Thai royal irrigation department's water management for seawater intrusion

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● **Abstract:** One of the main duties and responsibilities of Royal Irrigation Department (RID) is irrigation water management for household consumption and ecological environmental protection. An example of the water management activity is seawater intrusion control in Chao Phraya river, especially at Samlae (100 Kilometers from the estuary) where raw water pumping station of Metropolitan Waterworks Authority (MWA) was constructed for providing water supply at approximately 1,298.02 million cubic meters per year for 1,366,142 residents in eastern Bangkok. RID has been strictly monitored the salinity in Chao Phraya river since 2014. In dry season, the consequences of seawater intrusion for water consumption vary widely depending on the extent of the intrusion, the intended use of the water. Due to the salinity exceeds standards for the intended use of MWA, RID collaborated with MWA to continuously monitor the water salinity data from Telemetry system along Chao Phraya river for desalination management. RID allocates fresh water from Bhumibol, Sirikit, Khaew Noi Impounding Dams through Chao Phraya Diversion Dam (5-7 days to Samlae) and from Pasak Impounding dam through Rama VI Diversion Dam (3 days to Samlae) in order to reduce salinity degree in Chao Phraya river. RID uses the online water quality telemetry data to annually provide water to reduce salinity in Chao Phraya river before it increases in dry season. As a result, the salinity degree has been continuously decreased since 2014. During 2019 to 2020, Thailand is facing severe drought which also caused excess salinity at Samlae, RID therefore planning to allocate water from Mae Klong Dam, passing Phrayabanlue canal to Chao Phraya river through Singhanat floodgate which is located 17 kilometers above Samlae. The water pump's capacity is at 48 cubic meters per second to ensure safety water consumption.

● **Key words:** Seawater, Salinity, Water Management, Water Consumption, Chao Phraya River

1. Introduction

The missions of Royal Irrigation Department (RID) are (1) to develop water resources and increase irrigated area according their potential and ecological balance (2) to manage water allocation in equitable and sustainable manners (3) to encourage people participation in water resources management and development, and (4) to prevent and mitigate water hazards. Therefore, one of the main duties and responsibilities is irrigation water management for household consumption and ecological environmental protection.

The study will focus on water management activity for seawater intrusion control in Chao Phraya river, especially at Samlae (100 Kilometers from the estuary) where raw water pumping station of Metropolitan Waterworks Authority (MWA) was constructed for providing water supply at approximately 1,298.02 million cubic meters per year for 1,366,142 residents in eastern Bangkok.

There are 10 large scale storage dams in Chao Phraya river basin and 2 large scale storage dams in Mae Klong river basin to supply water budget for seawater intrusion by drainage through 2 diversion dams and temporary pumping station at Singhanat Floodgate.

Therefore, this paper will study about how RID manage water to reduce salinity affected Samlae pumping station to control water quality for 1,366,142 residents in eastern Bangkok.

2. Material and methods

2.1 Objective of the Study

To study about RID's water management for seawater intrusion in Chao Phraya river.

2.2 Study Area

The study area located mainly in Chao Phraya river basin and Mae Klong river basin as shown in figure 1 and 2.

