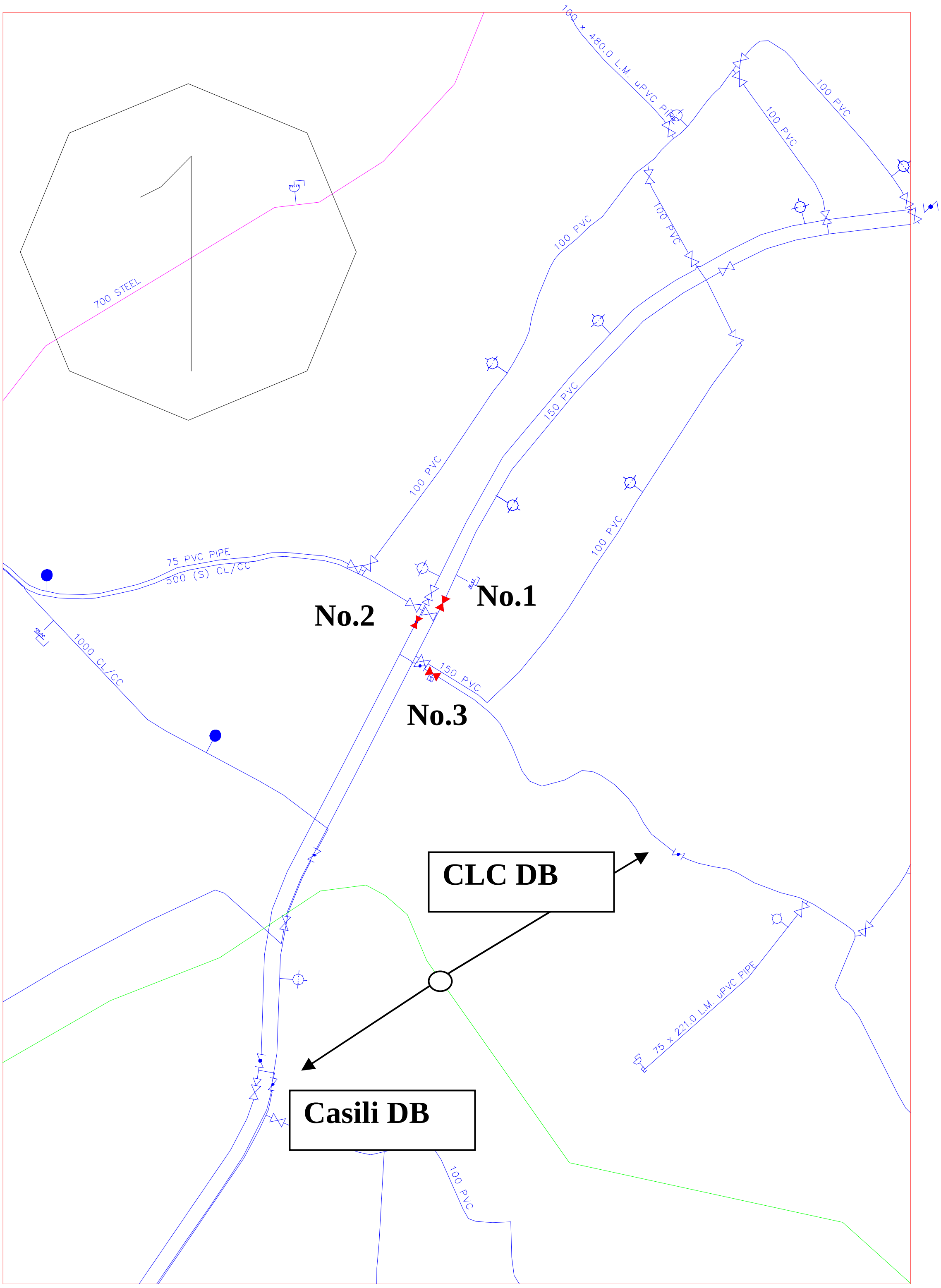
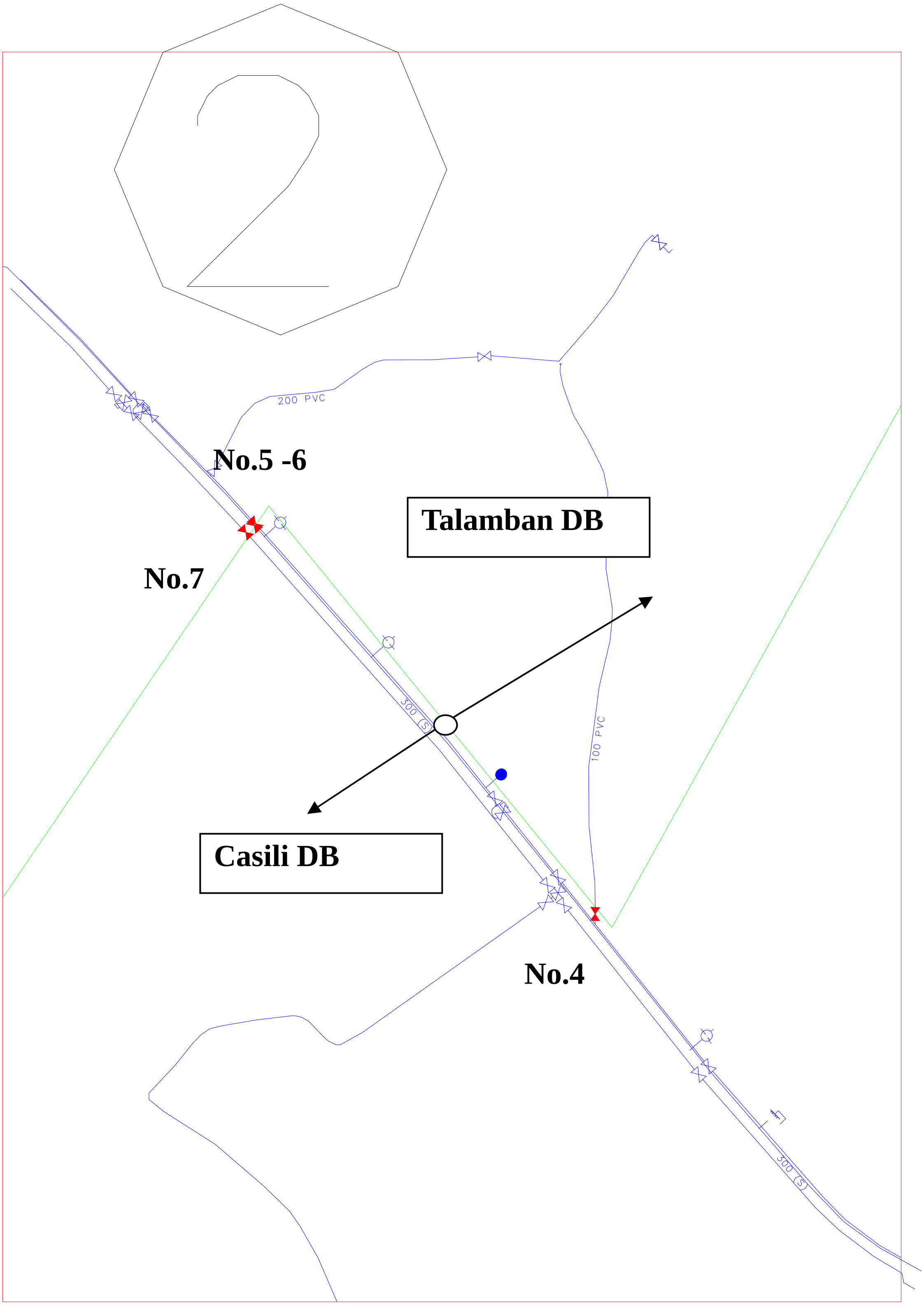
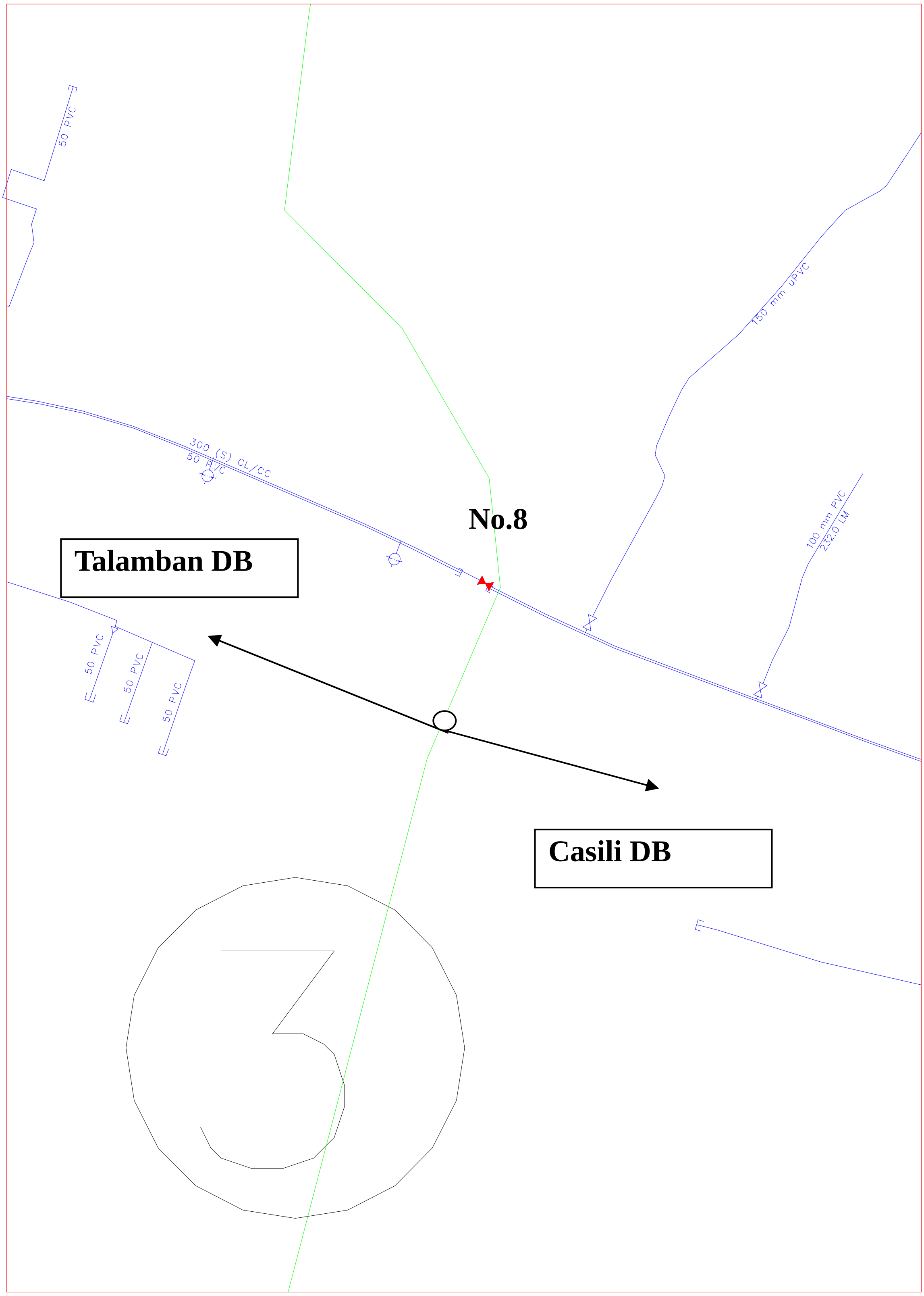


