Influence of Large Irrigation Dam Operation on Water Quality of Surface Water Bodies in Thai Wetlands near Saline Soil Spots

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A R T I C L E I N F O

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A B S T R A C T

A study of the water quality of surface water, both natural and man-made water bodies, using an electrical conductivity (EC) meter in lowland areas of the Mun River and its tributaries in front of large diversion dams, was conducted. Some natural swamps and man-made ponds are located near the local salt-making sites from the saline points along with the 3 provinces of Sisaket, Roi Et, and Surin provinces. The results of the year 2019 to 2020 field measurements showed that the mean EC in the swamps was largely influenced by the gate operation of the Rasi Salai dam, which was inversely proportional to the water level changes in the pool shown as an R^2 correlation of 0.66, 0.43, 0.68, and 0.25 for each group of water sources where A in the reservoir of the Dam, B in the Mun River and its tributaries connected to the reservoir rim, C in natural swamps and man-made ponds in floodplains or wetlands between the river and flood protection dikes (FPD) and D is other or similar to C but do not have FPD, respectively.

1. INTRODUCTION

Degradation of surface water quality is a critical environmental problem particularly in the region with intensive agriculture by mean of the water resources development including dam construction can influence the downstream (d/s) river water quality through the leaching of excess nutrients into water bodies through subsurface and surface runoff [1]. Water quality assessment is an important aspect of water resource management [2]. Various methods, techniques, or models have been proposed to qualitatively or quantitatively evaluate the water quality of rivers or lakes described [2]; for example, multivariate statistical techniques and SWAT (Soil and Water Assessment Tool) model applied in the Mun River Basin [3].

As the largest tributary of the Mekong River, the Mun River inputs about 20 billion cubic meters of water per year to the Mekong River. Its water quality of surface water has an important impact on the water environment in the middle and lower reaches of the Mekong River since the completion of a large water resource development project in 1993 including weirs and barrage dam in Surin and Sisaket provinces. The border area between middle and lower Mun River basin is an important agricultural area which has affected by saline soil dispersion influencing the degradation of water quality in the water bodies and direct effect to the reduction of agriculture product and others including the traditional salt making, forest products, traditional fishing ways, and way of traditional life culture [4].

Typical soil surface condition in the northeastern part of Thailand, including the Mun River basin, is affected by the salinity soil dispersion over the basin in Korat Plateau resulted from the rock salt under the earth. The research on the control of saline soil dispersion to the water sources and agricultural area has been continuously studying by some related agencies such as the Department of Mineral Resources (DMR) [5], the Land Development Department (LDD) [6], and the Royal Irrigation Department (RID). Inspection and analysis of saline soil and water quality sampling methods, both in the field and laboratory by mean of salinity was carried out based on the technical references of water quality standards manual from the U.S. Salinity Laboratory Staff, and FAO [7]. The popular field-testing method of water quality and salinity measurement is using kit test set that can be used for the key parameters such as pH, dissolved oxygen (DO), electrical conductivity (EC), water temperature, water turbidity, and NH_4N [5]-[7]. Even though, some agencies have been continuously recorded the water quality in the Mun River as for surveillance and warning for the degradation of water quality [8]. Most research mentioned above focused to carry out water quality in the main system of the river and its major tributaries. Some of them applied a popular method based on the Kendall test and water quality index (WQI) method [1]-[3] without the measurement of floodplain water quality yet. The objective of this study is to study spatial changes of

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water quality in water bodies in floodplains and wetlands of the river near old salt-making sites and or influenced by large irrigation dam in Thailand.

2. METHODOLOGY

Study Area

The Mun River is the largest river in the northeastern part of Thailand and is also a right-bank tributary of the Mekong River. It lies in the drainage basin approx. between latitudes of 14°N to 16°N and longitudes 101.5°E to 105.5°E with the basin area approx. to 82,000 km^2, where plateaus and mountains are in the southwestern area, and plains are situated in the central and eastern areas. The Mun River originates from Nakhon Ratchasima and flows towards the east for 673 km until it joins the Mekong River in the Ubon Ratchathani province [1, 2] as "Figure 1". The average runoff rate of the Mun River is approx. 959 m^3/s during the wet season and 367 m^3/s during the dry season, and the annual contribution to the Mekong River is about 2.5×10^{10} m^3 [9]. The Mun River is divided into three main reaches: Upper Mun, Middle Mun, and Lower Mun whereas the current study is focused on the end of the middle sub-basin.