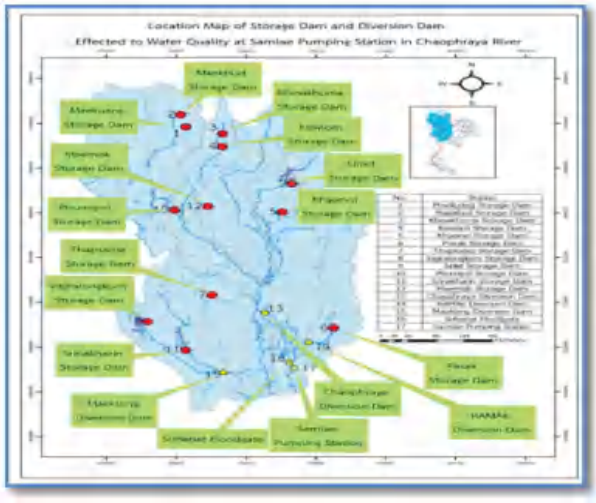

Figure 1 Water Budget in Chao Phraya and Mae Klong River Basins

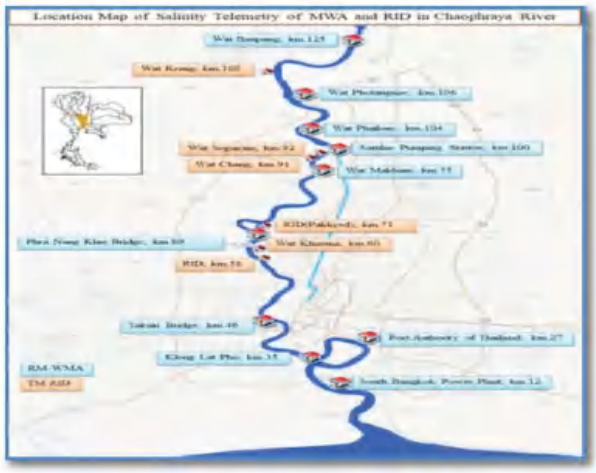

Figure 2 Salinity Telemetry Stations in Chao Phraya River

2.3. Monitoring Salinity in Chao Phraya River

(1) Daily monitoring salinity data at 7 A.M. from telemetry of MWA (10 water quality telemetry stations) and RID (6 water quality telemetry stations) as shown in graphic picture including discharge at Chao Phraya diversion dam and Bang Sai Royal Folk Arts and Crafts Center, monitoring seawater intrusion using salinity in Chao Phraya river (Figure 3), also salinity data from 16 telemetries and interpolated data from each telemetry station to show the spreading of seawater into fresh water (Figure 4)

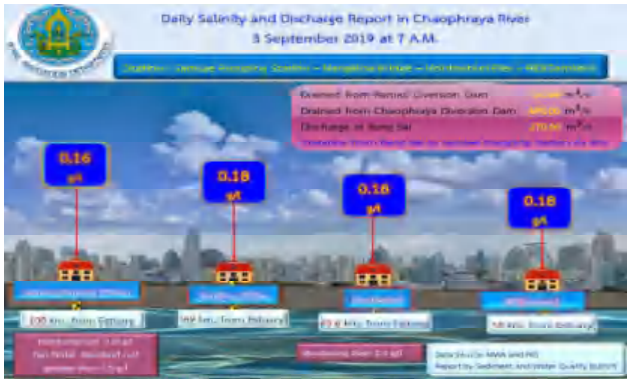

Figure 3 Daily Salinity and Discharge Report in Chao Phraya River

(2) 7-day Salinity Forecast modeled program using Real-Time Telemetry of MWA and RID.

The program is salinity forecasting software using MIKE 11 RR (Rainfall-Runoff Model), MIKE 11 HD (Hydrodynamic Model) and MIKE 11 AD (Advection- Dispersion Model) by inputting salinity data from MWA and RID to output the 7-day salinity forecasting at Samlae Pumping Station and also shows how much water should be allocated at Chao Phraya and Rama VI Dams as shown in figure 5.

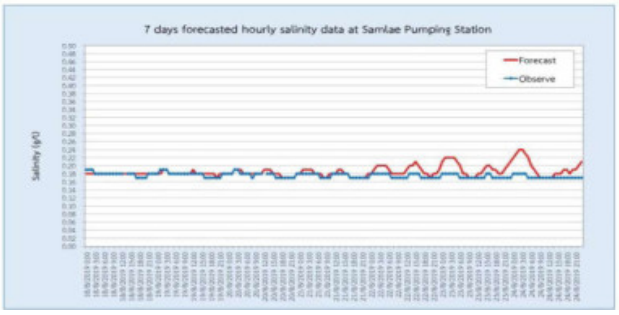

Figure 5 7-day hourly forecasted salinity data at Samlae Pumping Station

(3) Report daily water quality published in website and LINE application to Water Management Division and administrators of Thai RID.

2.4. Water Management

There are 10 large scale storage dams (Bhumibol, Sirikit, Mae Khud, Mae Kuang, Kewlom, Khewkhoma, Khaew Noi, Mae Mok, Thapsaloa and Pasak) and 2 diversion dams (Chao Phraya and Rama VI) directly allocated water to Chao Phraya river and also the water from Vajiralongkorn and Srinakarin Storage Dams are distributed through Mae Klong Diversion Dam to Phrayabanlue canal, then pumped to Chao Phraya river.