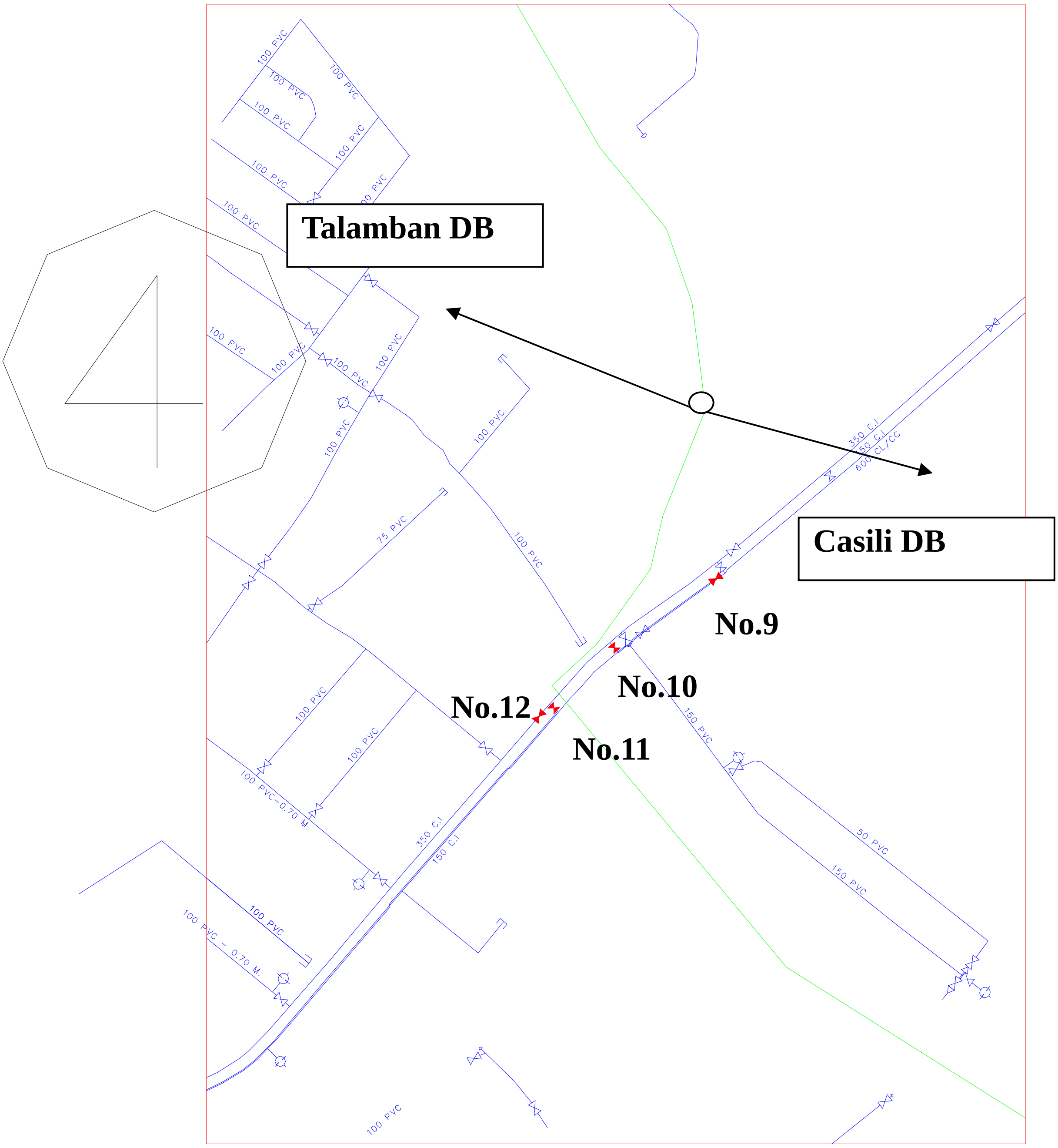
Figure C.II-08 Location of close valve

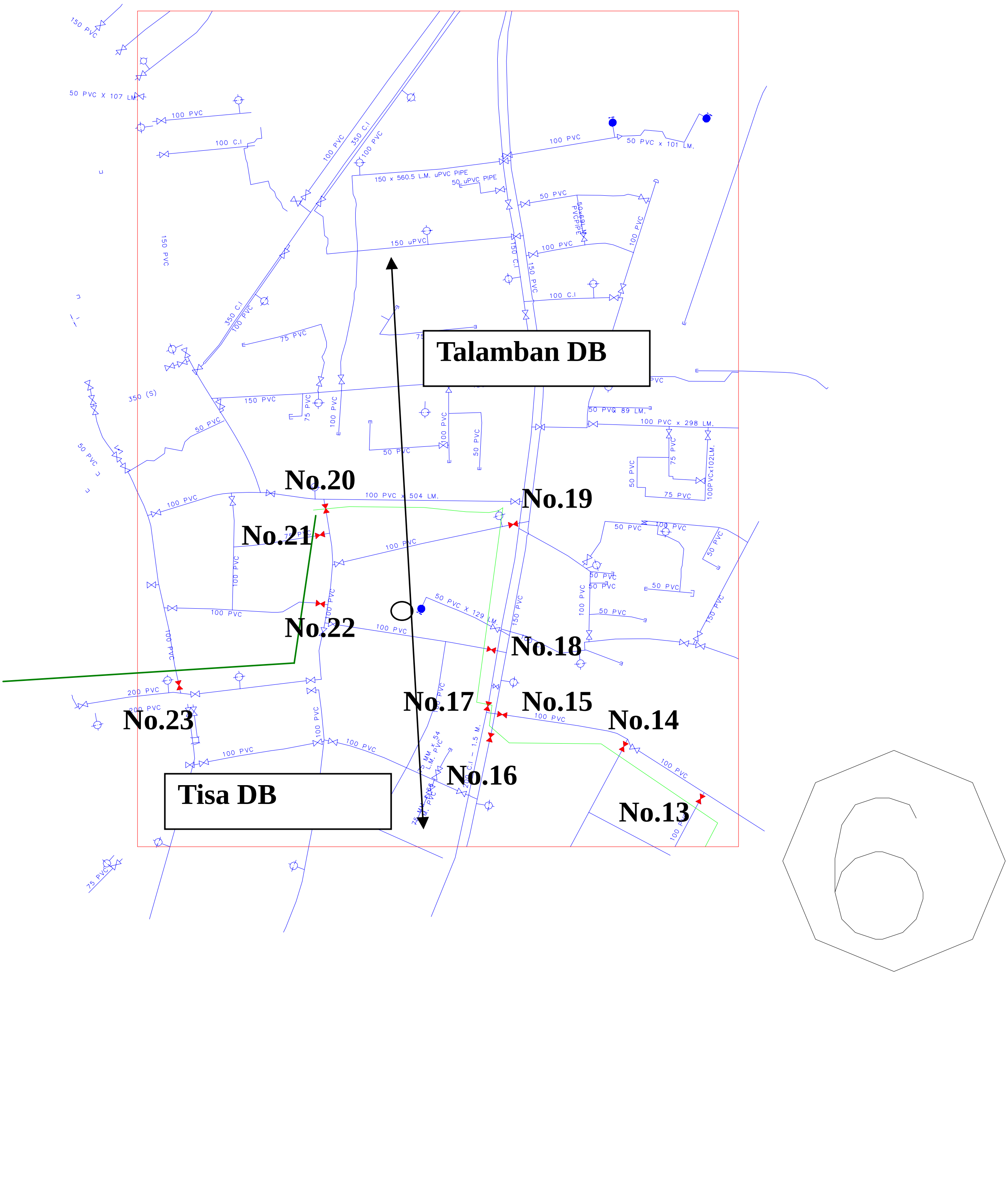


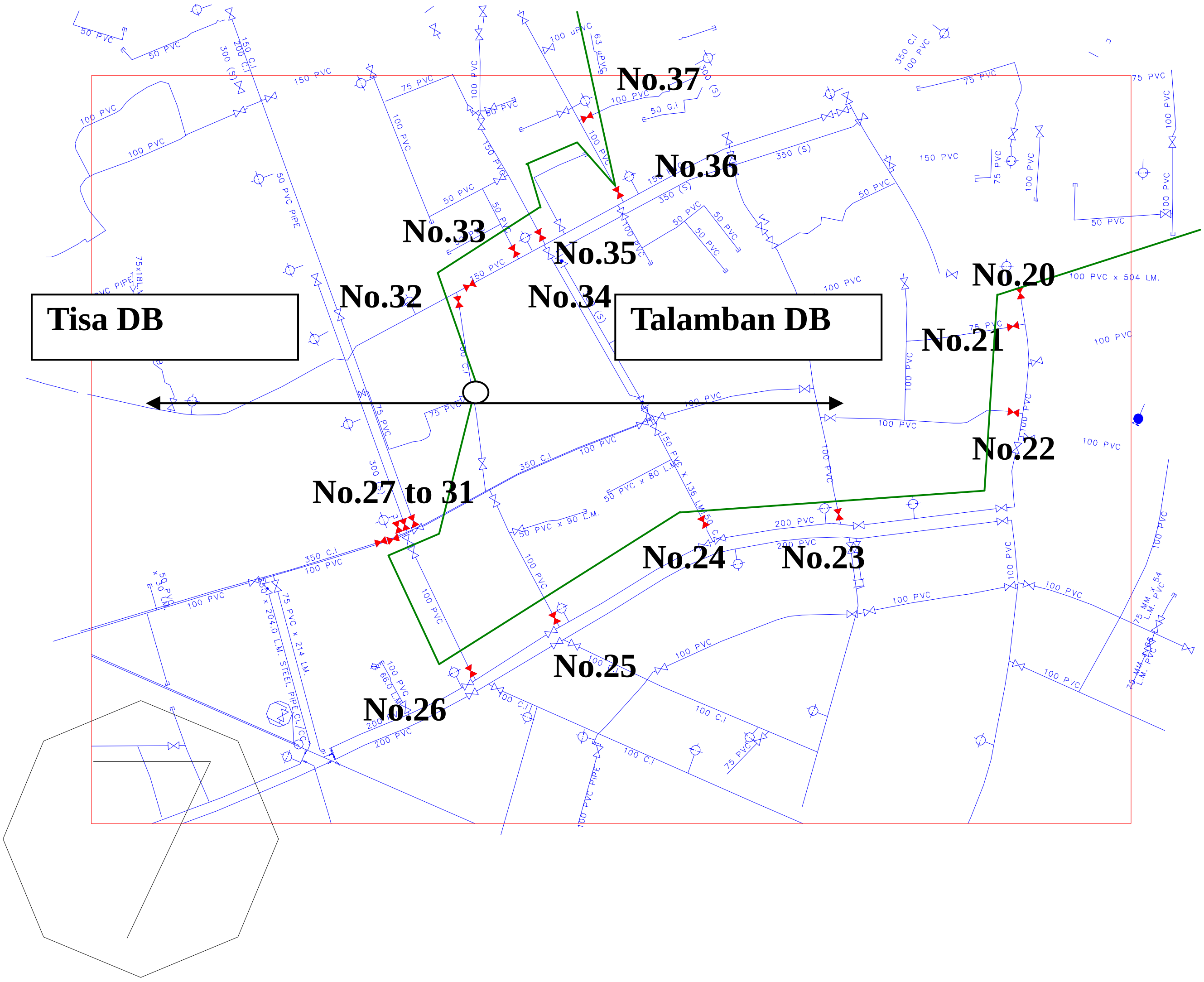
close of valve

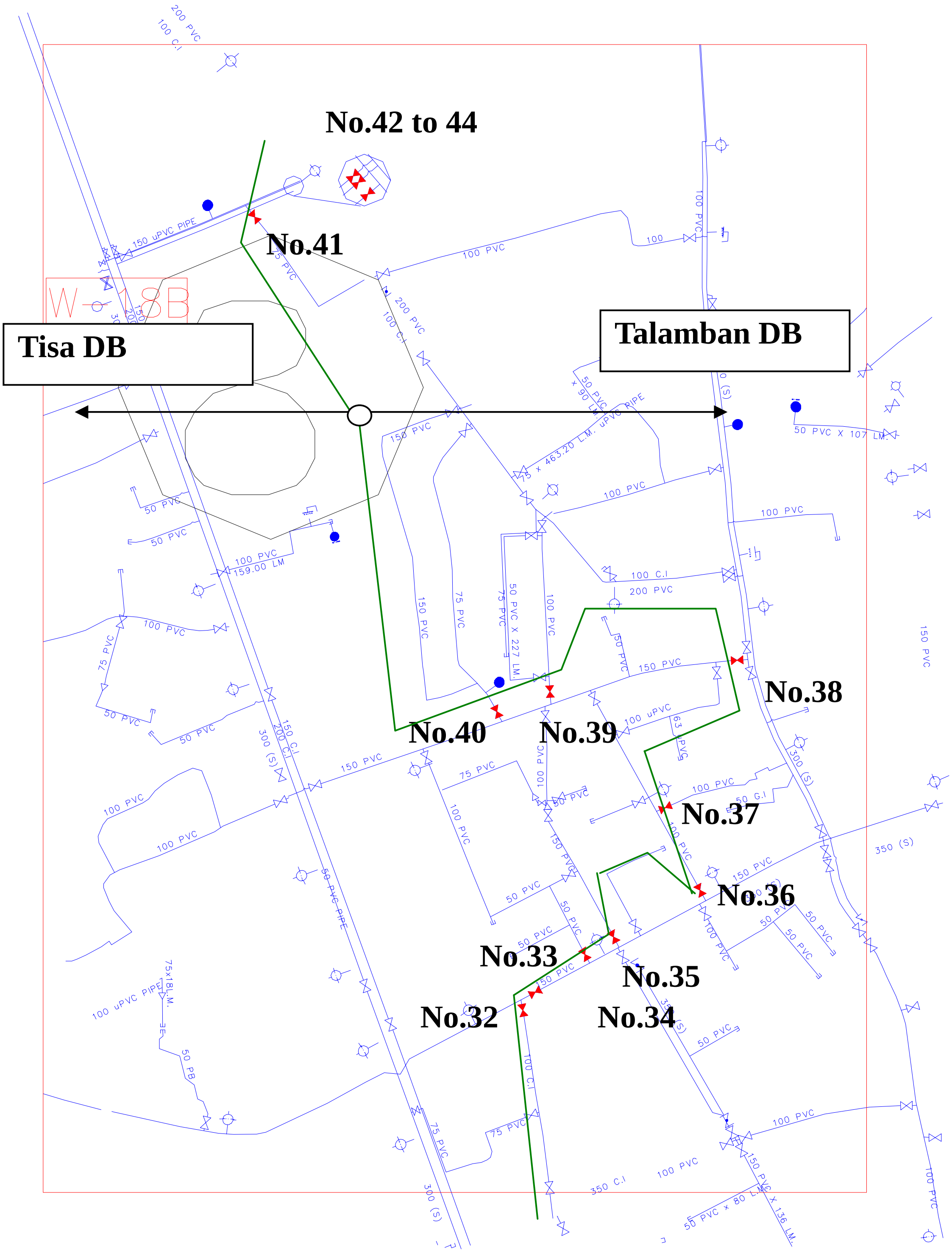

2
200 PVC
No.5 -6
Talamban DB
No.7
300 (S)
100 PVC
Casili DB
No.4
300 (S)

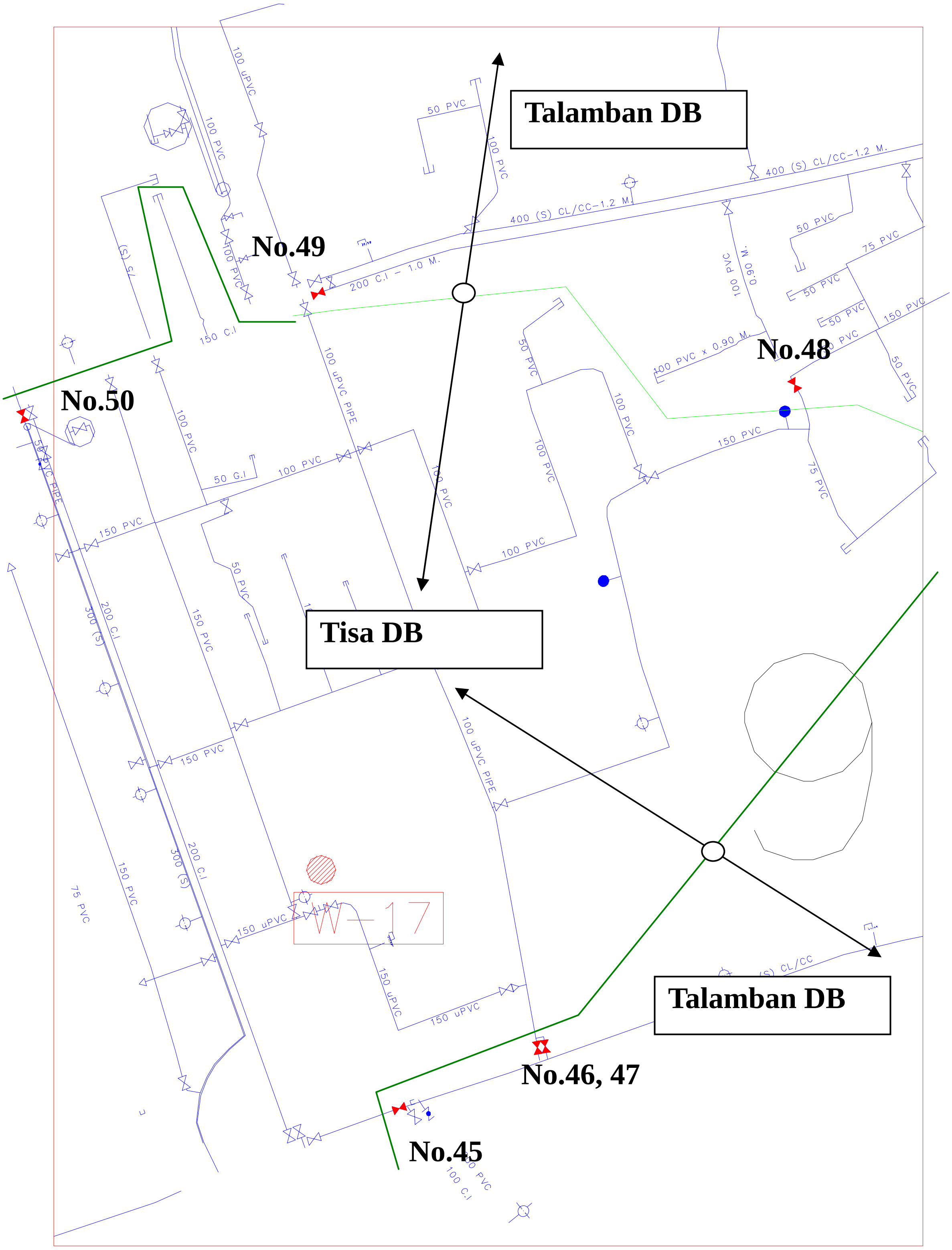

No.8
Talamban DB
Casili DB
300 (S) CL/CC
50 PVC
150 mm uPVC
100 mm PVC
232.0 LM
50 PVC
50 PVC
50 PVC
50 PVC

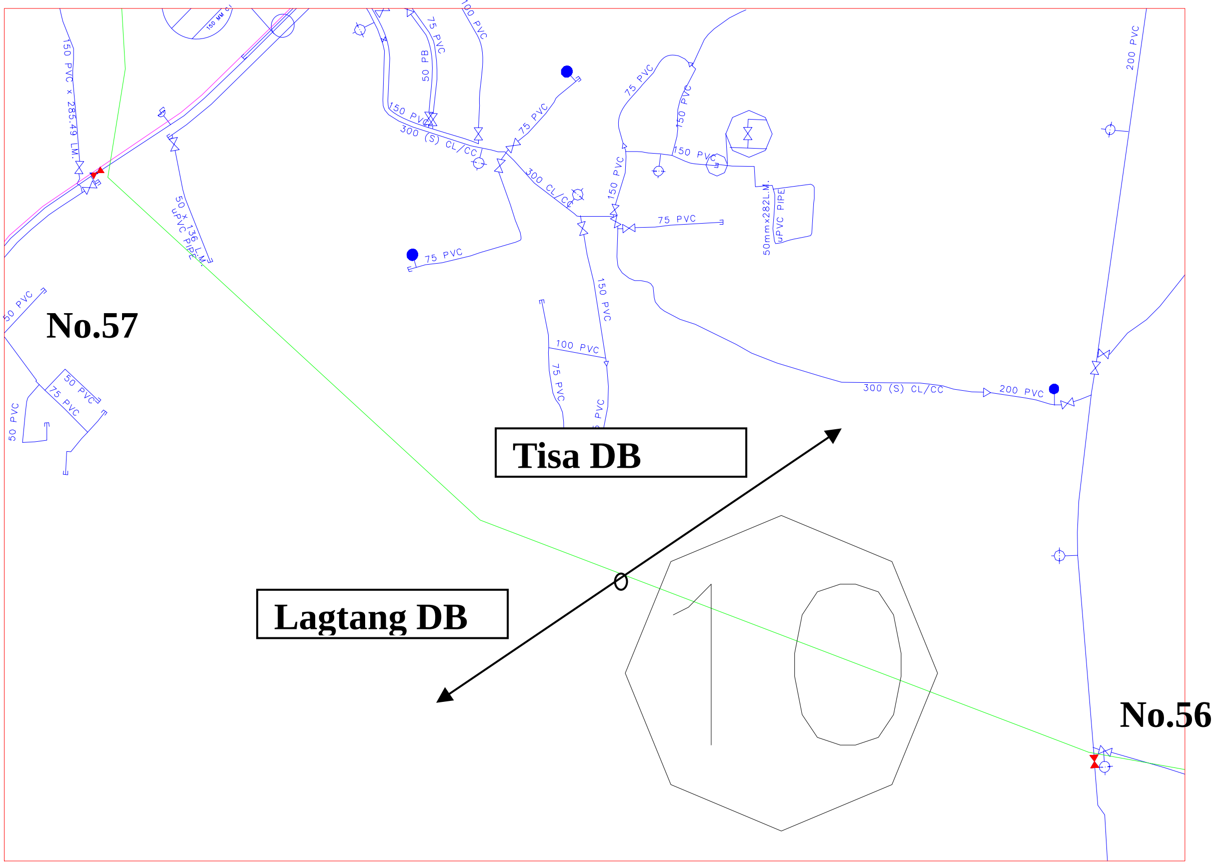

Talamban DB
Casili DB
No.9
No.10
No.11
No.12
4
100 PVC
75 PVC
150 PVC
50 PVC
350 C.I
150 C.I
100 PVC - 0.70 M.

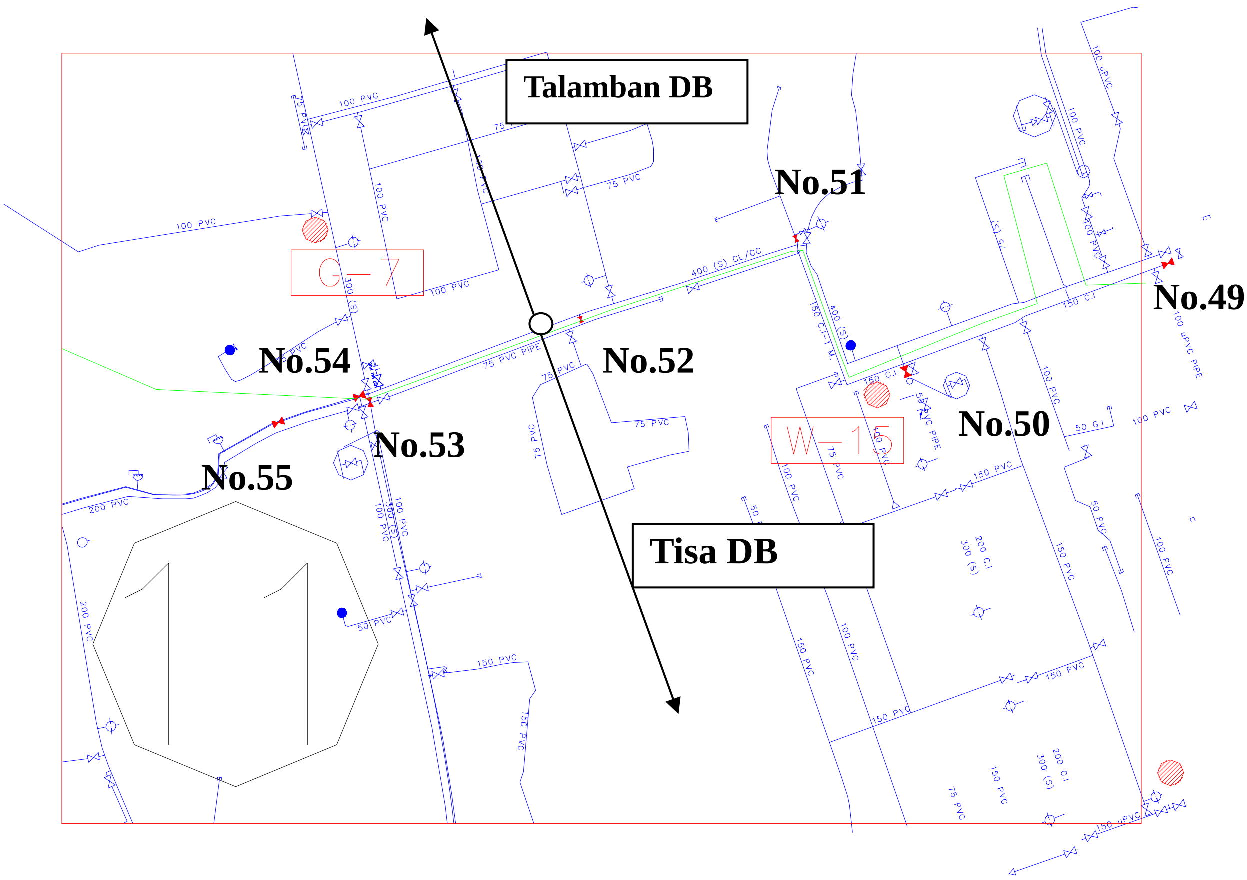

Talamban DB
No.20
No.19
No.21
No.22
No.18
No.17
No.15
No.14
No.23
No.16
Tisa DB
No.13
100 PVC x 504 LM.
150 x 560.5 L.M. uPVC PIPE
50 PVC x 107 LM.
50 PVC x 101 LM.
50 PVC x 129 LM.
100 PVC x 298 LM.