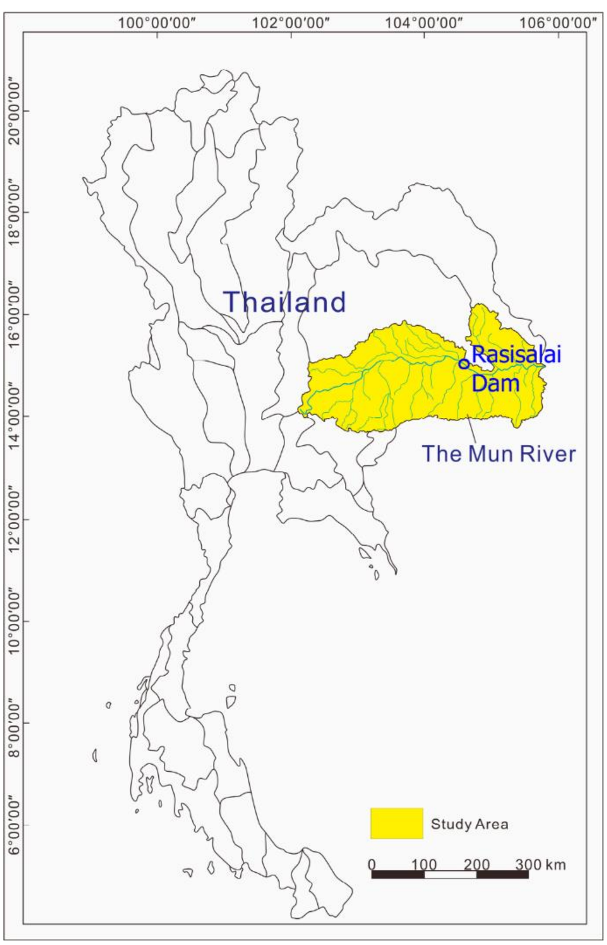

Fig.1. Map of the Study Area of the Mun River's Basin and Location of the Rasi Salai Dam.

In addition, the Department of Energy Development and Promotion (DEDP) has built several diversion dams and weirs in the Mun and Chi River under the Mekong-Chi-Mun River Development Project, including the Rasi Salai dam, located at latitude 15.3438°N and longitude 104.0987°E [10]. However, after the completion of the Rasi Salai Dam in 1993, and began to store water since the end of the year from the level of +116 to +119 m MSL. According to the results of monitoring the changes in land use in agriculture before and after the Rasi Salai Dam, reported by Khon Kaen University in 2001. It was found that most of the current reservoir area was once a swampy area with riparian forest [13]-[15]. There was land use in this area before the dam in 1988. But it has completely changed to a reservoir instead, as seen today. It was found that the riparian forest and dipterocarp forests in 1998 decreased from 11.60% and 0.155%. But there was a 1.22% and 7.82% increase in marshes and water bodies [13], respectively.