After received report from Sediment and Water Quality Branch, Water Management Division considered the 3 allocation options for desalination, increasing allocation of fresh water from (1) Chao Phraya Diversion Dam (Bhumibol, Sirikit, Mae Khud, Mae Kuang, Kewlom, Khewkhoma, Khaew Noi, Mae Mok and Thapsaloa Storage Dams) taking 11 days (2) Rama VI Diversion Dam (Pasak Storage Dam) taking 5 days (3) temporary pumping water station at Singhanat Floodgate allocated from Mae Klong Diversion Dam (Srinakarin and Vajiralongkorn Storage Dams) with capacity of 48 cubic meters per second, taking 1 day to reduce effect of seawater intrusion depending on active storage water in the storage dam.

Figure 6 Water Management Options to control Seawater Intrusion at Samlae Pumping Station

3. Result and discussion

Samlae Pumping Station was lacked of Telemetry during 2007 to 2014. In 2014, serious seawater intrusion at Samlae pumping station affected tap water as MWA did not use Reverse Osmosis (RO) Treatment System to desalinate water.

After 2014, there are WMA's 10 Telemetries and RID's 6 Telemetries. MWA and RID has been collaborated in sharing data for water management.

The active storage of storage dams allocated to Chao Phraya river since 2007 are shown in table 1 and 2

Table 2 The active storage of storage dams allocated to Chao Phraya river at 31 August from 2007 to 2019

Storage Dam	Full Capacity (mcm)	Full Active Capacity (mcm)	The Active Storage (mcm) at 1 November											
			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Phumipol	13,462	9,662	7,615	5,285	5,547	4,694	9,594	4,875	3,261	2,225	1,184	3,005	6,764	5,906
Sirikit	9,510	6,660	4,596	5,451	3,173	4,934	6,645	3,737	3,082	2,991	2,056	4,807	5,539	5,498
Maekhud	265	253	196	247	206	258	254	146	199	155	48	146	240	232
Maekuang	263	249	0	0	49	134	245	95	101	24	18	88	100	112
Kewlom	106	103	0	0	80	89	95	68	97	32	13	91	90	91
Khewkhoma	170	164	0	0	120	192	182	142	183	119	17	172	167	177
Khawnoi	939	896	51	80	512	732	900	689	894	744	370	903	927	697
Maemok	110	94	93	93	80	82	79	73	79	49	13	94	95	30
Pasak	960	957	967	954	96	973	145	774	962	817	637	988	957	739
Thapsaloa	160	143	146	154	171	147	217	136	132	44	51	149	148	41
Srinakharin	17,745	7,480	6,479	5,588	5,875	4,011	5,918	5,670	5,243	2,837	2,685	3,161	5,250	6,185
Vajiralongkorn	8,860	5,848	5,127	81	5,031	57	4,618	4,866	4,490	2,375	2,559	2,711	4,042	4,779
Total	52,550	32,508	25,270	17,932	20,938	16,303	28,892	21,271	18,722	12,412	9,651	16,315	24,320	24,488

Note: The active storage at 1. November is water budget for dry season and the red-colored numbers are lower than average value.

Table 2 The active storage of storage dams allocated to Chao Phraya river at 31 August from 2007 to 2019

Storage Dam	Full Capacity (mcm)	Full Active Capacity (mcm)	The Active Storage (mcm) at 31 August												
			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Phumipol	13,462	9,662	4,802	2,980	2,508	1,183	6,636	2,754	1,008	1,649	563	893	3,308	4,366	1051
Sirikit	9,510	6,660	3,169	4,210	2,513	2,752	6,070	2,394	1,782	2,651	970	2,906	3,581	4,381	1818
Maekhud	265	253	116	118	112	151	195	82	69	144	40	78	0	135	110.86
Maekuang	263	249	0	0	12	75	225	0	49	32	18	31	54	86	56.5
Kewlom	106	103	0	0	67	85	54	83	68	36	25	41	64	36	66.3
Khewkhoma	170	164	0	0	44	96	129	49	84	130	11	83	130	124	79.6
Khawnoi	939	896	30	24	109	353	811	47	442	627	196	311	720	410	195.22
Maemok	110	94	57	47	31	63	71	284	17	45	4	8	60	18	16.52
Pasak	960	957	232	262	13	434	55	169	161	658	115	247	0	361	49.2
Thapsaloa	160	143	15	82	54	41	107	30	25	19	29	32	0	23	18.98
Srinakharin	17,745	7,480	4,792	4,660	4,540	2,521	3,840	3,927	3,402	2,641	1,994	1,481	3,444	5,796	4011
Vajiralongkorn	8,860	5,848	3,947	78	4,175	45	3,344	3,930	3,299	2,228	1,791	1,608	3,150	5,317	3799
Total	52,550	32,508	17,160	12,461	14,178	7,799	21,537	13,749	10,406	10,860	5,756	7,719	14,512	21,053	11,272