No.37
No.36
No.33
No.35
No.32
No.34
Tisa DB
Talamban DB
No.20
No.21
No.22
No.27 to 31
No.24
No.23
No.25
No.26


No.42 to 44
No.41
Tisa DB
Talamban DB
No.38
No.40
No.39
No.37
No.36
No.33
No.35
No.32
No.34


Talamban DB
No.49
No.50
No.48
Tisa DB
Talamban DB
No.46, 47
No.45
400 (S) CL/CC-1.2 M.
200 C.I – 1.0 M.
100 uPVC
100 PVC
150 PVC
150 uPVC
50 PVC
75 PVC
W-17


No.57
Tisa DB
Lagtang DB
10
No.56


Talamban DB
No.51
No.49
No.54
No.52
No.50
No.53
No.55
Tisa DB
11
G-7
W-15

2) Water Demand of each Distribution Block in 2015

➢ Distribution Block Demand Estimation

In III-2 Water Supply Demand Projection, domestic niche demand of each LGU in 2007 is not described but only total MCWD demand is figured as 98,705 m^3/day. In this report, then, projected future demand is divided into each city/municipality based on the actual local consumption as of Dec. 2008 and projected increase volume up to target year. Due to the shortage of data, Lapu-lapu City and Cordova is summed up to one group. Adjusted result is shown in Table C.II-09. Projected increase volume, in Table C.II-10 comes from Table C.II-11

Table C.II-09 Projection of Future Demand of Each LGU

LGU	Demand (m^3/d)						
	(A). DEC. 2008	(B). Projected Increase from 2007 to 2015	(A)+(B)	Adjusted 2015 volume	(C). Projected Increase from 2007 to 2030	(A)+C	Adjusted 2030 volume
Cebu	72,198	23,362	95,560	95,303	51,994	124,192	123,962
Mandaue	16,444	15,901	32,345	32,258	36,656	53,100	53,002
Talisay	6,453	8,227	14,680	14,641	19,829	26,282	26,234
Laplap & Cordova	13,186	18,606	31,792	30,509	44,622	57,808	56,526
C.L.C area	9,590	5,860	15,450	15,409	16,971	26,561	26,513
Consolacion	4,543	2,810	7,353	7,333	6,118	10,661	10,641
Liloan	4,357	2,343	6,700	6,682	8,534	12,891	12,868
Compostela	690	707	1,397	1,394	2,319	3,009	3,004
Total	117,871		189,827	188,120		287,943	286,237

Table C.II-10 Increasing Volume from 2007 to Target Year

LGU	Increase Volume 2007-2015	Increase Volume 2007-2030
Cebu City	23,362	51,994
Lapu-lapu	16,788	40,652
Cordova	1,818	3,970
Lapu-lapu +Cordova	18,606	44,622
Mandaue	15,901	36,656
Compostela	707	2,319
Consolacion	2,810	6,118
Lilo-an	2,343	8,534
Talisay City	8,227	19,829

For example Increase volume 2007-2015 of Cebu City is 31,837-8,475=23,362 m^3/day as shown in table above

Table C.II-11 Result of Niche Water Demand Projection (m^3/day)

	Niche Demand	2007	2010	2015	2020	2025	2030
Cebu City	Residential, Commercial	0	6,418	18,286	24,835	32,603	41,722
	Communal	8,475	10,189	13,551	15,034	16,710	18,747
	Total	8,475	16,607	31,837	39,869	49,313	60,469
Lapu-lapu	Residential, Commercial	0	3,940	11,784	16,847	23,349	31,615
	Communal	3,416	5,183	8,420	9,638	10,915	12,453
	Total	3,416	9,123	20,204	26,485	34,264	44,068
Mandaue	Residential, Commercial	0	3,343	10,027	14,361	19,815	26,632
	Communal	1,831	3,946	7,705	9,007	10,305	11,855
	Total	1,831	7,289	17,732	23,368	30,120	38,487
Compostela	Residential, Commercial	0	143	491	795	1,227	1,839
	Communal	118	189	334	404	491	598
	Total	118	332	825	1,199	1,718	2,437
Consolacion	Residential, Commercial	0	949	2,646	3,525	4,560	5,763
	Communal	31	85	195	246	309	386
	Total	31	1,034	2,841	3,771	4,869	6,149
Cordova	Residential, Commercial	0	559	1,553	2,072	2,681	3,400
	Communal	150	238	415	497	597	720
	Total	150	797	1,968	2,569	3,278	4,120
Lilo-an	Residential, Commercial	0	438	1,728	3,057	5,776	7,250
	Communal	120	326	735	919	1,138	1,404
	Total	120	764	2,463	3,976	6,914	8,654
Talisay City	Residential, Commercial	0	2,214	6,506	9,138	12,432	16,517
	Communal	1,019	1,611	2,740	3,208	3,716	4,331
	Total	1,019	3,825	9,246	12,346	16,148	20,848
Total	Residential, Commercial	0	18,002	53,020	74,630	102,444	134,738
	Communal	15,160	21,767	34,095	38,953	44,181	50,494
	Total	15,160	39,769	87,115	113,583	146,625	185,232
Demand Adjustment	Residential, Communal	98,705	98,705	98,705	98,705	98,705	98,705
	Government	2,300	2,300	2,300	2,300	2,300	2,300
	Niche Demand	116,165	140,774	188,120	214,588	247,630	286,237

As to the breakdown, domestic demand is calculated by reducing projected commercial volume in Table C.II-11 and fixed government demand from total volume of each LGU. Table C.II-12 and 13 show breakdown of demand in each LGU and DB.

Table C.II-12 Breakdown of Water Demand by LGU

LGU	.	Water Demand (m^3/d) Dec. 2008	2015	2030
Cebu	Domestic	61,439	79,452	102,915
	Commerce	8,601	13,551	18,747
	Government	2,158	2,300	2,300
	Total	72,198	95,303	123,962
Mandaue	Domestic	14,584	24,553	41,147
	Commerce	1,860	7,705	11,855
	Government	0	-	-
	Total	16,444	32,258	53,002
Talisay	Domestic	6,286	11,901	21,903
	Commerce	167	2,740	4,331
	Government	0	-	-
	Total	6,453	14,641	26,234
Laplap & Cordova	Domestic	10,455	21,674	43,353
	Commerce	2,731	8,835	13,173
	Government	0	-	-
	Total	13,186	30,509	56,526
Consolacion	Domestic	4,511	7,138	10,255
	Commerce	32	195	386
	Government	-	-	-
	Total	4,543	7,333	10,641
Lilo-an	Domestic	4,322	5,947	11,464
	Commerce	35	735	1,404
	Government	-	-	-
	Total	4,357	6,682	12,868
Compostela	Domestic	675	1,060	2,406
	Commerce	15	334	598
	Government	-	-	-
	Total	690	1,394	3,004
Total	Domestic	102,271	151,725	233,443
	Commerce	13,442	34,095	50,494
	Government	2,158	2,300	2,300
	Total	117,871	188,120	286,237

Table C.II-13 Breakdown of Water Demand by DB

Distribution Block	.	Water Demand (m3/d) Dec. 2008	2015	2030
Lagtang	Domestic	6,286	11,901	21,903
	Commerce	167	2,740	4,331
	Government	-	-	-
	Total	6,453	14,641	26,234
Tisa	Domestic	31,664	41,315	53,516
	Commerce	3,268	5,149	7,124
	Government	2,158	2,300	2,300
	Total	37,090	48,764	62,940
Talamban	Domestic	29,775	38,137	49,399
	Commerce	5,333	8,402	11,623
	Government	0	-	-
	Total	35,108	46,539	61,022
Casili	Domestic	14,584	24,553	41,147
	Commerce	1,860	7,705	11,855
	Government	0	-	-
	Total	16,444	32,258	53,002
CLC	Domestic	9,509	14,145	24,125
	Commerce	82	1,264	2,388
	Government	-	-	-
	Total	9,590	15,409	26,513
Mactan	Domestic	10,455	21,674	43,353
	Commerce	2,731	8,835	13,173
	Government	-	-	-
	Total	13,186	30,509	56,526
Total	Domestic	102,271	151,725	233,443
	Commerce	13,442	34,095	50,494
	Government	2,158	2,300	2,300
	Total	117,871	188,120	286,237

Assuming regionally flat NRW rate of 30% in 2007, 20% in 2015 and 17% in 2030, total demand including NRW is calculated.

2008 December consumption volume comes from summation of consumption volume of each billing zone within the LGU. Since Cordova consumption and Lapu-lapu City consumption is not clearly demarcated in the data, consumed volume is summed up into one "Lapu-lapu & Cordova" category.

Table C.II-14 Distribution Block Demand

Area Group	Distribution	Dec-2008 w/o NRW	Dec-2008 with NRW (30%)	2015 w/o NRW	2015 with NRW (20%)	2030 w/o NRW	2030 with NRW (17%)
South	Lagtang	6,453	9,219	14,641	18,301	26,234	31,607
	Tisa	37,099	52,986	48,764	60,956	62,940	75,831
	Talamban	35,108	50,154	46,539	58,173	61,022	73,521
North	Casili	16,444	23,491	32,258	40,323	53,002	63,858
	CLC	9,590	13,701	15,409	19,261	26,513	31,943
	Mactan	13,186	18,836	30,509	38,136	56,526	68,104
Total		117,871	168,387	188,120	235,150	286,237	344,864

Table C.II-15 Daily Consumption by Billing Zone in 2008 Dec.

Zone	City/Municipality	Daily Consumption	
1	Cebu City	4,811	
2		6,965	
3		2,969	
4		5,594	
5		3,494	
6		2,796	
7		3,134	
8		2,764	
9		3,153	
10		3,273	
11		4,807	
12		2,571	
13		6,925	
14		3,470	
15		7,886	
16		4,995	
17	Mandaue City	8,672	5% of this zone volume is consumed in Cebu City
18		8,206	
19		12,659	
19-1	Consolacion	4,543	
19-2	Lilo-an	4,357	
19-3	Lapu-lapu City (Except MEPZ)	3,759	Only Opon Channel side
20		16,570	
20-1	Talisay	6,453	
20-2	Compostela	690	
20-3	Cordova	9,426	Include MEPZ, Cordova and Lapu-lapu City except Opon Channel side
20-4	MEPZ	-	
21	Government	2,158	This volume is consumed in Cebu city
Total		117,871	

➢ **Demand Projection by City/Municipality including NRW**

To estimate increasing volume from 2007 to 2015, demand including NRW is calculated by each LGU. Domestic volume between Lapu-lapu City and Cordova is estimated assuming 0.89 to 0.11 consumption rate considering the 2007 Dec. connection number. Domestic connection number in Lapu-lapu City is 7,780 and that in Cordova is 980.

Table C.II-16 Increasing Volume from 2007 to 2015 by LGU

	2007 Supply (in m^3/d with 30% of NRW)			2015 Supply (in m3/d with 20% of NRW)		
	Domestic	Commercial	Total	Domestic	Commercial	Total
Compostela	725	169	894	1,325	418	1,743
Lilo-an	6,085	171	6,256	7,434	918	8,352
Consolacion	6,361	44	6,405	8,922	244	9,166
Mandaue	20,768	2,616	23,384	30,691	9,632	40,323
Cebu	90,663	12,107	102,770	102,190	16,939	119,129
Talisay	7,779	1,456	9,235	14,876	3,425	18,301
Lapu-lapu	10,602	4,880	15,482	24,113	10,525	34,638
Cordova	1,310	214	1,524	2,980	518	3,498
Total	144,293	21,657	165,950	192,531	42,619	235,150

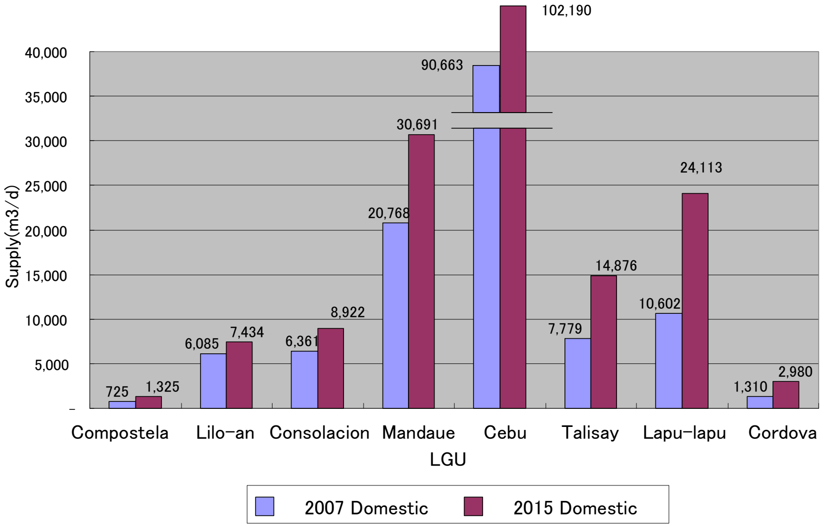


Figure C.II-09 Domestic Demand Projection

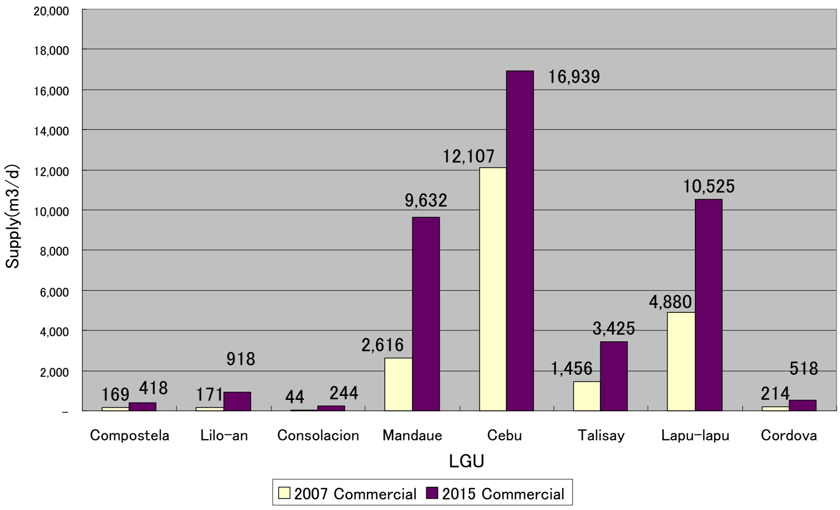


Figure C.II-10 Commercial Demand Projection

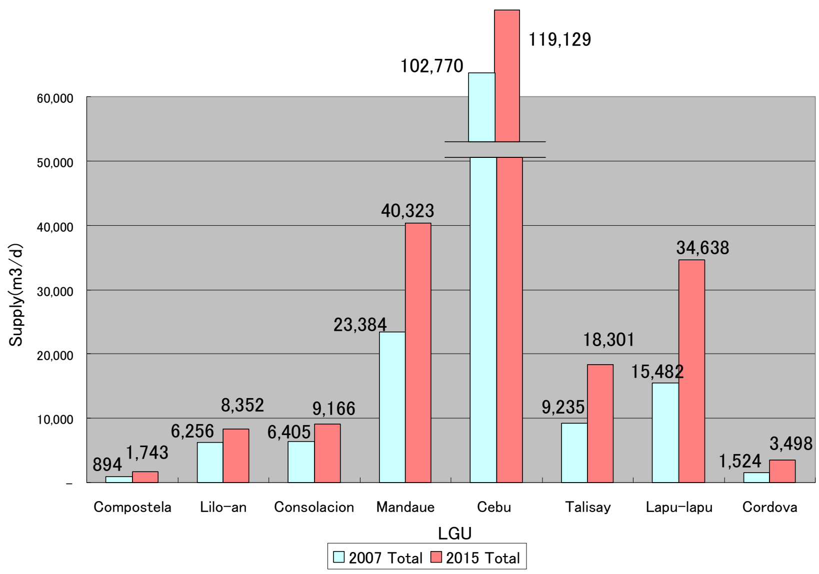


Figure C.II-11 Total Demand Projection

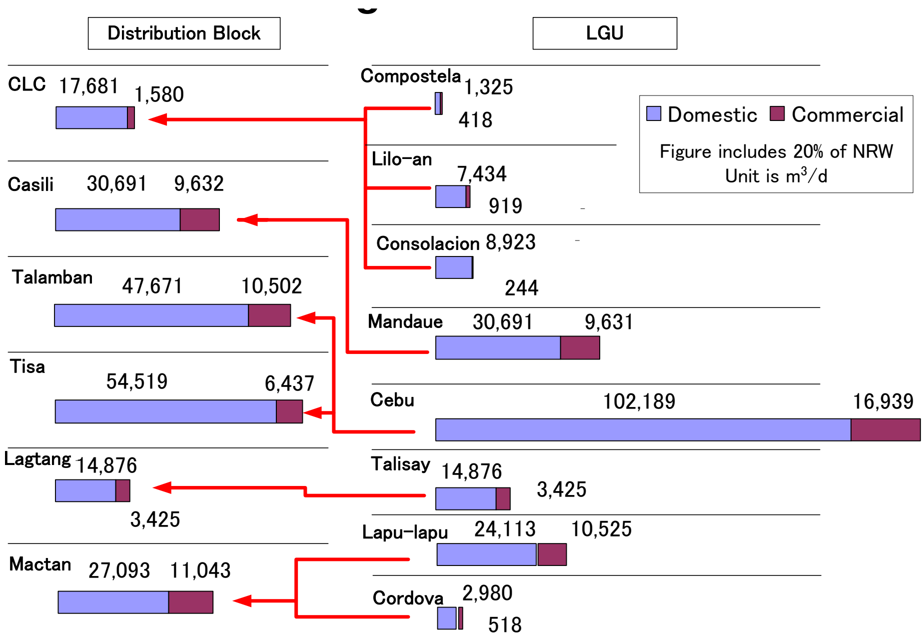


Figure C.II-12 Demand Re-alignment

3) Allocation for Water Source and Water Supply

Demand-Supply balance of each distribution balance is shown in Figure C.II-13. Breakdown of the supply is also shown in Figure C.II-14 and Figure C.II-15.

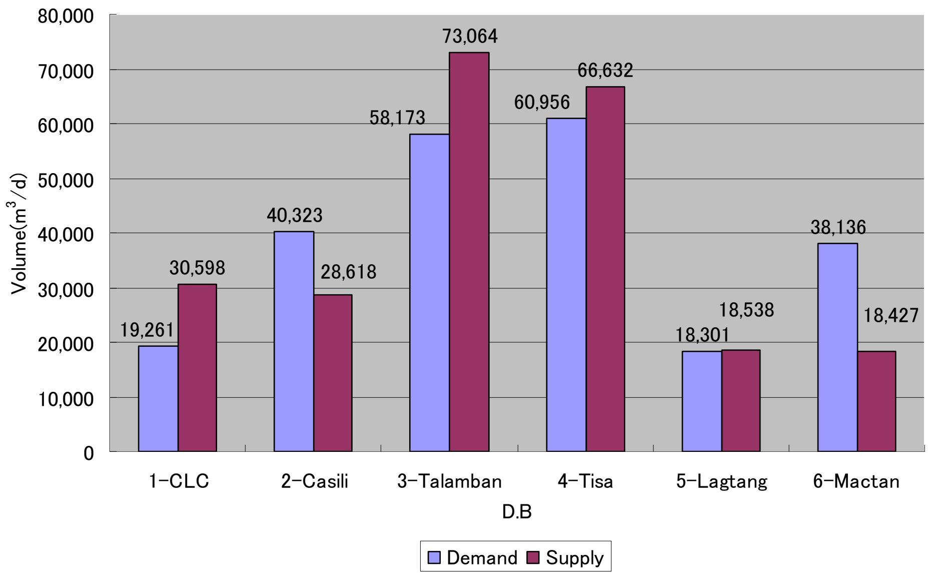


Figure C.II-13 Demand-Supply Balance

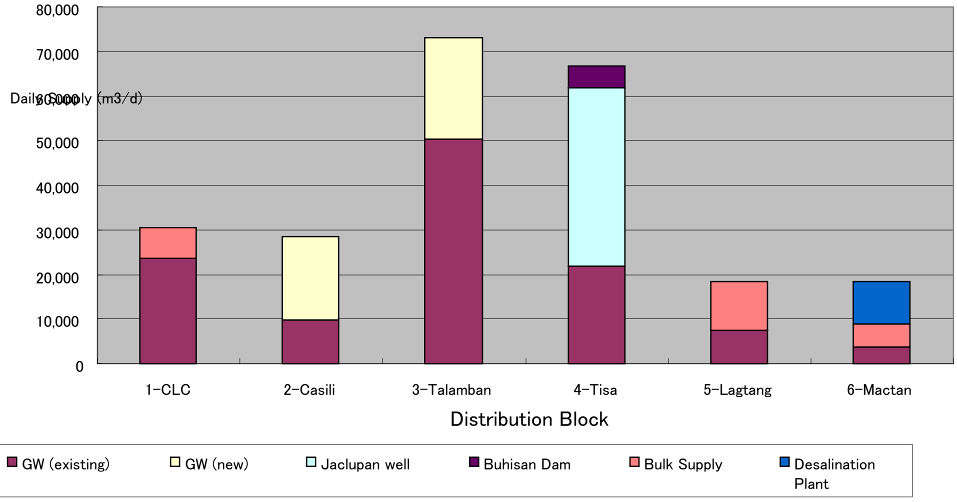


Figure C.II-14 Breakdown of Water Supply Source

Table C.II-17 Demand-Supply Balance by DB and Water Source

DB	Demand (m^3/d)	Supply (m^3/d)							Supply-Demand (m^3/d)
		GW (existing)	GW (new)	Jaclupan well	Buhisan Dam	Bulk Supply	Desalination Plant	Total	
1-CLC	19,261	23,598				7,000		30,598	11,337
2-Casili	40,323	9,918	18,700					28,618	-11,705
3-Talamban	58,173	50,264	22,800					73,064	14,891
4-Tisa	60,956	21,932		40,000	4,700			66,632	5,676
5-Lagtang	18,301	7,538				11,000		18,538	237
6-Mactan	38,136	3,827				5,000	9,600	18,427	-19,709
Total	235,150	117,077	41,500	40,000	4,700	23,000	9,600	235,877	727