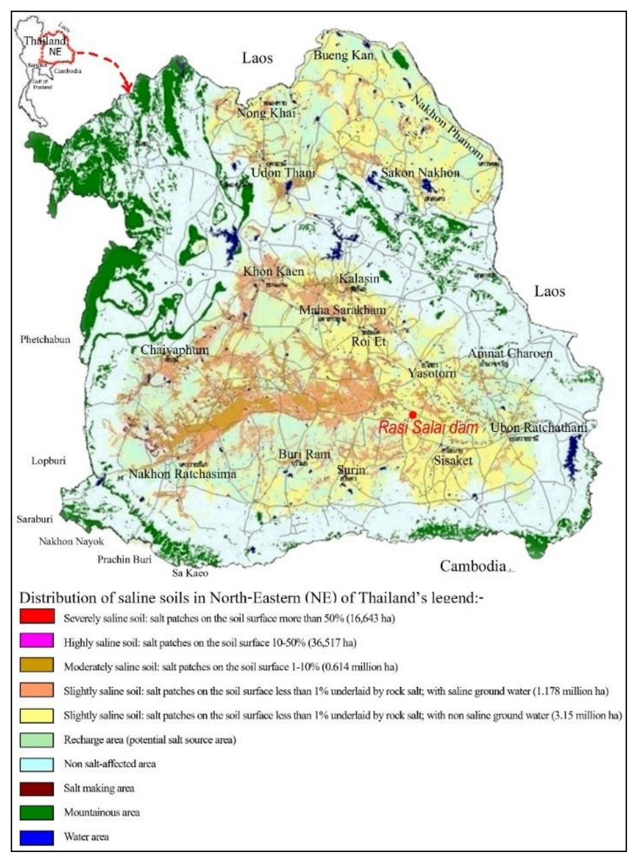

Fig. 2. Location of the Rasi Salai Dam on the Distribution of Saline Soils in NE of Thailand Mapping (adapted from the original map [17, 18]).

In addition, villagers in the floodplains and wetlands of the Mun River basin claim that the dam affected 50 areas of salt-making sites because it was submerged. Currently, only three salt-producing sites are left. Villagers still believe that the dam increases the salinity of the water source [16]. Therefore, the water quality was examined in the Mun River with dams such as Rasi Salai from 1993 to 1994 according to the DEDP [11]. To confirm the saline soils in the Northeast (NE) of Thailand, LDD studied the effects of salinity dispersal. It was found that a large portion was affected by the influence of rock salt under the earth in the Korat plateau. Surface salt is also found in some rice fields in NE Thailand. In addition, Distribution maps of saline soils in northeastern Thailand were developed by LDD as “Figure 2” [17]-[20].

Water Quality Observation

Monitoring of saltwater impacts using EC following the completion of the dam construction in the Kong-Chi-Mun Project, including the Rasi Salai Dam, was recorded from August 1993 to October 1994 [11]. Samples were collected at three sites: upstream (u/s) 10 km, downstream (d/s) 10 Km and at the dam respectively. Those observations focused on the mainstream only. Therefore, this research aims to observe water quality in various water bodies on floodplain and or wetlands of Mun and tributaries such as Huai Thap Than, Lam Phlapla and Lam Siao Yai "Figure 3". A portable conductivity meter (EC meter) and GPS are used to monitor water quality and location of measurement points in the field. Some water bodies are located near traditional salt-making areas that can cause salinity water. The in-situ testing was repeated 1 to 3 times. A randomized method was applied with public participation in this study. The total number of water quality observations in the studies was 39 between December 2019 and August 2020.

Water Quality Analysis

Simple statistical analyzes and spatial distributions were used to verify the relationship of the EC values obtained at each point measurement to the level of water retention (WSL) in the reservoir. Additionally, standard deviation analyzes for each EC for each group of water bodies and reservoir water levels will be used for discussion of the results. Firstly, Group A is the measurement in the Mun River and its tributaries in the reservoir area of the dam. Group B is in the Mun River and the outer tributaries connected to the reservoir. Group C is in the water bodies in the floodplains and or wetlands with riparian forest along the Mun River between the river and the flood protection dikes (FPD). Finally, Group D is others with some are like C but without FPD. EC measurement points, water sources, old and current salt-making areas are shown in "Figure 3" and “Figure 4”. The results of this analysis are for discussion and comparison with the original findings of the year 1993 to 1994 surveys [11].

Dam Operation

The study investigated the water level in the Mun River that overflowing its riverbanks to the water bodies in the floodplain and wetlands. The operation of the Rasi Salai Dam gate control operations at different water levels in the reservoir will also affect water distribution and change in water quality in such water bodies. Operation of the dam using seven radial gates, each with 12.5 m wide and 7.5 m high with a gate sill level of 112 m MSL and maximum water retention level of 119 m MSL. Typical water retention level in the reservoir performed within the range of 116 to 119 m MSL. It depends on the amount of river flow and crop season. While the average river flow rates during dry and flood seasons are approx. 3 and 700 m^3/s, the gates are almost completely closed during the dry season and fully open during the floods, respectively. In the study, the water level in the Mun River and floodplains was modeled using RAS models [12]. 29 cross-section profiles were entered as geometric data along the river reach in this model. The model starts from upstream M. 4 (RID hydrological observation station) passes through the dam and ends at the downstream M. 5 (RID hydrological observation station) with stations at 108.6, 9.5, and 0.2 km respectively. Water levels along the various cross-sections obtained from the model are overlaid on the Digital Elevation Model (DEM) map. Lidar DEM with a map resolution of 5 m x 5 m, which RID provided in 2020, is used to show the water level and the depth above the ground at various points. The results of this study are used to discuss the influence of dam operations on water salinity in water bodies.