Note: The red-colored numbers are lower than average value

Water budget means the water needed for allocation during dry season since November of the current year to May of the next year. In 2007, 2009, 2010-2012, 2017-2018 , the water budget were higher than average, the annual maximum value of hourly salinity in these years were up to standard except for 2017. Due to the former 4 years having below-average water budget, higher water volume was allocated in 2017 after maximum salinity date.

In 2010, 2013-2016 the water budget was lower than average. The annual maximum value of hourly salinity was higher than average maximum value.

The collaboration between RID and MWA in monitoring salinity and allocating water in Chao Phraya river resulting in significant decrease of salinity after 2014. The maximum value from 2014 to 2018 were 1.92, 1.09, 0.87, 0.84 and 0.20 grams per liter, respectively. In 2015, water budget was less than 2014 but the maximum salinity is also less than 2014. In conclusion, the collaboration between RID and MWA to monitor salinity and allocate water using telemetries in Chao Phraya river resulting in decreasing Seawater Intrusion effect. (Table 3 and Figure 7-8)

Table 2 The active storage of storage dams allocated to Chao Phraya river at 31 August from 2007 to 2019

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Maximum Salinity(g/l)	0.21	0.16	0.18	1.10	0.22	0.19	0.57	1.92	1.09	0.87	0.84	0.20	0.23
Mean Salinity(g/l)	0.12	0.12	0.13	0.18	0.12	0.12	0.19	0.24	0.23	0.22	0.17	0.15	0.17
Sum Drainage(m^3/sec)	73,160	56,839	26,862	29,254	118,770	77,163	22,536	20,346	17,476	18,450	100,555	43,670	18,595
Mean Drainage(m^3/sec)	301.07	233.91	110.54	120.39	488.77	317.54	92.74	83.73	71.92	75.93	413.81	179.71	76.52
Active Storage at 31 August (10 Reservoir; mcm/s)	8,421	7,722	5,463	5,233	14,353	5,892	3,705	5,991	1,971	4,630	7,918	9,940	3,462
Active Storage at 31 August (12 Reservoir;mcm/s)	17,160	12,461	14,178	7,799	21,537	13,749	10,406	10,860	5,756	7,719	14,512	21,053	11,272

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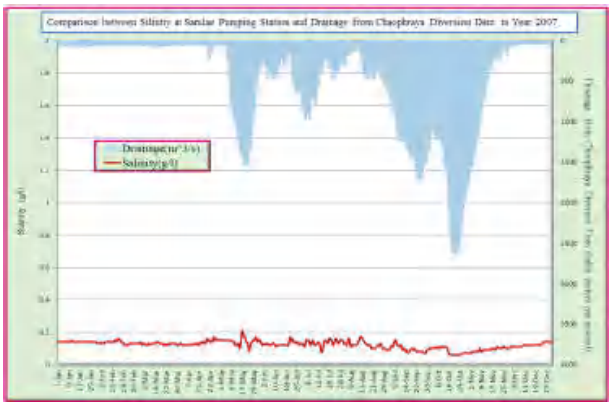