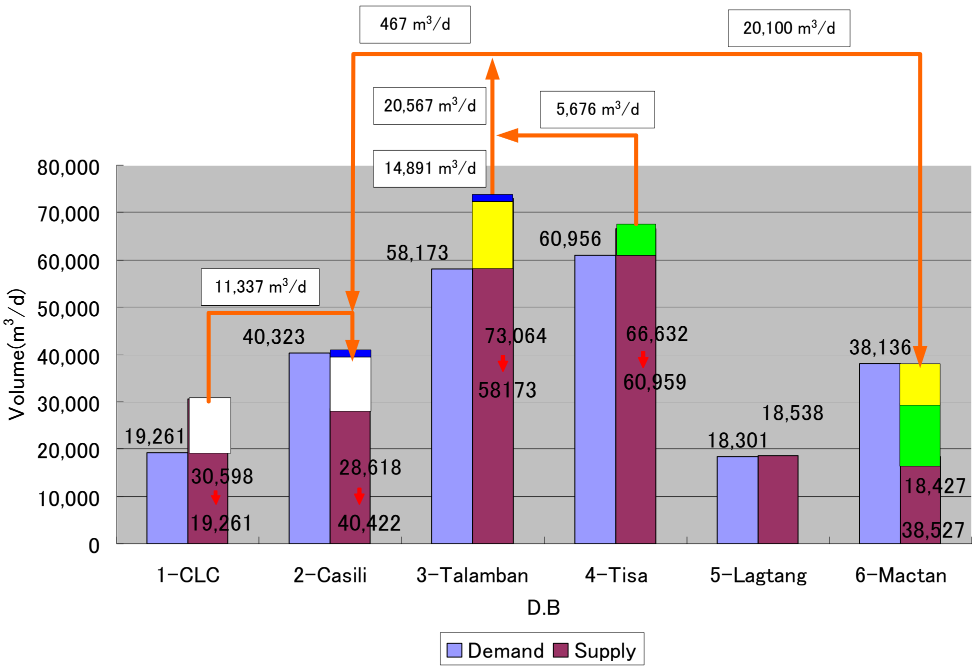


Figure C.II-15 Demand-Supply Balance

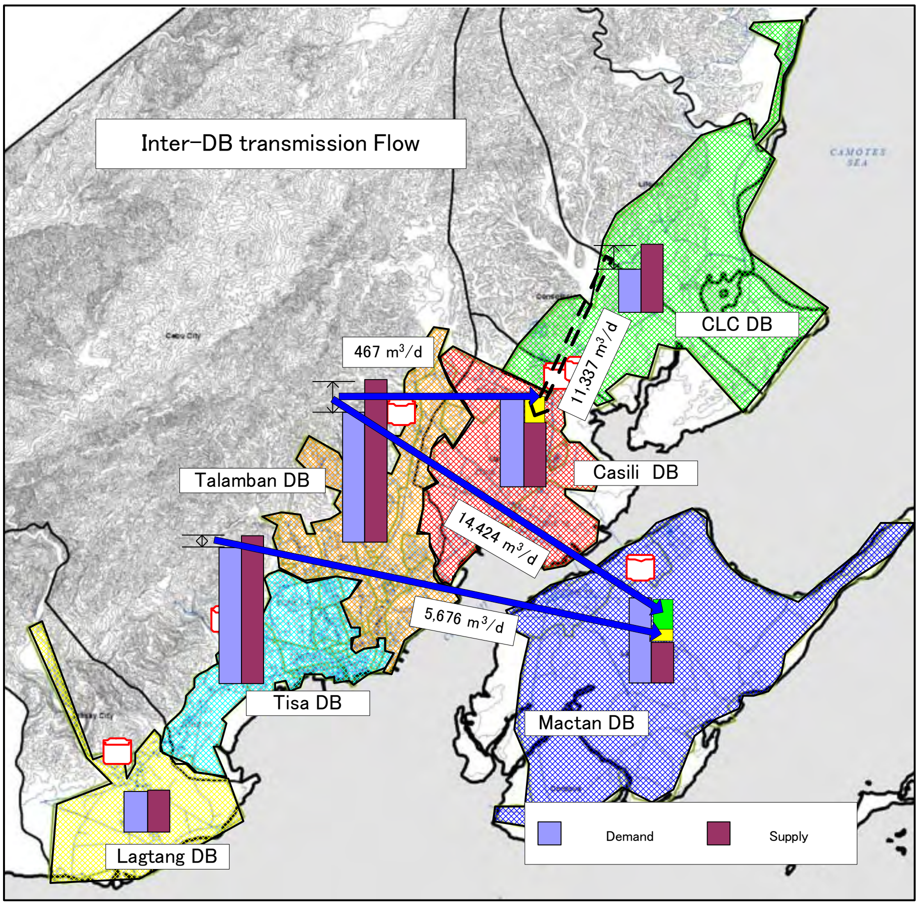


Figure C.II-16 Demand-Supply Balance

(4) Improvement of Water Supply Facility

1) Jaclupan Facility Improvement

Intake volume from Jaclupan Well field varies every month due to the fluctuation of underground water level mainly in accordance with rainfall as shown in the Figure below.

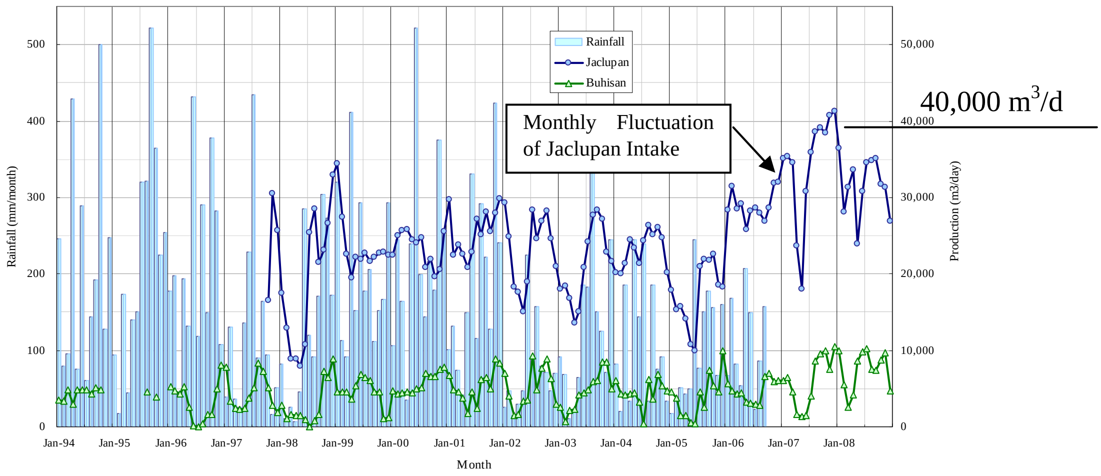


Figure C.II-17 Intake Facilities in Jaclupan

To reduce the river bed water seepage and also to keep its water level as constant as possible, additional underground wall is recommended to construct at the lower side of existing weir structure as is shown in the figure.

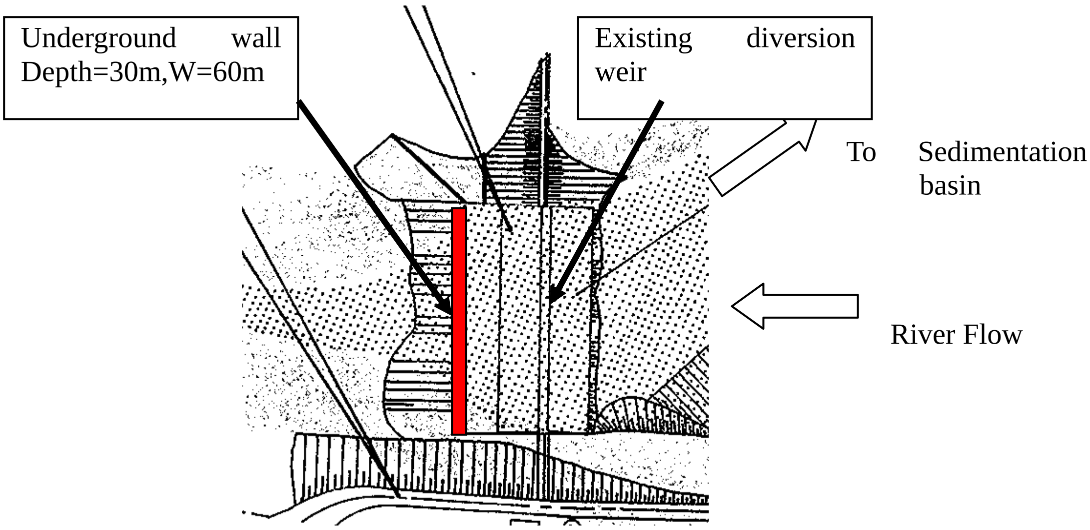


Figure C.II-18 Jaclupan Conversion Weir and new underground wall location

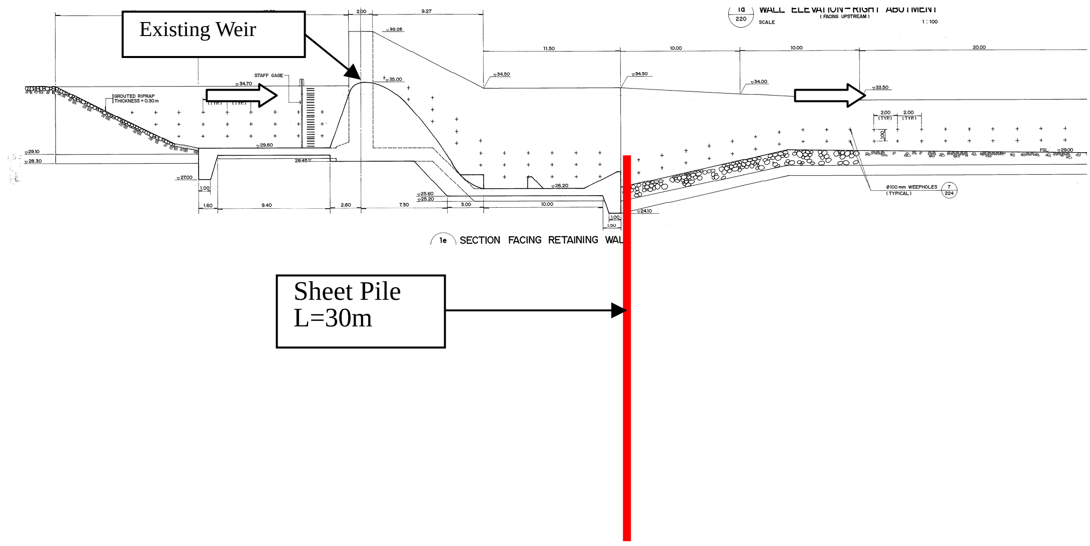


Figure C.II-19 Jaclupan Conversion Weir and new underground wall Section

Existing Jaclupan pump abstraction level is nearly 30m from ground level, so above illustrated sheet pipe can help raise groundwater level within Jaclupan well field.

Underground wall type is sheet pipe wall-type since it is less expensive than soil mixing wall-type

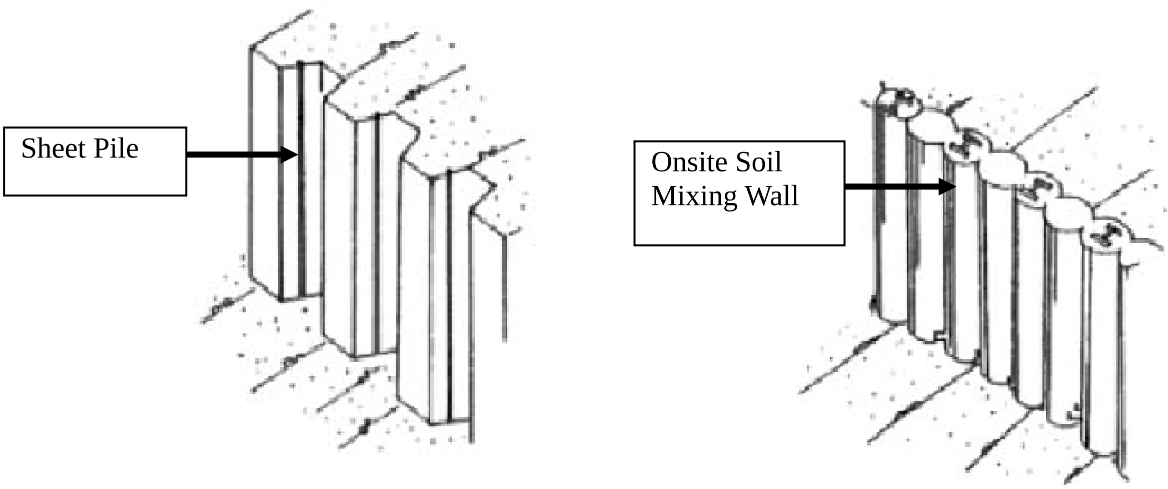


Figure C.II-20 Wall Type

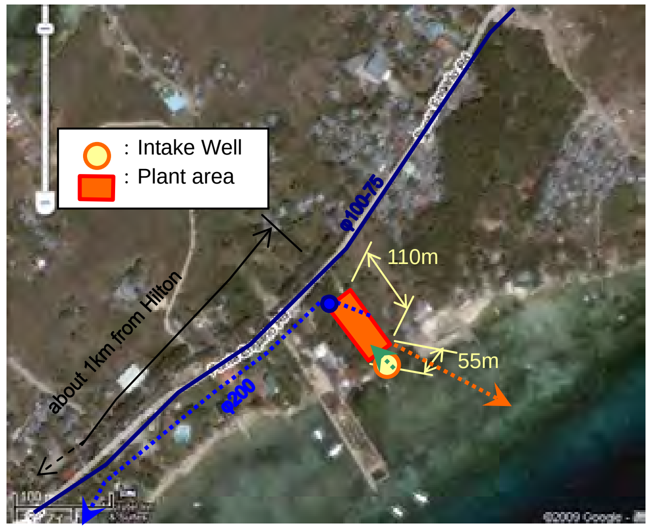
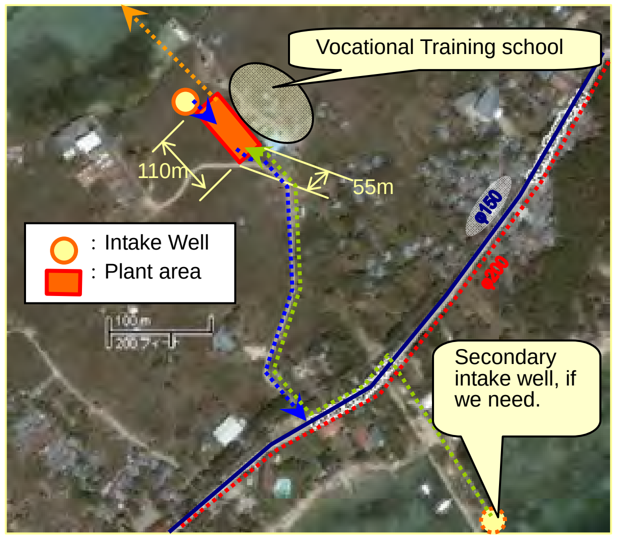
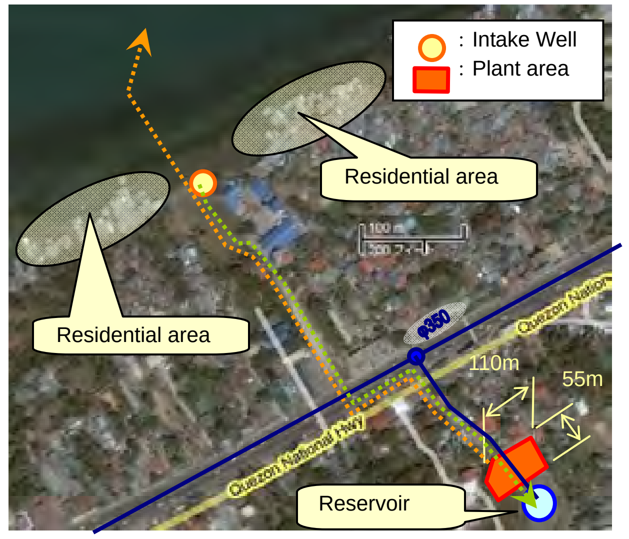
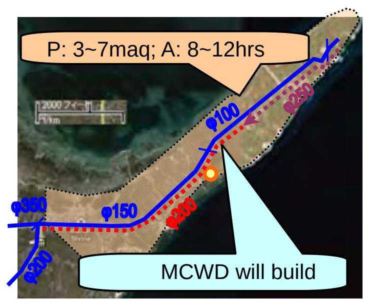
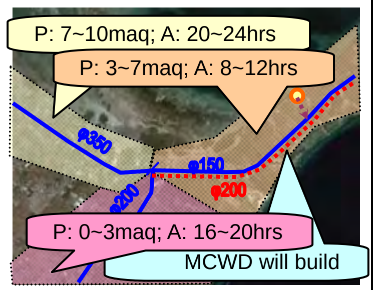
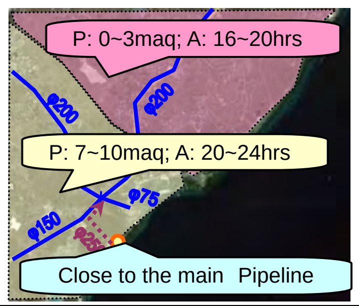
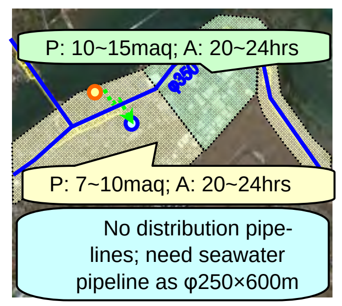
2) Desalination Plant Development

Capacity of the desalination plant as of 2015 is 9,600 m^3/d and it can be expanded in future in case water source supply from outside of MCWD jurisdiction is insufficient. Location, intake/discharge system, treatment system of the plant and treated water usage is determined based on the two technical report, one is “Feasibility Study of Seawater Desalination Facility for Water Supply in Metro Cebu – Final Report – September 2005” (JBIC Study 2005) and “Preparatory Survey on the Programme Grant Aid for Environment and Climate Change (Water Technology) in the Republic of the Philippines” (JICA Study 2009). Project outline of the both report is described in the support report.

Since 5,670 m^2 of plant area is required, plant is located in the Site No.2 of JICA Study candidate location shown in Figure xxx considering land availability. Comparison table of location is shown in Table C.II-18 The site recommended in the JBIC study is too far from supply area and is neglected

Figure C.II-21 Location of Desalination Plant

Table C.II-18 Comparison of Candidate sites for Desalination Plant

Number and location	Site No.1 at the south of peninsula 	Site No.2 at the base of the pen-insula 	Site No.3 by the bay of Hadsan cove resort 	Site No.4 by the MCWD R.T. 
Map and site abstract Map: from Google earth				
Raw seawater quality	**Adequate.** ➢ Possibility of good quality seawater. ➢ Some smell and some floating wastes were detected. Should estimate the quality of seawater.	**Adequate.** ➢ Possibility of good seawater quality. ➢ It is possible to intake seawater from either coast; in the case of seawater quality problems.	**Good**. ➢ Maybe, best site to intake seawater based on quality.	**Risky; quality of the raw seawater is not good.** ➢ Detected anaerobic decomposition of organic matter through odor. It comes from wastewater and trash. ➢ Concentrated seawater discharge may affect the coastal environ-ment; need to discharge effluent far from coastline.
Area for plant / intake and desalina-tion	**Wide enough, but a little risky.** ➢ Intake: very near the sea. ➢ Plant: wide enough; but difficult to extend. The foundation of the site is good.	**Very wide.** ➢ Intake: very near the sea. ➢ Plant: wide enough; easy to extend. The foundation of the site is good.	**Very wide.** ➢ Intake: Near the sea, and the coral areas contain clean water. ➢ Plant: wide enough; easy to extend; the foundation of the site is good.	**Wide enough, a little risky.** ➢ Intake: Near the sea. A little far from the Plant. ➢ Plant: enough. The foundation of the site is good. Difficult to ex-tend the plant area.
Wastewater discharging point	**Adequate.** ➢ A little far from resort coast. ➢ Face to open sea	**Adequate.** ➢ Far from resort coast or residential areas	**Adequate, a little risky.** ➢ Far from residential areas, but near the resort coastline. Cleansing chemicals may cause bubbles; resorts may not want to accept such problems.	**Most risky.** ➢ Near residential area. Cleansing chemicals may cause bubbles, so discharging line needs to be extended far from the coastline.
Power supply	**May be able to obtain power.**	**May be able to obtain power.** Need expense to wire for electricity for the Plant	**May be able to obtain power.** Need expense to wire for electricity for the Plant	**May be easy to obtain power.**
Connection to the existing water supply	➢ **Easy** to connect in the constructing pipeline. ➢ Supply to the water shortage area possible, leading to **service availability.** 	➢ **Easy to connect in the constructing pipe-line.** ➢ Supply to the water shortage area possible, leading to service availability, and in-creased pressure. 	➢ **Need** to lay a new pipeline. ➢ Supply to the water shortage area possi-ble, leading to service availability, and in-creased pressure. 	➢ **Easy** to connect in the reservoir. 
Land owner and land cost	Private (Chinese Philippino), may be available at reasonable price.	Private (An American company), may be available at reason-able price.	Private (Chinese Philippino), may be expensive.	Well site: Private (Chinese Philippino), may be available at reasonable price. Plant site: Owned by MCWD.
Resettlement	Not necessary.	Not necessary.	Not necessary.	Not necessary.
Evaluation	**Best alternative site plan.** This site plan is superior in water qual-ity, meeting supply demand. New main pipeline under construction makes it connected.	**Best site plan**. This site plan meets supply service demand, but may be difficult to buy the site in the affordable cost.	This site plan is superior for water quality and in meeting supply demand, but may be difficult to buy the site in the affordable cost.	This plan is the lowest cost required, but lacks water quality, seriously.