3. RESULTS AND DISCUSSION

Water Quality

Field measurements were conducted between 05-07 December 2019, 21-22 February 2020, 15-17 August 2020, and 4 September 2020 with mean water retention level (WSL) in the reservoir and EC of 117.33 m MSL and 72.9 mS/m with a standard deviation of WSL and EC at 0.71 m MSL and 140.0 mS/m, respectively. In addition, the EC analysis results for water bodies in each Group A to D show the spatial distribution with isohyet lines. Their results overlap with floodplain land use, classified using Sentinel-2 satellite imagery [21] as shown in "Figure 4". Such land use analyzes include riparian forests on floodplains and wetlands in the study area. High EC results are caused by shallow water levels in natural swamps near saline soils. This effect causes water in saline soil to flow back into marshes with lower water levels because of lower reservoir levels, for example, at 116.32 m MSL. This effect increases the salinity of water in some natural swamps, including water in the Mun River and in some tributaries.

The details of the field measurements for each group in floodplains, including the coordinates, reservoir water level, EC values, distance from the dam, and stream names are given in Tables 1 to Table 4, respectively.

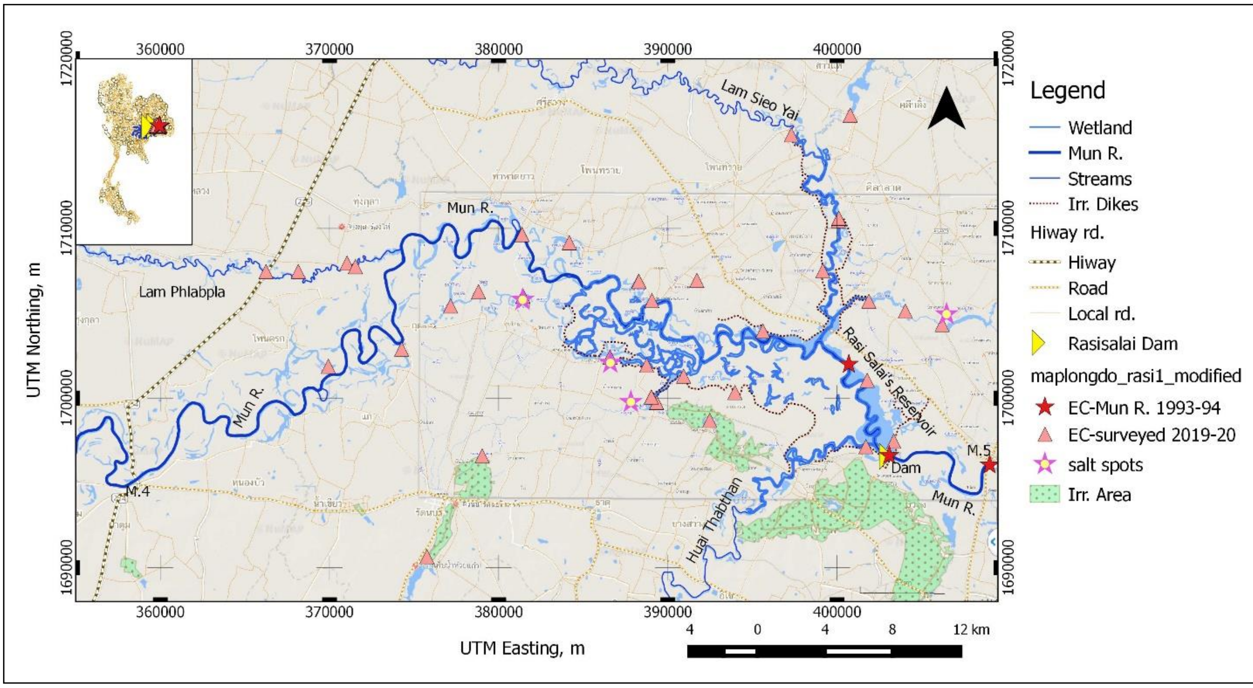

Fig. 3. Location of all EC Observation in the Mun River Floodplain upstream Rasi Salai Dam in 1993-1994 and 2019-2020