Figure 7(a) Salinity & Drainage 2007

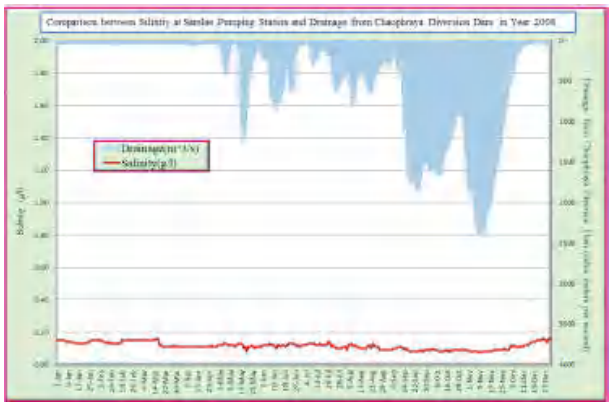


Figure 7(b) Salinity & Drainage 2008

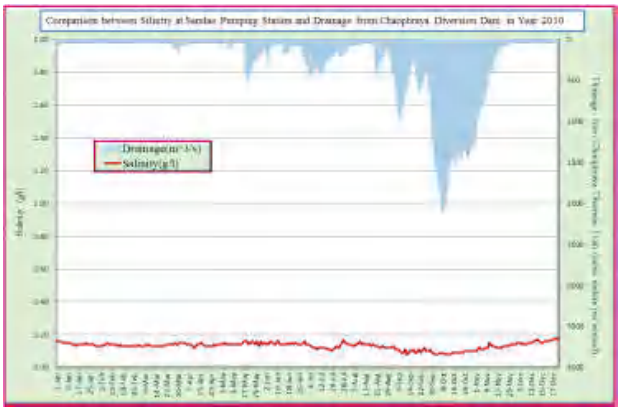


Figure 7(d) Salinity & Drainage 2010

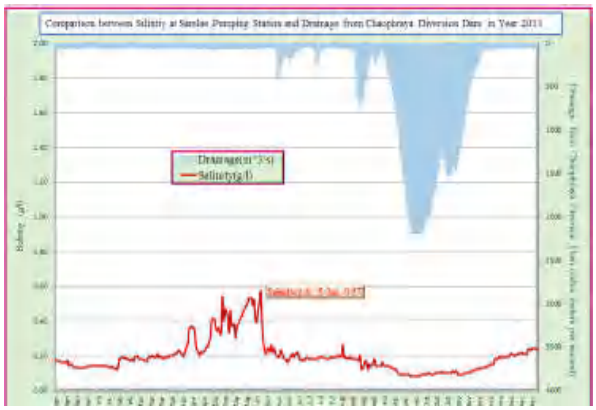
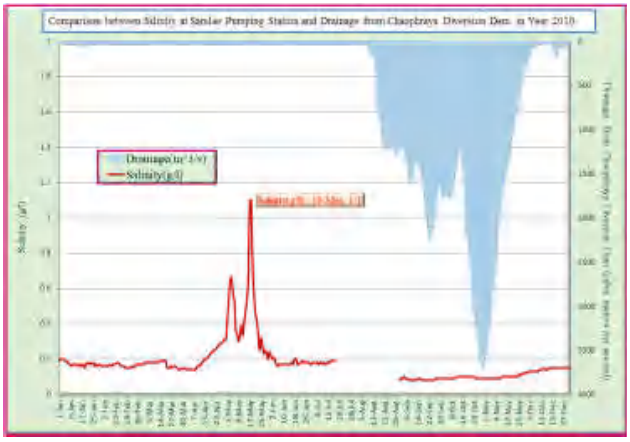


Figure 7(g) Salinity & Drainage 2013



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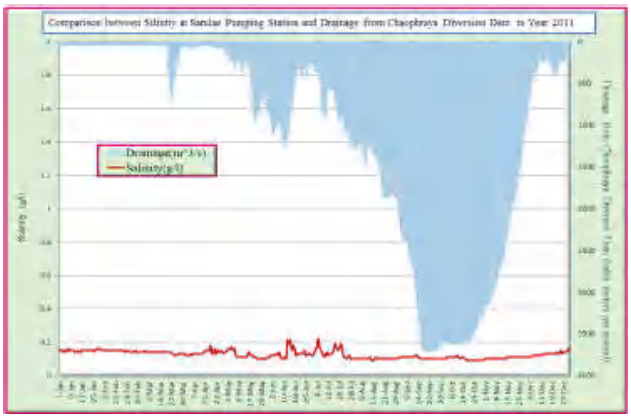