Proposed treatment system is drawn in Figure C.II-.22 and rough layout plan of the plant is shown in Figure C.II-23

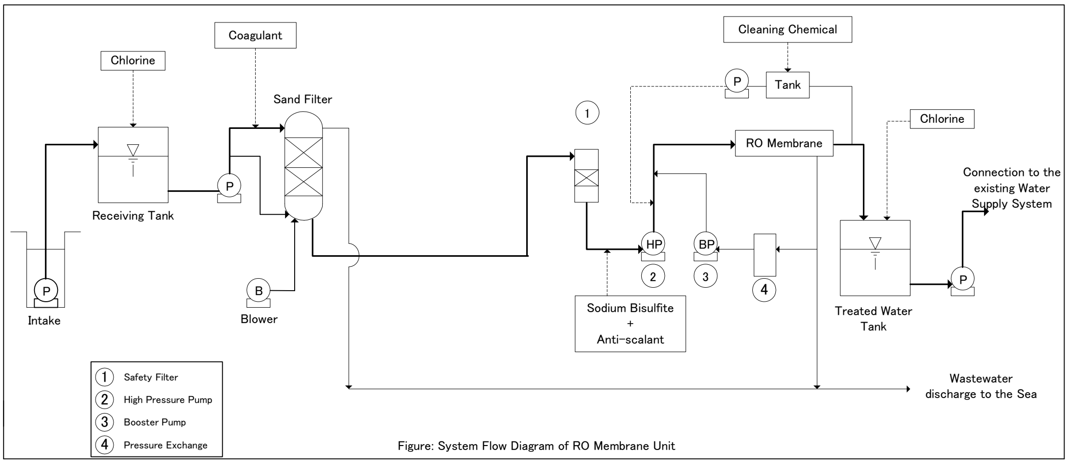


Figure C.II-22 Treatment System

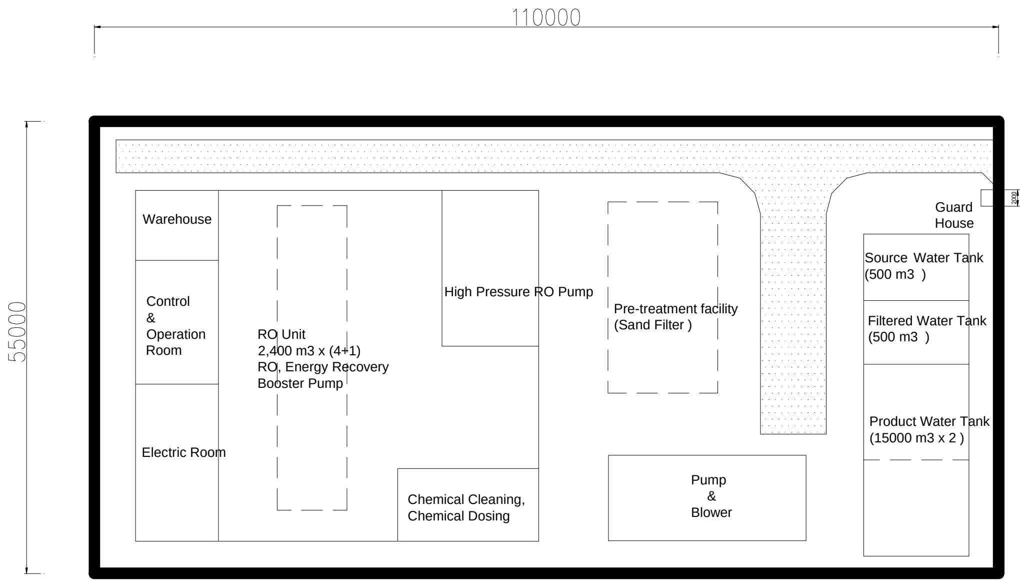


Figure C.II-23 General Layout Plan

Required area for proposed 9,600 m^3/day capacity RO plant is calculated to be 5,670 m^2 (=0.45 x 9,600 + 1,350) from two studies and proposed 6,050m^2 (=110m x 55m) area is enough for construction.

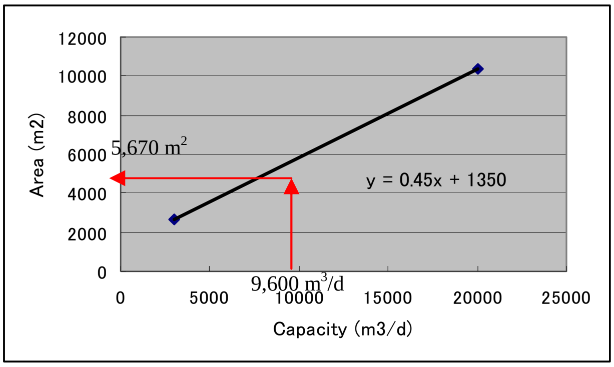


Figure C.II-24 Required area for Desalination plant

Treated water is transmitted to the new reservoir next to the existing Pusok reservoir. Diameter of transmission pipe is 400mm and length is 8.1 km as shown in Figure C.II-25.

Figure C.II-25 Transmission Line from Plant

Construction and O&M cost is estimated based on the following data.

Sea Water Desalination Plant with the capacity of 9,600 m^3/d ;

- **Construction Cost = 9,600 x 26,000 / 1,000,000= 250 million PHP**
- **O&M Cost = 9,600 x 7,500 / 1,000,000= 72 million PHP/year**
- **Land Acquisition Cost is estimated to be 90.75 Million PHP (=6,050 m^2 x 15,000 PHP/m^2)**
- **Transmission Pipe Diameter is 300mm of DCIP, length is 8.1 km**

(Capacity Calculation of Proposed Desalination plant)

a) Design Conditions

- Product water 9,600m^3/day
- Raw seawater/Product water quality
  Raw water TDS 35,000 ~ 38000 mg/L, Ave. 35,900 mg/L[1]
  Product water TDS less than 500 mg/L
- Recovery rate 40 %, 25 ℃
- RO inlet FI (Fouling Index) value less than 4
- RO inlet turbidity less than 0.5 NTU
- Max. operation temperature 45℃
- Free chlorine less than 0.1 mg/L
- pH range 2 to 11

b) Seawater intake facility

Seawater is collected through shallow wells described below.

[1] Source：JBIC (Japan Bank for International Cooperation), 4.2.11 Seawater Design Value, Final Report of Feasibility Study of Seawater Desalination Facility for Water Supply in Metro Cebu, September 2005

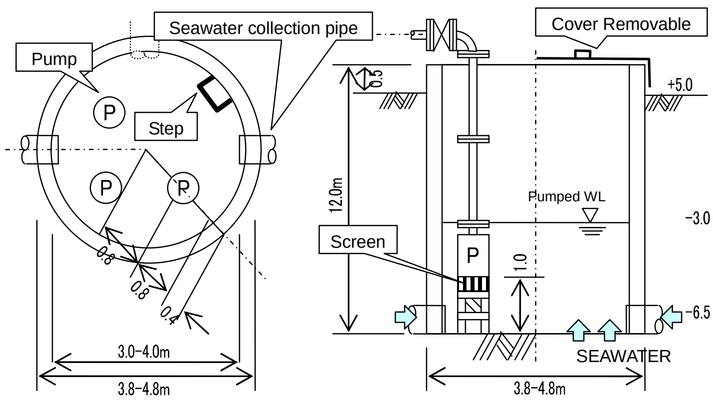


Figure C.II-26 Well for Collecting Seawater

To collect 24,000 m^3/d (=9,600/0.4) of seawater, each of three wells equips following pumps.

200 mm x 2.80 m3/min x 15 m x 15 kw x 3 (one stand-by)

c) Raw water (Seawater) storage tank

15 minutes of intake volume is designed to be storage volume.

V = (24,000 / 24 / 60 x 15) = 250 m^3
B=5.0 x W=5.0 x H=4.0 x 3 units V=300 m^3

d) Pre-treatment

5 module (including 1 stand-by) is designed.

- Feeding pump (Filter Pump)
  Centrifugal pump 32 m^3/hour (768 m^3/day) x 40 mH x 8 unit x 4 module
- Sodium Bisulfite dosing system
  Chemical NaHSO$_3$ Solution (35%)
  Tank 500 L x 3 unit
  Dosing Pump 3.5 L/min x 700 KPa x 0.1 Kw x 230 V x 3 Phase x 60 Hz x 3 unit
- Multi media filter
  Fouling Index, Sludge Density Index values both less than 4 or 3.
  Type Vertical Multi Filtration
  Filter Media Anthracite + Sand
  Dimension 1,830 x 2,400 mmHg / unit (2.7 m^2/unit) x 10 unit
  Operation Velocity 13 m/hour
  Backwash 30 m/hour, once every one or two weeks
- Anti-scalant dosing system
  Tank 500 liter x 3 units
  Dosing Pump 3 ml/ min x 1.57 MPa x 0.02 kW x 230 V x 3 phase x 60 Hz x 10 unit
- Safety filter
  Unit 10 units
  Material Polypropylene
  3 ml/ min x 1.57 MPa x 0.02 kW x 230 V x 3 phase x 60 Hz x 10 unit

e) RO membrane unit

- RO membrane
  Material Polyamide thin composite
  Structure Spiral
  Nominal Capacity 2,400 m^3/day/ unit x 5 unit (including 1 stand-by)
  Production water Total Dissolved Solid
  TDS less than 500 mg/L, within
  WHO standard for drinking water

Salt rejection Not less than 99 %
Feed flow rate (approx.) 250 m^3/hour = 6,000 m^3/day
Recover 40 %
Product flow rate (approx.) 11.7 m^3/day/element
Nos. of elements 206 (=2,400 m^3/day/ 11.7 m^3/day/element)
Max. Feed flow per element 17 m^3/day/element
Dimension of element 8" dia x 40" length
Maximum pressure 6.8 MPa
Maximum pressure drop 70 kPa

- Vessel

Vessel dimension φ284 x 7,700 : (8 inch)
Maximum operating pressure 7.0 MPa
Unit vessel weight 152 kg
Inlet pressure 6.17 to 6.28 MPa
Outlet pressure 0.05 to 0.15 MPa
Brine pressure 5.78 to 5.9 MPa

- High pressure pump

Nos of unit 3
Type Multistage High-pressure Centrifugal Pump
Specification 45m^3/hr x 6.17Mpa x 110KW x 440V x 3phase x 60Hz
Pipe and valve material PVC, SUS 316L, Dupley Stainless Steel

- Booster pump

Nos of unit 3
Type Multistage Centrifugal Pump
Specification 63 m^3/hour x 25 mH x 7.5 KW x 440 V x 3phase x 60Hz
Material 904L, for parts that get wet

- Energy recovery device

Nos of unit 6
Type Positive displacement, ERI, USA or equivalent
Material alloy, ceramic and grass fibered reinforced plastic

f) RO membrane Chemical Cleaning System

- Cleaning Chemical
  Citric acid 20,000 mg/L, need to adjust pH up to 4 by NaOH
  Phosphate compound 20,000 mg/L, need to adjust pH up to 10 by H_2SO_4
- Chemical Tank
  Nos. of unit 3 c/w dome top
  Type Cylindrical
  Capacity 4 m^3
  Material Polyethylene
- Pump
  Nos. of unit 3
  Type Centrifugal
  Specification DNφ100 x 66-108 m^3/hr x 37 to 30 mH x 15 kW x 440 V x 3 phase x 60 Hz
  Material Pump head Stainless Steel 316
  Impeller Stainless Steel 316
  Shaft Stainless Steel 316
- Bag Filter
  Nos. of unit 3
  Housing material Stainless steel Opening 5 μm

- Conditions

Frequency of Chemical cleaning every three months Discharging wastewater Dilution or after neutralization
Operation Semi-automatic

g) Post treatment facility

To inject soda ash for pH adjustment and chlorine for disinfection to serve product water as drinking water.

Table C.II-19 Outline of Post Treatment Facilities

Item		Soda ash dosing for pH adjustment	NaOCl for disinfection
Location		After RO skid	Before distribution
Flow (m^3/day)		2,400 m^3/day	
Dosing Rate (mg/L)		3	1.5
Tank	Unit	3	3
	Type	Cylindrical	Cylindrical
	Capacity (L)	300	300
	Material	Polyethylene	Polyethylene
Feeder	Unit	3	3
	Chemical (kg/day)	3	1.5

- **Outline of Former Desalination Plant Study**

(Outline of the Plant proposed in JICA Study 2009)

Table C.II-20 Outline of the Plant proposed in JICA Study 2009

Item	Facility	Specification	Remarks
1. Design Capacity		3,000 m^3/day	
2. Service Population		20,000 person	
3. Main Facility	(1)Intake Well	Diameter 4.0 m	
	(2)Intake Pump	200mmx2.60m^3/minx15kwx3units	
	(3)Storage Tank	4.0m(W)x5.0m(L)x4.0m(H)	
	(4)Pre-treatment	Sand Filterx3units	
	(5)RO Membrane	1,000m^3/day x 3units	Spiral Type
	(6)Desalinized Water Tank	10.5m(W)x12.0m(L)x4.0m(H)	
	(7)Wastewater Tank	4.0m(W)x5.0m(L)x4.0m(H)	
	(8)Generator	750 kvA	
	(9)Others	Administration Building, Road, Drainage	Excluding the fence and gate

（Treatment System）

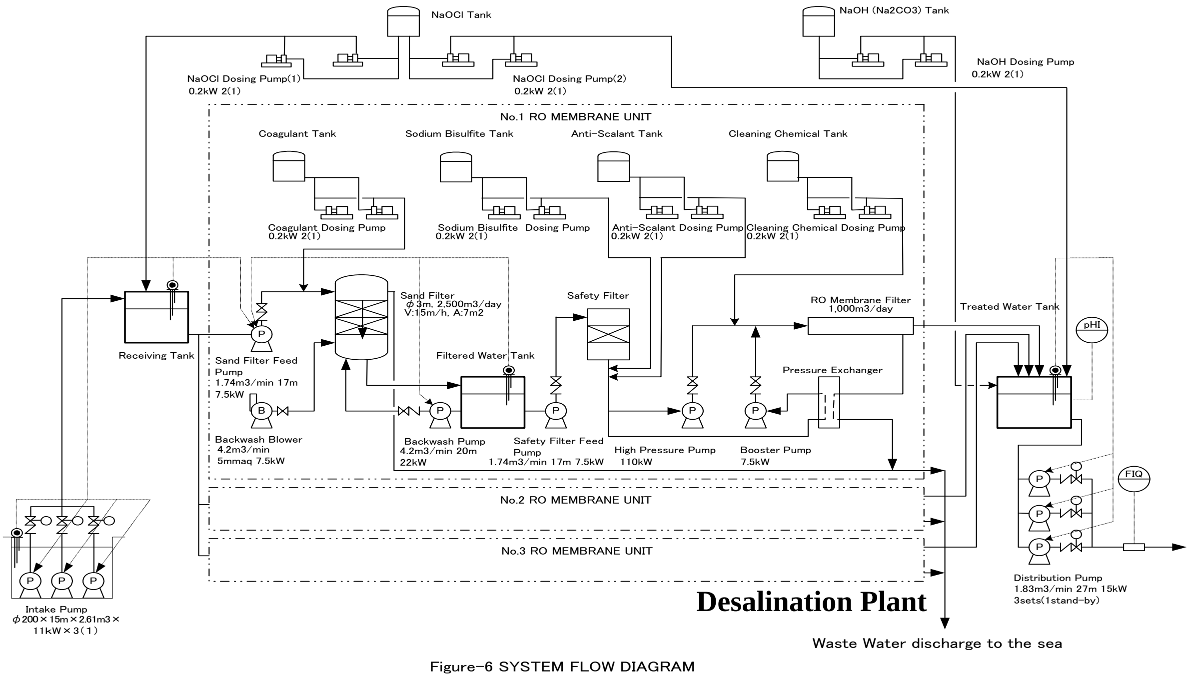


Figure C.II-27 Flow Diagram

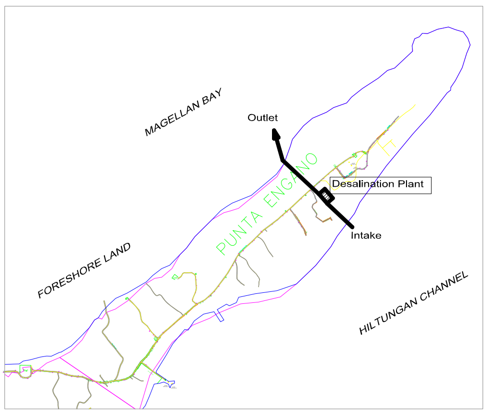
(Layout Plan)

(Outline of the Plant proposed in JBIC Study 2005)

Outline of the plant is described in Table C.II-21.