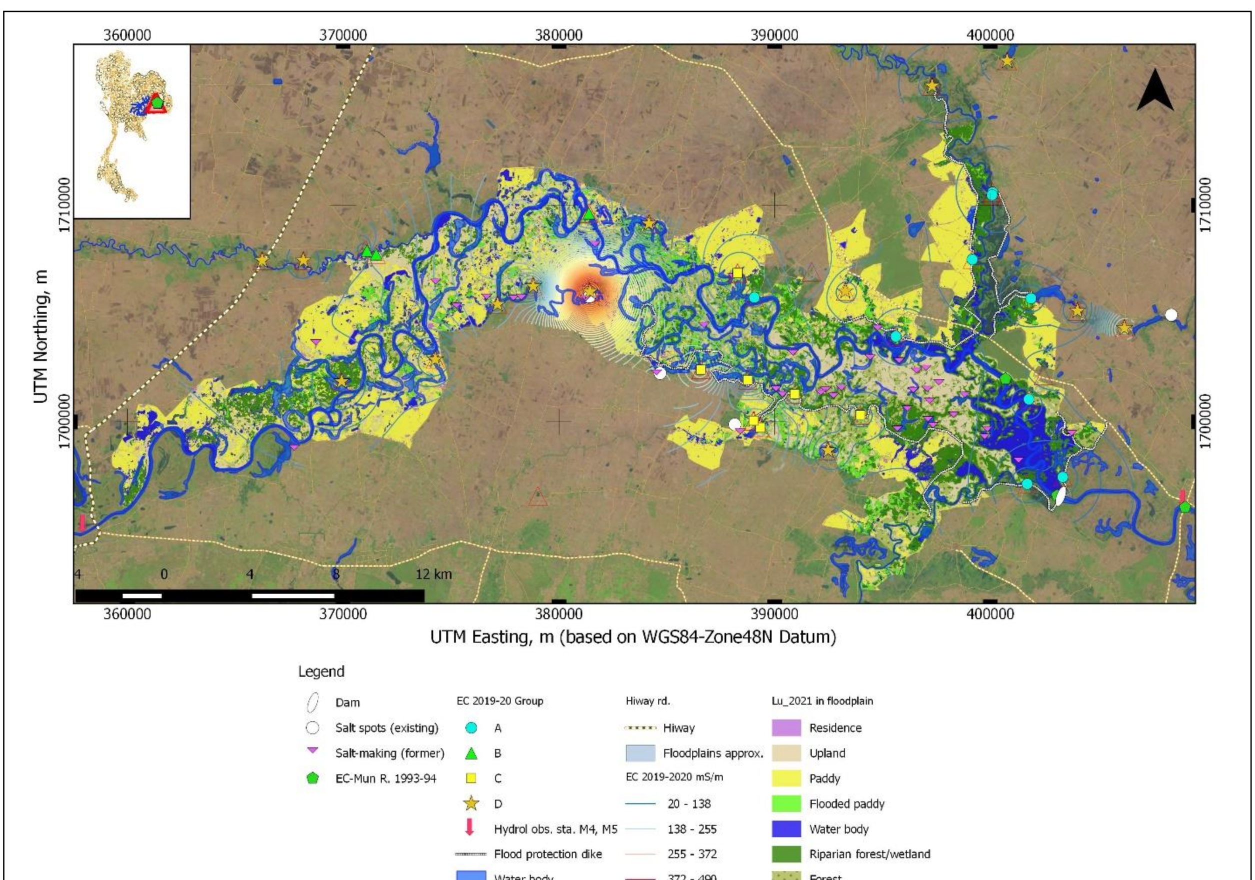

Fig. 4. Map showing the EC Monitoring Points for each Water Body A: Reservoir B: in the Mun and its Tributaries C: Floodplain/Wetlands between Mun River and Flood Protection Dikes (FPD) D: Same as C but outside FPD; Including Spatial Distribution with the Isohyet Lines of EC investigated in 2019 - 2020 (unit in mS/m) and Shows Land Use Classification on Floodplains/Wetlands, overlaid on Sentinel-2 Satellite Imagery: L1C_T48PUC_A021208_20210329T033157 [21]