Figure 7(e) Salinity & Drainage 2011

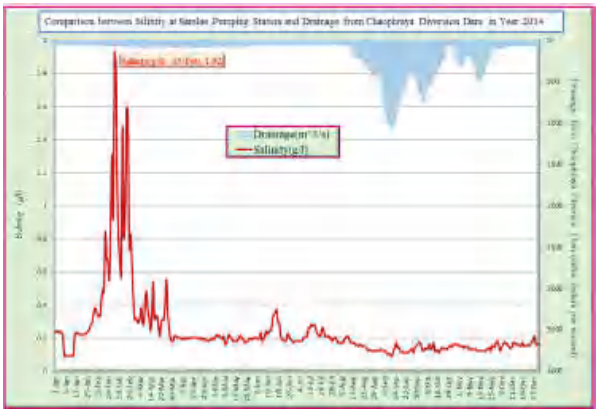

Figure 7(h) Salinity & Drainage 2014

Figure 7(i) Salinity & Drainage 2015

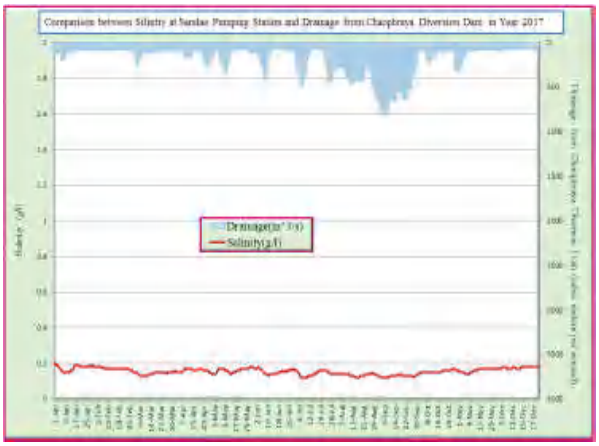

Figure 7(l) Salinity & Drainage 2018

Figure 7(j) Salinity & Drainage 2016

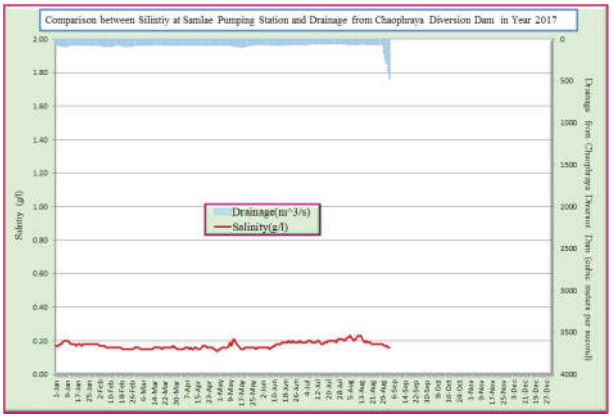

Figure 7(m) Salinity & Drainage 2019

Figure 7(k) Salinity & Drainage 2017

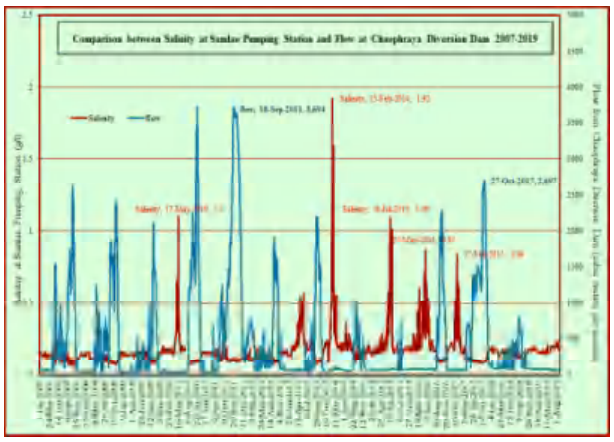

Figure 8 Salinity and Drainage at Chao Phraya Diversion Dam from 2007 to 2019.

4. Conclusion and suggestion

One of the main duties and responsibilities of Royal Irrigation Department (RID) is irrigation water management for household consumption and ecological environmental protection. An example of the water management activity is seawater intrusion control in Chao Phraya river, especially at Samlae (100 Kilometers from the estuary) where raw water pumping station of Metropolitan Waterworks Authority (MWA) was constructed for providing water supply at approximately 1,298.02 million cubic meters per year for 1,366,142 residents in eastern Bangkok.

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