System flow is as follows

Candidate site was a little north of JICA study site. Layout plan is shown in following figure



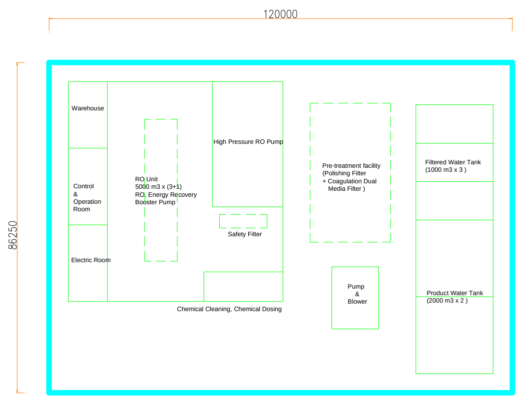


Figure C.II-28 Location

Figure C.II-29 Layout Plan

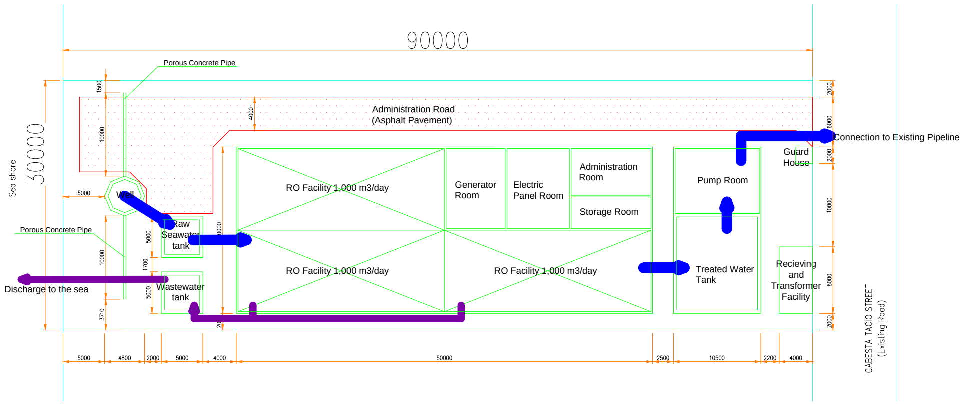


Figure C.II-30 Water Flow

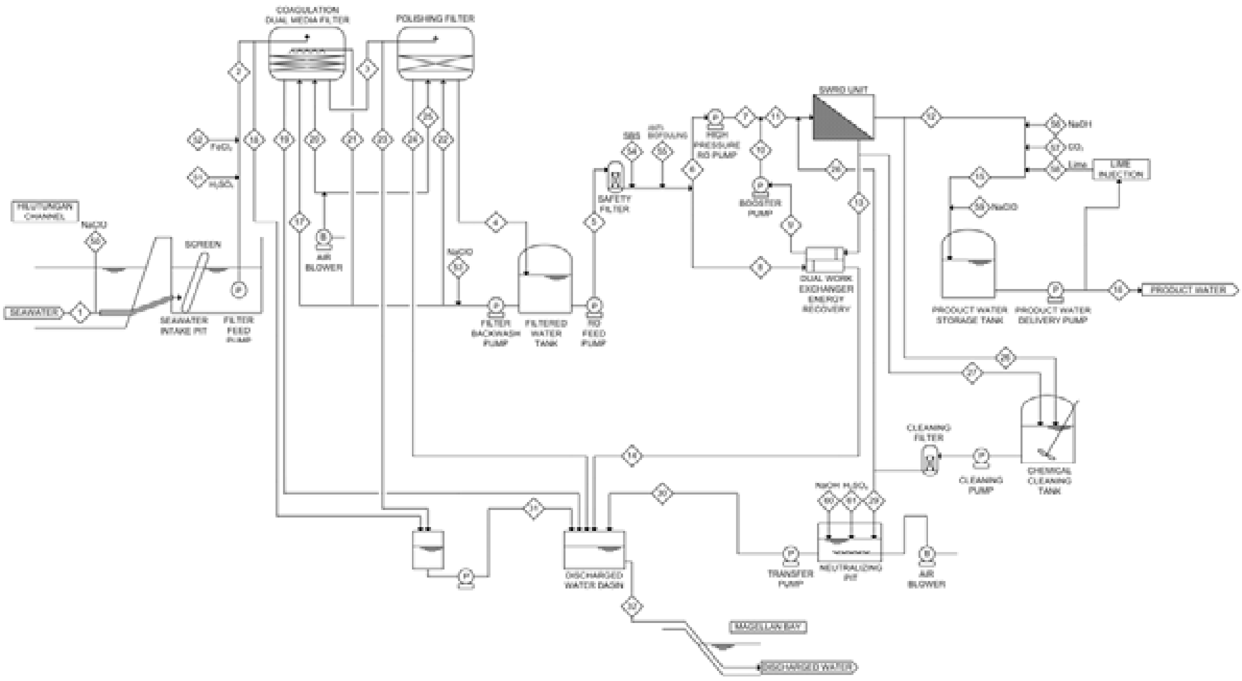


Figure C.II-31 System Flow

Table C.II-21 Outline of the JBIC Project

Item		Content
Project Name		Punta Engaño SWRO Desalination Project (SWRO=Sea Water Reverse Osmosis)
Location		Punta Engaño, Lapu-lapu City
Primary Water Use		Industry （MEPZ）
Total Production Capacity		15,000 m^3/day (with additional 5,000 m^3/day capacity for O&M or Stand-by)
Desalination Facility Description		
	Intake	Shore intake (under seawater) from Hilutungan Channel, Intake volume is 20,000 m^3/day
	Pretreatment	Design Flow 30,000 m^3/day =1,250 m^3/hour , Coagulation dual media filter + Polishing Filter (6+1stand-by) SDI (Silt Density Index) <3.5
	Main Treatment	Single Stage Reverse Osmosis System, 3+1stand-by unit, 5,000 m^3/day per unit Membrane Type;Spiral Wound Type, Material; Polyamide(PA)
	Post Treatment	Product Water 625 m^3/day Sodium Hypochlorite (NaClO) ; Disinfection. Sodium Hydroxide (NaOH) ; pH Adjustment Lime (Cao, $Ca(OH)^2$) ; Langelier Saturation Index and taste control
	Brine Disposition	Return to sea of Magellan Bay
	Recovery Ratio	50%
	Feed-water Description	Total Dissolved Solution 35,000 mg/l, Water Temperature 30°
	Product-water Description	TDS <500 mg/l, Boron <2.0 mg/l, pH:7.5-8.5, LSI: slightly positive
	Operation Pressure Range	5.5 – 6.0 MPa
	Energy Recovery	Dual Work Exchanger Energy Recovery (DWEER)
	Energy Source	New 13.8 kV distribution line of 10Km from new 138 kV substation of TRANSCO (The National Transmission Corporation)
	Specified Electricity Consumption	3.4kWh/m^3
Start-up Date		2010 (planned)
Project Delivery Method		Undecided

3) Tisa WTP Improvement

Although existing facility also equips rapid sand filter as stand-by facility or for emergency use, facility are already deteriorated and new construction is desirable. Treatment flow has varied every month as monthly precipitation varies. Although average flow is 4,700 m^3/day in 2015, maximum capacity should be 10,000 m^3/day based on the past performance below/

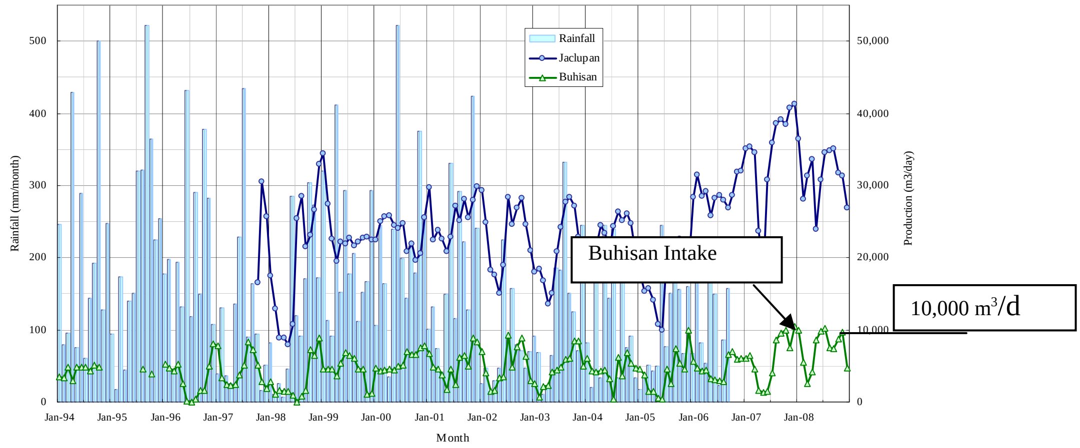


Figure C.II-32 Buhisan Intake

Treatment flow is as follows.

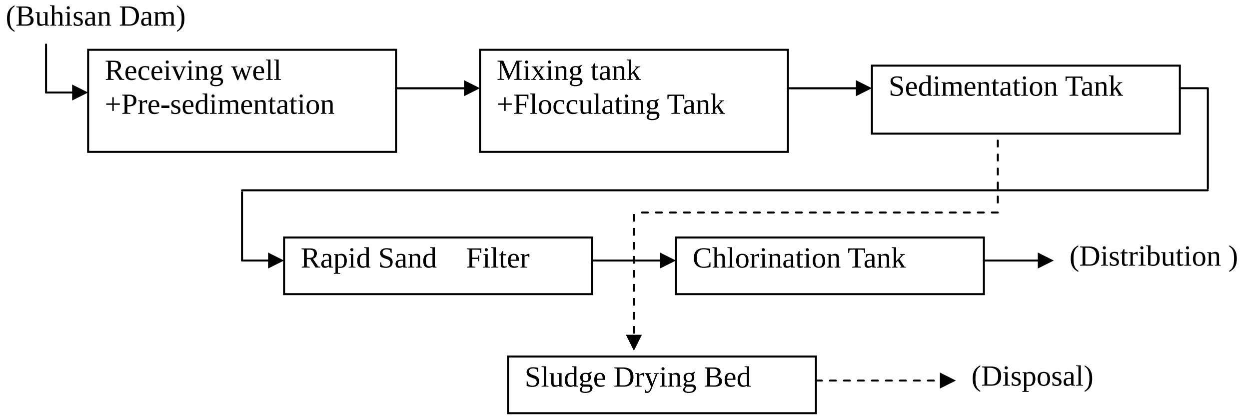


Figure C.II-33 Flow Sheet of Proposed Treatment Plant

Rough alignment of the facility is described in Figure C.II-25 based on the capacity calculation of the plant and hydraulic profile is in the Figure C.II-26. Capacity calculation is shown in Table C.II-22.

Water quality of existing Tisa WTP is described in Table C.II-22, which shows only Calcium Hardness does not clear the National Drinking Standard.

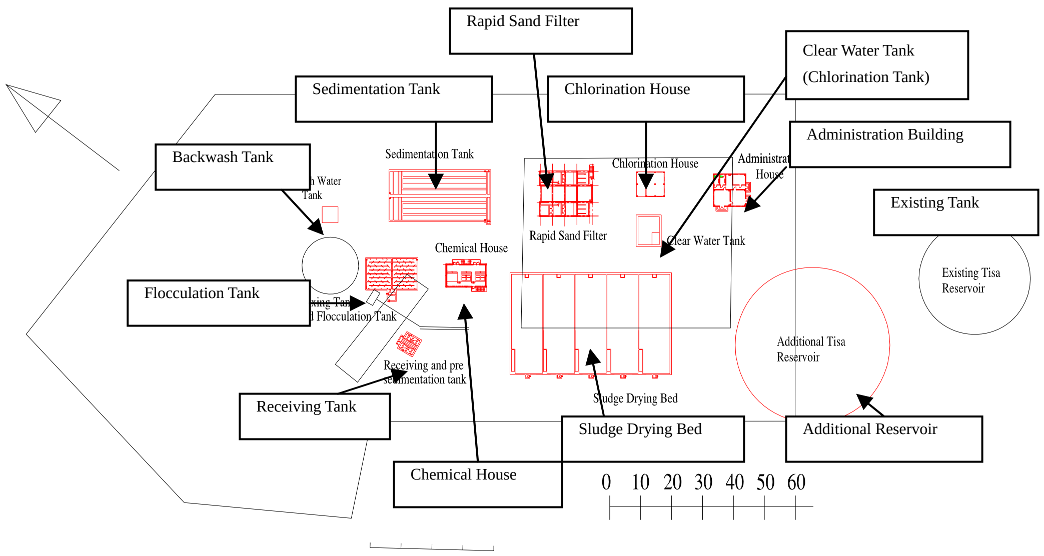


Figure C.II-34 Proposed Treatment Plant Facility

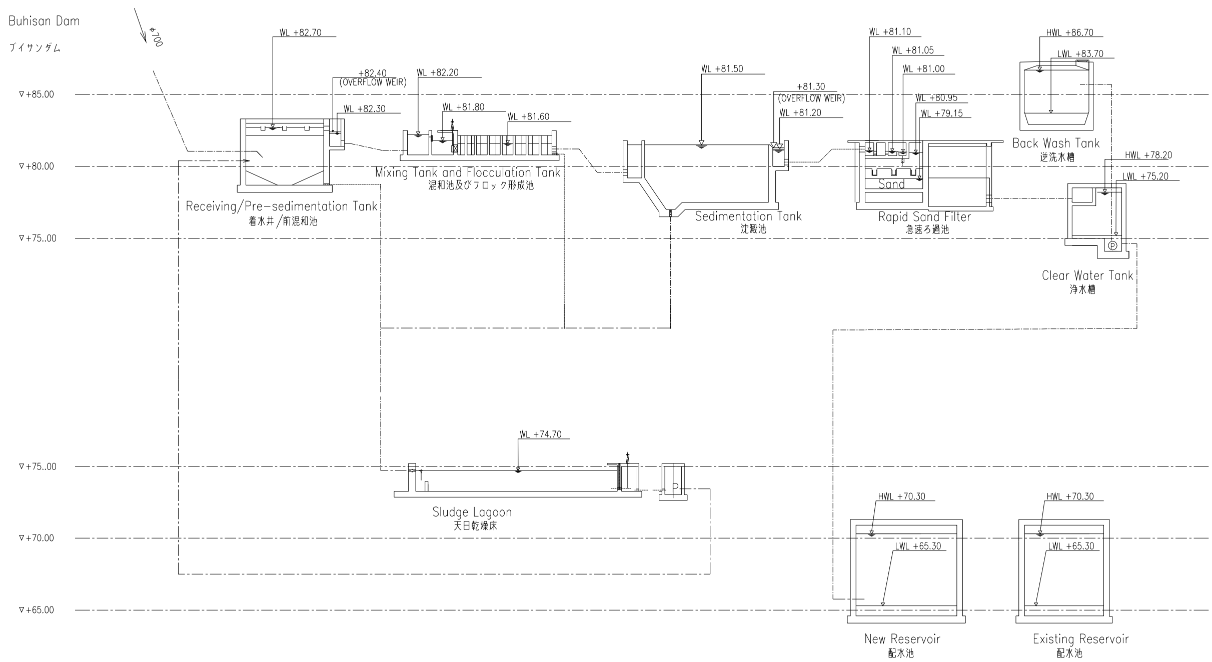


Figure C.II-35 Hydraulic Profile

Table C.II-22 Capacity Calculation of the WTP and Main Facility Dimension

Item	Unit	Quantity				
Design Flow	m^3/d	10,000		Design Conditions	Receiving Tank / Pre Sedimentation	Retention Time 10min.
	m^3/h	417			Mixing Tank	Retention Time 1.0min.
	m^3/m	6.94			Flocculation Tank	Retention Time 15min
	m^3/s	0.116			Sedimentation Tank	Surface Load 15mm/min
					Rapid Sand Filter	Velocity 150m/d
					Backwash Tank	One Backwash Volume
					Sludge Tank	Daily Generated Sludge
					Drying Bed	Drying time 150 days、Surface Load 30kg/m^2

Facility	Dimension	Unit	Quantity	Facility	Dimension	Unit	Quantity
Receiving Tank / Pre Sedimentation	No.		2	Rapid Sand Filter	No.		8(1stand-by)
	W	m	2.5		W	m	4
	L	m	4.8		L	m	2.5
	H	m	3		Area	m^2	80
	Area	m^2	12		V (w.o stand-by)	m/d	143
	Volume	m^3	72		V (w. stand-by)	m/d	125
	Retention Time	min	10.4	Backwash Tank	No.		1
Mixing Tank	No.		1		W	m	4.5
	W	m	2.5		L	m	4.5
	L	m	1.5		H	m	3
	H	m	1.4		Area	m^2	20.3
	Area	m^2	3.8		Volume	m^3	60.8
	Volume	m^3	5.32	Drying Bed	No.		5
	Retention Time	min	0.8		W	m	10
Flocculation Tank	No.		2		L	m	32
	W	m	1.1		H	m	1
	L	m	64		Area	m^2	1,600
	H	m	0.8				
	Area	m^2	141				
	Volume	m^3	113				
	Retention Time	min	16.2				
Sedimentation Tank	No.		2				
	W	m	7.6				
	L	m	30				
	H	m	3				
	Area	m^2	456				
	Volume	m^3	1,368				
	Surface load	mm/min	15.2				

(Cost Estimation of WTP)

As to the cost of WTP, it is, of course, desirable to sum up the each component cost, sedimentation tank, Rapid Sand filter, etc. The cost, however, is based on the comprehensive unit cost per m^3/d of capacity based on the past construction cost data since it is difficult to determine detailed specification of the plant.

From the data in Table xxx and Table xxx, unit construction cost of 20,000 PHP/m^3/day seems appropriate, while unit O&M cost is estimated as 136 PHP/m^3/day/year

Construction cost and O&M cost is shown below.

- Construction cost 10,000 m^3/day x 20,0000 PHP/m^3/day = 200 million PHP
- O&M cost 4,700 m^3/day x 136 PHP/m^3/day/year = 0.64 million PHP

Table C.II-23 Construction Cost of WTP

WTP	Capacity (m^3/d)	Construction Cost (Million Japanese Yen)	Unit Price (Yen/m^3/d)	Unit Price (PhP/m^3/d)	
Cal, Sri Lanka	60,000	1,127	19,000	9,500	NJS estimation
Candy, Sri Lanka	36,670	2,064	57,000	28,500	ditto
Trabali, Nepal	4200	112	27,000	13,500	ditto
Carmen WTP, Cebu	42,000	1,259	30,000	15,000	NJS estimation in 2005
Kapsabet, Kenya	3,800	262	70,000	35,000	NJS estimation in 2008
Embu, Kenya	11,000	518	48,000	24,000	NJS estimation in 2009
Southern Bali, Indonesia	25,920	655	26,000	13,000	NK estimation in 2009
Average				19,786	→ 20,000

Table C.II-24 O&M cost from temporary designed plant

WTP capacity (m^3/d)	46,000
O&M cost (Chemical cost , PHP per year)	Alm 706.2 kg/d*30d*12month*10P/kg=2,542,320P Chlorine 141.3 kg/d*30d*12month*73P/kg=3,713,364P 6,255,684P
Unit cost (PHP per m^3/d/year)	136

(Calcium Hardness Removal Facility)

From the water quality test of raw water and finished water, Total Hardness of treated water does not clear PNSDW. To remove (Calcium) hardness of raw water, there are many treatment methods like, Alkali coagulation, ion-exchange, complex salt and pellet reactor method. Of the above said methods, pellet reactor method can be employed due to its compactness. Treatment process of this facility is; a) pH value of raw water is controlled at 9.0 using caustic soda, b) calcium ion is deposited on the surface of pellet and c) pellet with calcium scale is replaced by new pellet. This facility is designed to install before receiving well which has act as pH control tank using sulfuric acid. Since the calcium detached to the pellet is chemically stable, its recycle, e.g. for white sand beach, etc is to be considered. Using 100m/hr (= 2,400m^3/day/m^2) of passing velocity, 2 set of contact tower with diameter of 1.5m is adopted in case of hardness removal.

Anyway, selection of hardness removal method and its design criteria should be determined based on the Jar-test of the raw water

Construction cost is estimated nearly 33 million PHP based on the NJS data. The cost, however, is not included in the Project cost.

Table C.II-25 Hardness Removal Facilities Cost

Hardness Removal Facilities (Design Flow is 46,000m^3/d)							
Mechanical Facility			set	90,000,000	1	90,000,000	Include Chemical Dosing Facilities
Electrical Facility			set	60,000,000	1	60,000,000	
Total						150,000,000	

(Construction cost of 10,000 m3/day hardness removal facility is 10,000 x 150 Million PHP / 46,000=32.6 Million PHP)

Table C.II-26 Water Quality Analysis of Tisa WTP

May 19, 2009 data

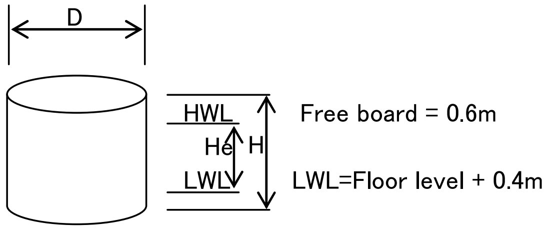
Parameter	Unit	Raw Water	Treated Water	Removal Rate	PNSDW '07 Level
Chloride (CL)	mg/l	9.8	10.8	-10	250
Total Dissolved Solids (TDS)	mg/l	596	478	20	500
Total Suspended Solids (TSS	mg/l	6	0	100	
Total Solids (TS)	mg/l	602	478	21	
Total Iron	mg/l	0.15	<0.15	>1	1.0
Sulfate	mg/l	178	185	-4	250
Nitrate	mg/l	1.2	<0.89	>25	50
Nitrite	mg/l	0.006	0.002	67	30
Fluoride	mg/l	0.08	0.14	-75	1
pH	-	7.28	7.78	-	6.5-8.5
Conductivity	μS/cm	826	678	18	
Turbidity	NTU	0.95	0.66	31	5
Calcium Hardness	ppm	339	236	30	300 (as $CaCO_3$)
Total Hardness	ppm	477	369	23	300 (as $CaCO_3$)
Calcium	ppm	136	94.5	31	100
Magnesium	ppm	33.7	32.5	4	-
Chromium	ppm	<0.010	<0.010	-	0.05
Alminum	ppm	0.076	<0.02	>25	0.2
Copper	ppm	<0.02	<0.02	-	1
Cyanide	ppm	<0.010	<0.010	-	0.07
Manganese	ppm	1.44	<0.01	>99	0.4
Color (Apparent)	Pt/Co	7.2	3.9	46	10

4) Reservoir Development

Dimension of the reservoir is as follows

Table C.II-27 Dimension of each Reservoir

Location	Effective Capacity (m^3)	Effective Depth He (m)	Inner H (m)	Inner Diameter (m)
Casili	5,000	5.0	6.0	36
Talamban	10,000	5.0	6.0	50
Tisa	10,000	5.0	6.0	50



Typical drawing of the circular tank is shown in Figure C.II-27.

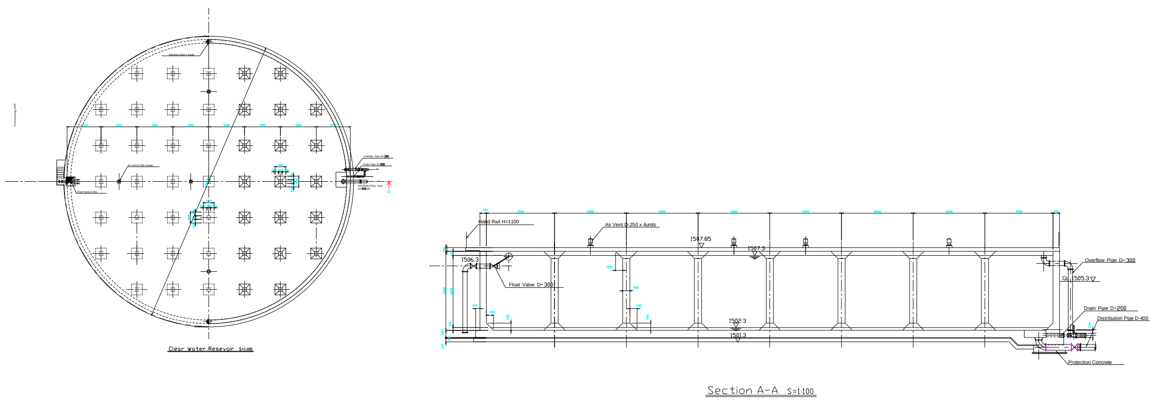
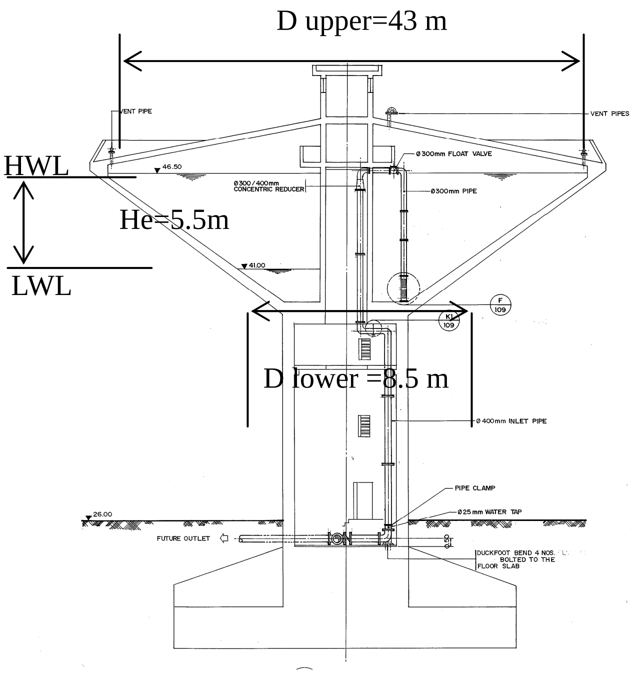


Figure C.II-36 Typical Circular Reservoir

Meanwhile, MCWD is planning to construct same capacity (2,000m^3) of additional Mactan Pusok Tower next to existing one, one more same structure tower is proposed in near-by area. In case 4,000 m^3 capacity new tank is constructed, its dimension is as follows.



Upper area=43x43x0.785=1,451m^2
Lower area=8.5x8.5x0.785=56.7m^2
V= (1,451+56.7)/2x5.5=4,146 m^3

Figure C.II-37 Pusok Tower

Location of the each proposed reservoir is shown in Table C.II-29.

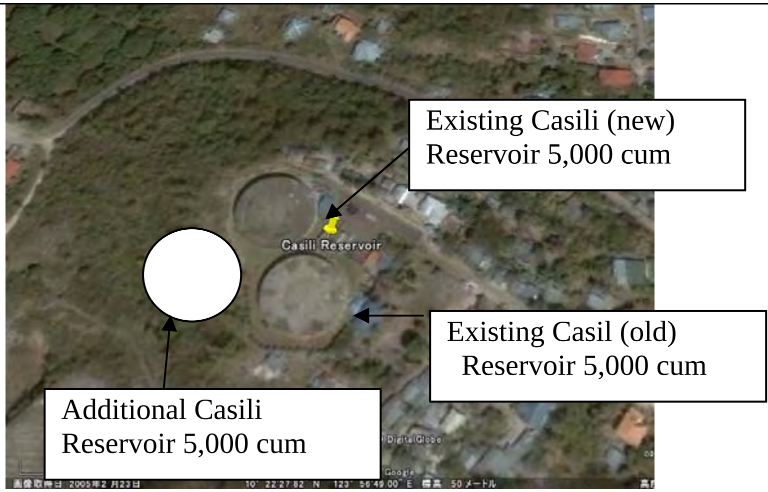
Required land area is calculated assuming twice of the inner diameter projected area is necessary.

Table C.II-28 Land Acquisition Area

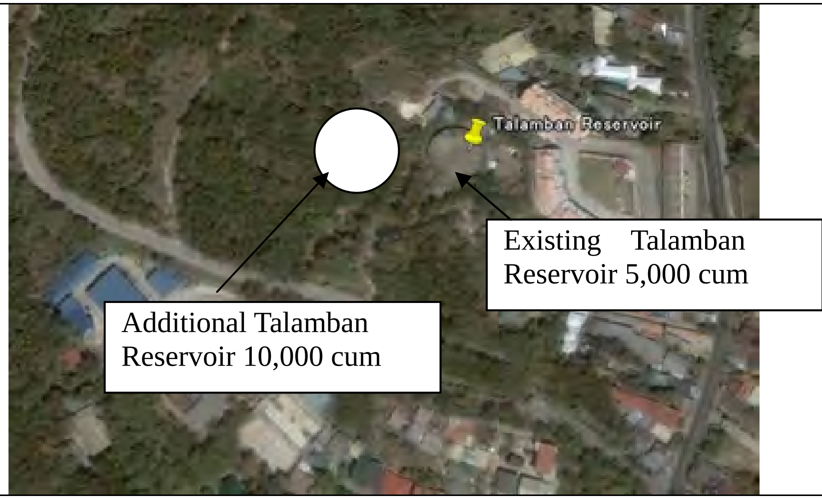
Location	Area (= Projected area x 2) m^2
Casili	=36x36x0.785x2.0 =2,035m^2
Talamban	=50x50x0.785x2.0 =3,930m^2
Tisa	=50x50x0.785x2.0 =3,930m^2
Mactan	=43x43x0.785x2.0 =2,903m^2

Table C.II-29 Location map of additional reservoirs

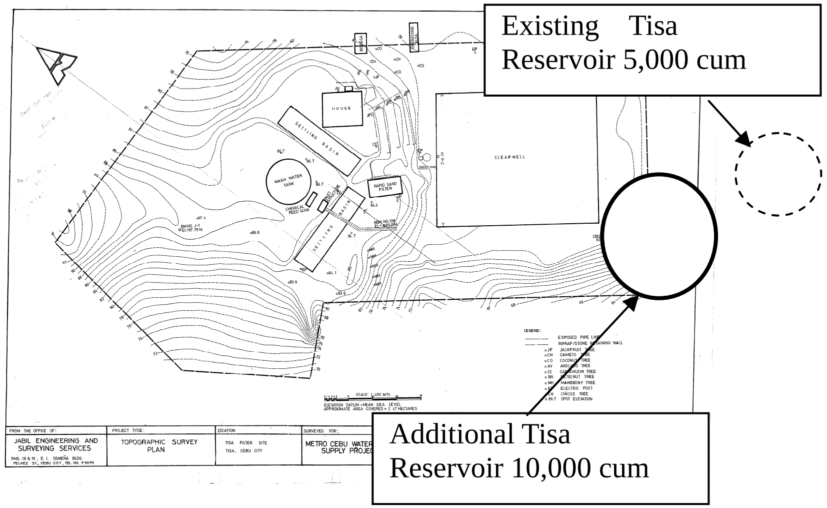
Casili reservoir



Talamban reservoir



Tisa reservoir



Mactan reservoir

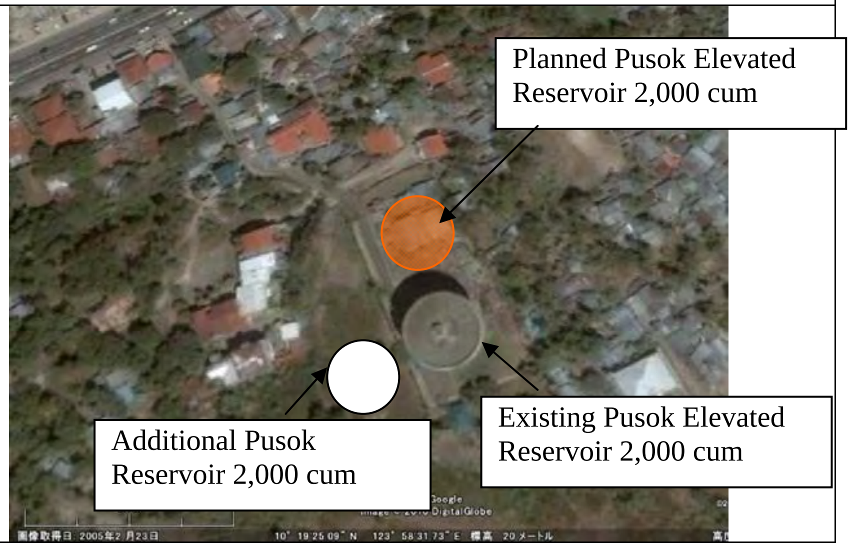


Figure C.II-38 Additional Tisa Reservoir on Newly Revised Google Map

As to the Mactan Reservoir, it is recommendable to transmit the imported water from Cebu Island directly to the new reservoir without injecting into network on the way. Inlet pipe and outlet pipe is to be clearly separated. And also new reservoir should receive treated water from the desalination plant to mix with the different type of source water to prevent bad effect of Boron (B) since it is likely to occur concentration of Boron in treated water from Desalination Plant fail to clear the Philippine drinking standard.

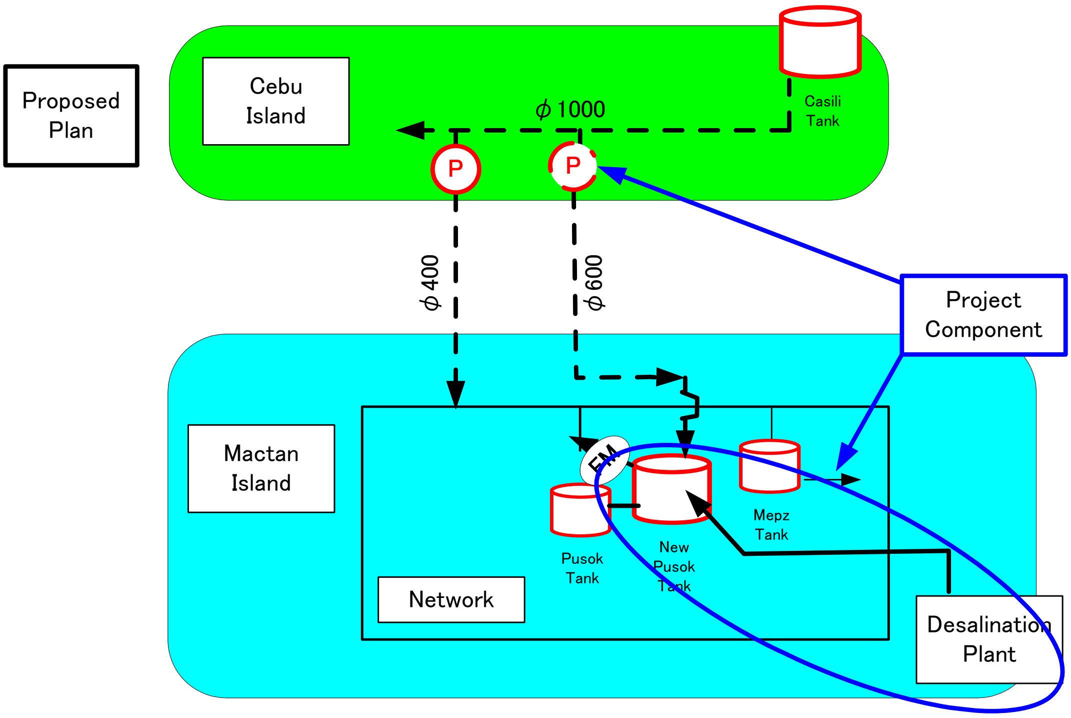


Figure C.II-39 Development concept of Mactan reservoir and Desalination Plant

5) Transmission pipe

Alternative Plan on Water Transmission Pipe Line

Due to the local distribution of water source and demand, kinds of study on transmission route of produced water to consumption site are to be investigated.

Location of newly developing groundwater wells, whose volume is also described in Table C.II-30, is shown in the map below. From the supply demand balance of each distribution block, new Casili groundwater source is developed to fill the demand gap of its own block, while new Talamban groundwater source is provided as Mactan block source.

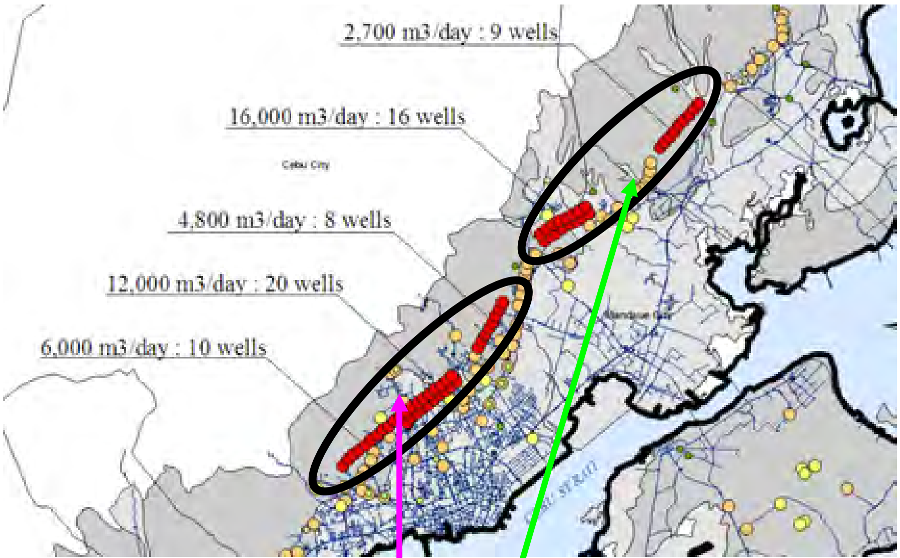


Figure C.II-40 Intake Well Location

Table C.II-30 Water Supply and Water Demand Balance

DB	Demand (m^3/d)	Supply (m^3/d)							Supply-Demand (m^3/d)
		GW (existing)	GW (new)	Jaclupan well	Buhisan Dam	Bulk Supply	Desalination Plant	Total	
1-CLC	19,261	23,598				7,000		30,598	11,337
2-Casili	40,323	9,918	18,700					28,618	-11,705
3-Talamban	58,173	50,264	22,800					73,064	14,891
4-Tisa	60,956	21,932		40,000	4,700			66,632	5,676
5-Lagtang	18,301	7,538				11,000		18,538	237
6-Mactan	38,136	3,827				5,000	9,600	18,427	-19,709
Total	235,150	117,077	41,500	40,000	4,700	23,000	9,600	235,877	727

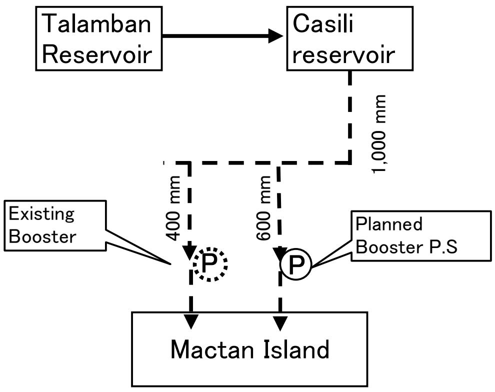
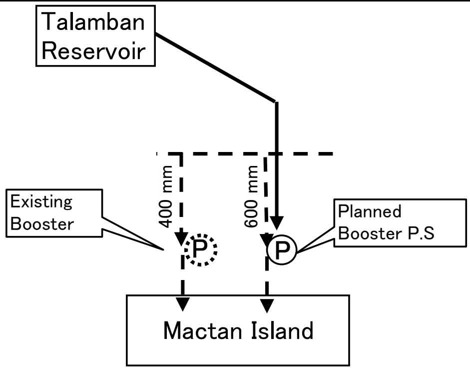
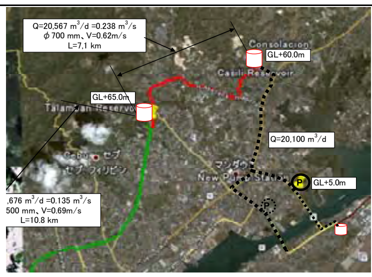
Based on the original concept, transporting excess water from Tisa/Talamban to Mactan area through Talamban reservoir, Casili reservoir and existing 1,000 mm pipe line, following three route is compared.

1) Route from Talamban reservoir to Mactan island
2) Overall plan from Tisa reservoir to Mactan island and
3) Route from Tisa reservoir to Talamban reservoir considering future circumferential road.

➢ **Talamban to Mactan Island**

Since 98% of the water from Talamban reservoir to Casili reservoir is exported to Mactan Island, this route looks "de-route" comparing with the direct transmission line from Talamban to new bridge-side booster pump station. Table xxx is the comparison result. From the table, alterna-tive route is difficult to adopt.

Table C.II-31 Transmission Route Alternative

Case	Proposed route	Alternative route
Outline		
Transmission Route Map		
Advantage	Existing network is utilized Export to Mactan from Casili reservoir through 1,000 mm pipe is just coincident with predetermined policy of MCWD	Water source is stably acquired from Talamban well field without distributing to Mandaue area. From the topographic conditions, the water is conveyed by gravity (siphon) without pump station.
Disadvantage	New Pumps have to be installed in Talambam reservoir site.	Some hundreds cmpd of water supply falls short for Mandaue area.
Evaluation	Inter-reservoir pipe is also useful for emergency use. Considering that the future supply from North area is promising, utilization of Casili reservoir and existing pipeline is recommendable., ○	If Mactan Island supply is the first priority, this route is desirable. If not so, alternative plan is not recommended. △

➢ **Alternative Transmission Route for Mactan Supply**

From the demand-supply balance, Mactan area, which lacks enough supply source, has to be covered by the water newly produced in Tisa and Talamban DB area. Two alternative plan is compared with originally proposed transmission plan as is shown in Table C.II-25. Due to the availability of existing large 1,000 mm pipe and booster pump station, original plan is recommendable.

➢ **Tisa to Talamban**

Cebu City has its urban land use plan and it contains proposed circumferential road as shown in Figure C.II-41. This route, however, passes more hilly route than future ground well-field and it is not so economical to use this route instead of using existing heavy traffic road.

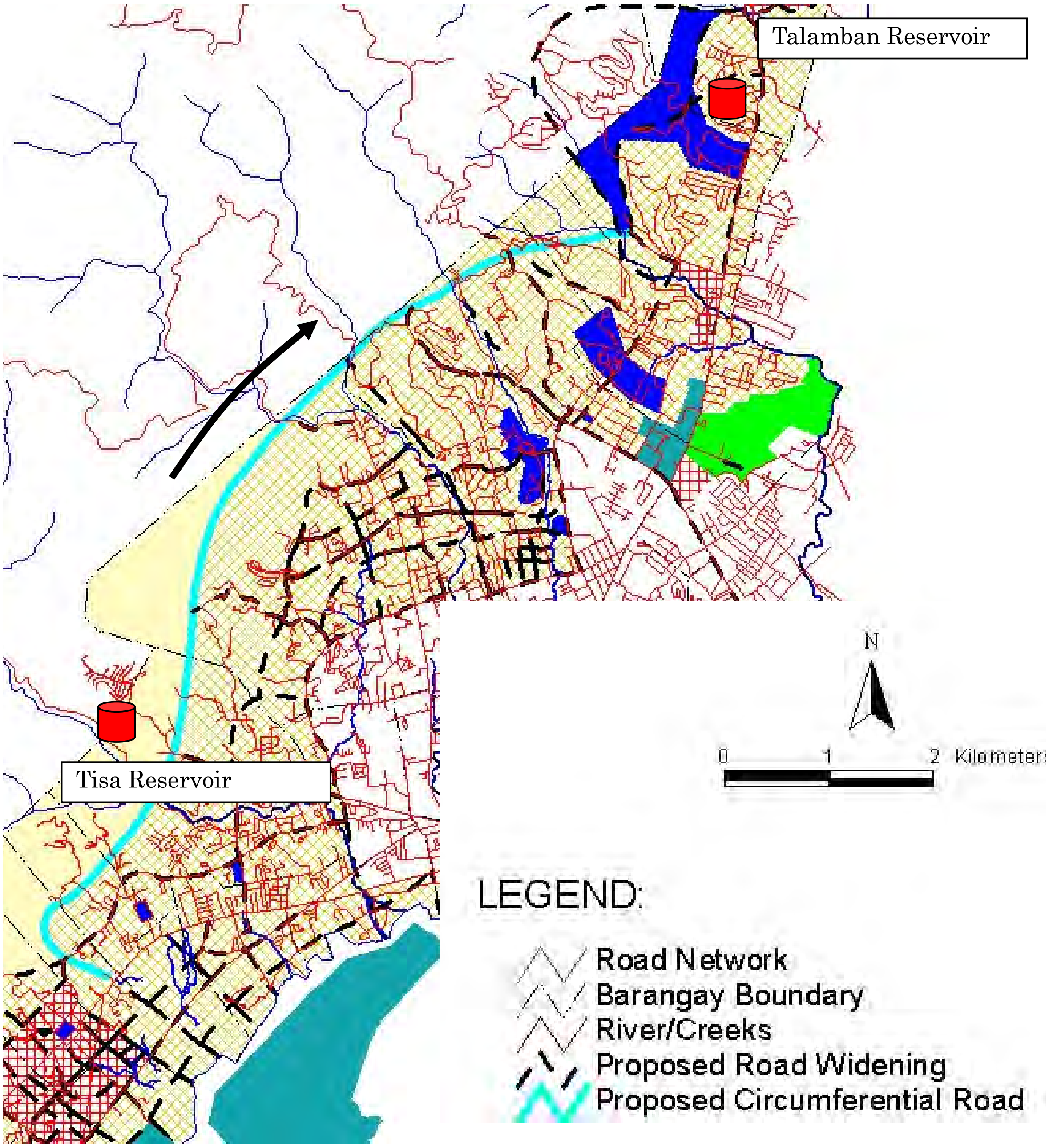


Figure C.II-41 Alternative Route from Tisa to Talamban

Based on the Transmission Plan (2), green volume is developed to balance the DB except for Mactan DB, and after the completion of the above-said development, Mactan DB shortage (⇕) is filled by additional development of Talamban/Tisa water source

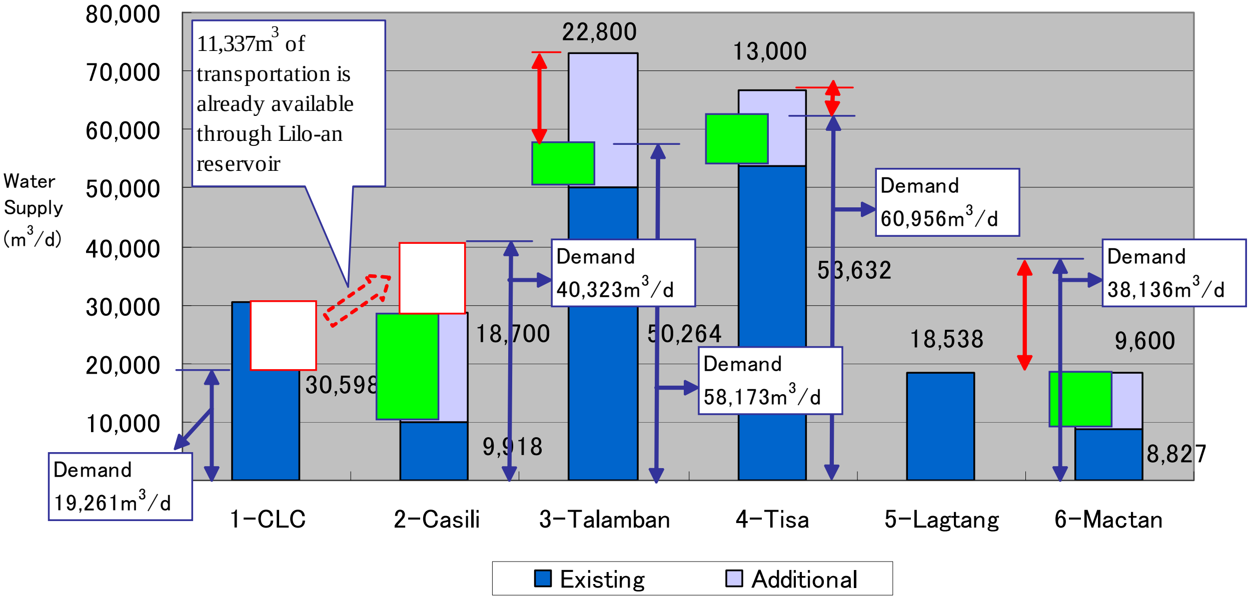
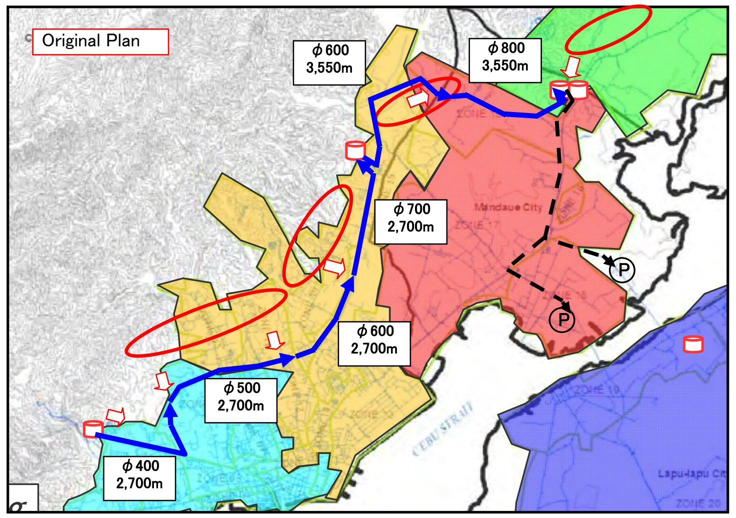
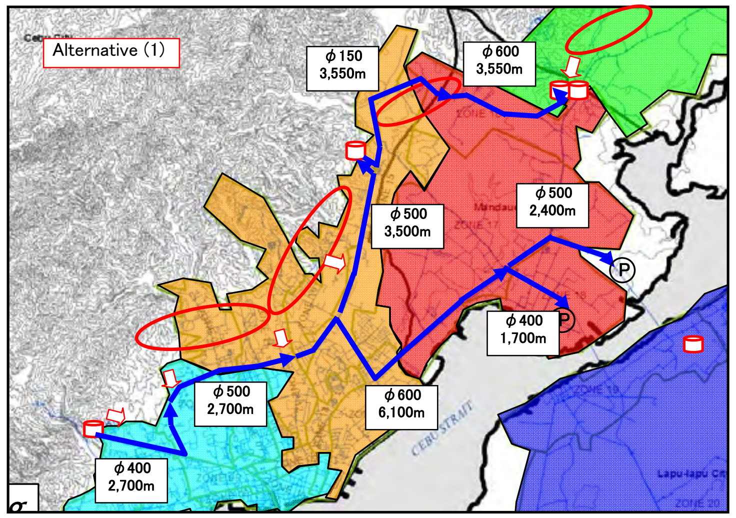
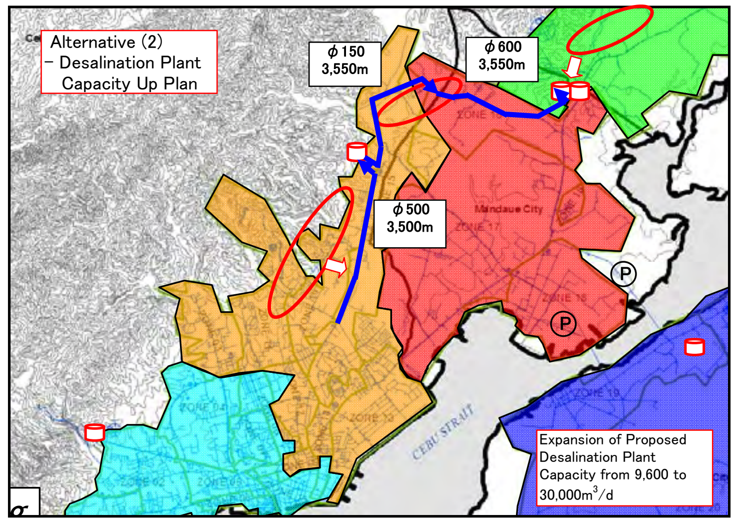


Figure C.II-42 Staged Development of Water Source

Table C.II-32 Comparison Table of Additional Supply Plan to Mactan Area

Case	Original case	Alternative (1)	Alternative (2)
Outline	Water source shortage in Mactan is covered by transporting water from Tisa/Talamban through Talamban reservoir, Casili reservoir, existing 1000mm pipe and booster pump station near ridge	Water source of booster pump station comes directly from Tisa/Talamban area through independent line.	Water source is covered by expansion of capacity of proposed Mactan desalination plant from 9,600 to 30,000 m^3/d
Plan			
Initial Cost (Direct cost base)	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 800 / 3,550 / 48,500 / 172 700 / 2,700 / 40,500 / 109 600 / 6,250 / 31,300 / 196 500 / 2,700 / 25,000 / 68 400 / 2,700 / 15,900 / 43 Total / 17,900 / / 588	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 600 / 9,650 / 31,300 / 302 500 / 8,600 / 25,000 / 215 400 / 4,400 / 15,900 / 70 150 / 3,550 / 4,500 / 16 Total / 26,200 / / 603 Break down (Mactan Route) 388 (Talamban-Casili Route) 215	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 600 / 3,550 / 31,300 / 111 500 / 3,500 / 25,000 / 88 150 / 3,550 / 4,500 / 16 Sub-total / 10,600 / / 215 Desalination Plant & Pipe (Capacity increase 9,600m^3/d to 30,000m^3/d) (8,100m Transmission diameter 400 mm to 700 mm) Plant Construction increase Cost 530 Pipe line increase cost 199 Total cost 944
Merit	In case future supply from northern Cebu area, like Carmen or Danao, transmission line can transfer water from Casili to Talamban, Tisa area.	Separate consideration of Mactan supply and Talamban/Casili DB balancing is possible	For the time being, export of water source from Cebu island to Mactan island is not necessary.
Demerit	Initial cost is pretty expensive	Existing 1,000 mm pipe line and proposed booster pump station can not effectively utilized	➢ Existing and proposed booster pump station is not effectively utilized ➢ Initial cost is most expensive
Total Evaluation	◎	○	△

Additional Study on Mactan Island Supply

To decide the optimum capacity of New Mactan Desalination Plant from the economical point of view, cost comparison is reviewed corresponding to the following three cases.

(Case 1) Proposed 9,600 m^3/day of Plant with 20,100 m^3/day import from Cebu Island
(Case 2) All of 29,700 m^3/day is imported from Cebu Island without Desalination Plant
(Case 3) Desalination Plant with capacity of 29,000 m^3/day will be constructed. No import from Cebu Island

Summary of cost comparison shows there is negligible difference among three plans. Optimum capacity is difficult to find.

Table C.II-33 Cost Comparison

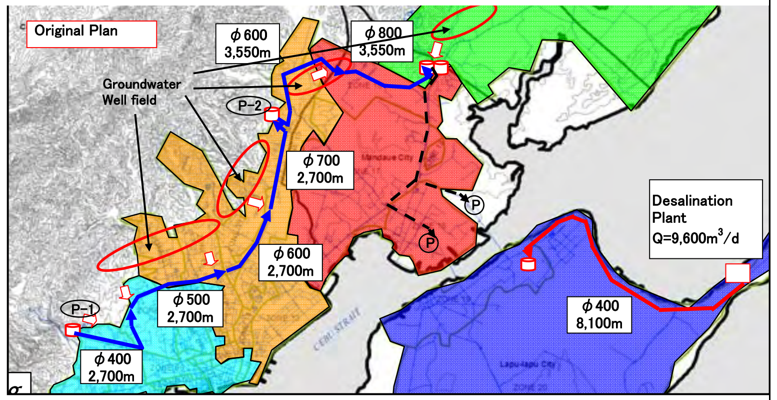
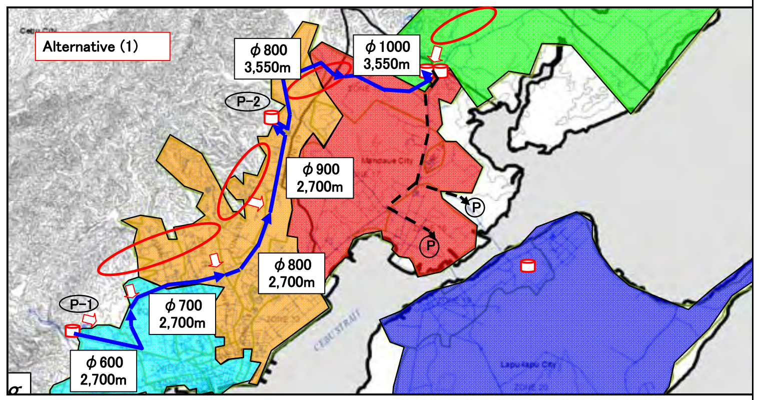
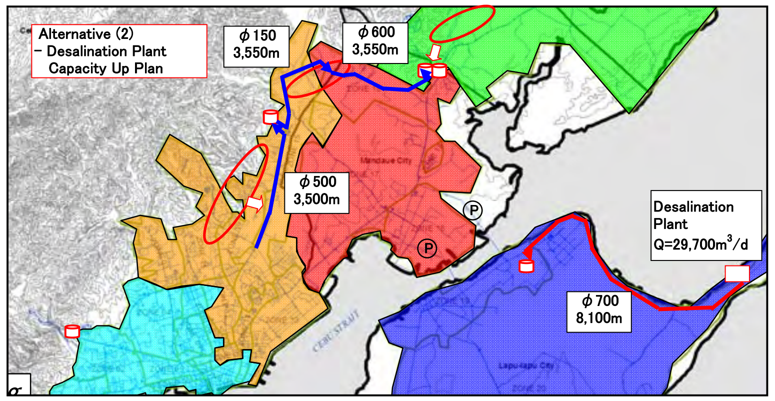
	Initial Cost	Item considered
Case 1	1,267 Million PHP	Water Source Development Cost of 20,100 m^3/day Transmission pipeline cost of 20,100 plus local water source collection 2 inter-reservoir pump stations Desalination Plant (including transmission pump) with capacity of 9,600 m^3/d Desalinated water transmission pipe to convey 9,600 m^3/day
Case 2	1,344 Million PHP	Water Source Development Cost of 29,700 m^3/day Transmission pipeline cost of 29,700 plus local water source collection 2 inter-reservoir pump stations
Case 3	1,315 Million PHP	Transmission pipeline cost for only local water source collection Desalination Plant (including transmission pump) with capacity of 29,700 m^3/day Desalinated water transmission pipe to convey 29,700 m^3/day

Although considering expensive running cost of desalination plant, Case 2 seems most economical, high initial cost of transmission line is the bottle neck of the implementation.

Initial cost of Case 3 is average of Case 1 and Case 2. Maintenance cost of 29,700 m^3/day capacity of desalination is outstandingly high among three cases.

To respond with rapidly increasing Mactan demand, desalination plant with capacity of 9,600 m^3/day is to be constructed in priority project and second stage supply can be contemplated considering bulk supply contract within and outside of MCWD jurisdiction., like import of water from Carmen or Danao.

Table C.II-34 Comparison Table of Additional Supply Plan to Mactan Area

Case	Original case	Alternative (1)	Alternative (2)
Outline	Water source shortage in Mactan is covered by transporting water from Tisa/Talamban through Talamban reservoir, Casili reservoir, existing 1000mm pipe and booster pump station near ridge	9,600 m^3/d of desalination volume is covered by additional groundwater development in Tisa/Talamban area	Shortage volume of 29,700 m3/d in Mactan is covered by Desalination Plant. Pipe line in Mactan Island is installed to satisfy its own demand only.
Plan			
Initial Cost (Direct cost base)	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 800 / 3,550 / 48,500 / 172 700 / 2,700 / 40,500 / 109 600 / 6,250 / 31,300 / 196 500 / 2,700 / 25,000 / 68 400 / 2,700 / 15,900 / 43 P1 55 P2 64 Sub-Total 17,900 707 Desalination Plant Capacity (m^3/d) / Unit Cost ($PhP/m^3/d$) / Direct Cost (MPhP) 9600 / 26,000 / 250 Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 400 / 8,100 / 15,900 / 129 Sub-Total 379 Additional Water source develop cost volume / Unit Cost 20,100 / 9,000 / 181 Total 1,267	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 1000 / 3,550 / 68,500 / 243 900 / 2,700 / 58,500 / 158 800 / 6,250 / 48,500 / 303 700 / 2,700 / 40,500 / 109 600 / 2,700 / 31,300 / 85 500 / 0 / 25,000 / 0 P1 83 P2 96 Total 17,900 1,077 Additional Water source develop cost volume / Unit Cost 29,700 / 9,000 / 267 Total 1,344 From cost estimation Groundwater additionally produced = 41,500 m3/d Well construction + Raw water transmission cost= 254,239,000+114,879,000 = 369,170,000 PhP ∴ Unit development cost = 369,170,000 / 41,500 = 9,000(PhP/m3/d)	Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 600 / 3,550 / 31,300 / 111 500 / 3,500 / 25,000 / 88 150 / 3,550 / 4,500 / 16 Sub-total 10,600 215 Desalination Plant Capacity (m^3/d) / Unit Cost ($PhP/m^3/d$) / Direct Cost (MPhP) 29,700 / 26,000 / 772 Transmission Line Diameter (mm) / Length (m) / Unit Cost (PhP/m) / Direct Cost (MPhP) 700 / 8,100 / 40,500 / 328 Sub-Total 1,100 Total 1,315
Desalination water rate	9,600 (New plant) + 5,000 (Supplied desalination water) /38,136 = 38 %	5,000 / 38,136 = 13 %	(29,700 + 5,000) / 38,136 =90 %
Merit	In case future supply from northern Cebu area, like Carmen or Danao, transmission line can transfer water from Casili to Talamban, Tisa area. Desalination water is distilled by groundwater source, so Br quality is acceptable	Desalination plant, whose running cost is high, can be avoided. No need to worry about Br quality	No need of water import from Cebu Island.
Demerit	Initial cost is pretty expensive	Initial cost is a little higher than original plan	Initial cost is most expensive in three plans and running cost of desalination plant is also expensive Desalination water occupies 90 % of water demand, Br quality can be surpass drinking standard.
Total Evaluation	◎	○	△