Table 1. Group A: EC value in the Mun River and its Tributaries within the Reservoir of the Dam (Dam sta. is 9.5 km of a River Reach measured from M.5)

Lat	Lon	WSL, m MSL	EC, mS/m	Distance from the dam, km	River name
15.3519	104.0996	117.90	16.1	1.5	M[1]
15.3490	104.0843	117.90	14.4	1.6	TT[1]
15.4265	104.0855	117.89	14.1	21.5	NK[1]
15.4707	104.0688	117.89	16.6	27.0	LS[1]
15.4694	104.0685	117.89	21.4	33.1	LS[1]
15.4103	104.0272	117.89	26.1	18.0	M[1]
15.3844	104.0848	116.32	23.4	8.0	M
15.4263	103.9660	116.35	32.8	31.0	M
15.4426	104.0601	116.32	30.2	22.0	LS[1]
15.4707	104.0688	116.32	33.2	27.0*	LS[1]

Note *Repeat Measurement and [1] is in the Wetland, while M, LS, NK, TT means Mun, Lam Sieo Yai, Huai Namkhem (Branch of LS), Huai Thabthan respectively.

Table 2. Group B: EC value in the Mun River and the Outer Tributaries Connected to the Reservoir

Lat	Lon	WSL, m MSL	EC, mS/m	Distance from the dam, km	River name
15.2969	103.5953	117.91	63.4	117.0	M
15.4612	103.8943	117.90	32.9	46.0	M
15.4454	103.7980	117.89	21.4	67.0	PP[1]
15.4436	103.8026	117.89	76.2	66.1	PP[1]
15.4612	103.8943	116.32	91.7	46.0*	M

Note *Repeat Measurement and [1] is in the Wetland, while M and PP means Mun and Huai Phlabpla respectively.

Moreover, the relationship between the above EC groups and the reservoir water level (WL) is shown in a linear graph as shown in "Figure 5" to "Figure 8". The relationship (R^2) between EC and WL was 0.66, 0.43, 0.68 and 0.25 with standard deviations of 7.5, 29.4, 88.8 and 223.7 mS/m for Group A, Group B, Group C and Group D., respectively.

High jump EC was found in Group D and led to a low correlation as “Table 4”, “Figure 4” and “Figure 8”. Since most of the bottom of the pond is higher than the reservoir level, during which the dam maintains the water level below 117 m MSL, the influence of the dam is avoided. This causes some of the soil water near the saline to flow back into swamps and rivers and eventually increase the salinity. But if the water retention level is higher 117 m MSL, it will have a better effect, allowing the water to flow into the water bodies, thus reducing the salinity of the water. Moreover, the field measurement time is too short, rarely repeated measurements, and the reservoir water level does not change much. The maximum EC, however, appears in natural swamps near the old salt-making area at the bottom of the pond at 118 m MSL, a 1.8 km long channel connecting this pond with Mun River at stations 52.5 or 43 km from the dam “Figure 4”. It is considered one of the marshes influenced by the management of the dam in the flood season. A study by the Social Research Institute [16] and map of saline soil distribution in NE Thailand in “Figure 2” confirms the discovery of saline soil close to this swamp that the community had previously used for salt-making. Field surveys and RAS models confirmed that swamps benefited from dam operations, when the reservoir water level exceeded 118 meters, the water in the Mun River could flow into the swamp. It positively affects the quality of the water in this water source. On the other hand, if the water level in the reservoir drops below that, the water quality in this swamp will deteriorate. This is because the water in the soil, which is already salty, will flow back into the marsh and increase the salinity. As a result, this water cannot be used in agriculture.

Table 3. Group C in the Water Bodies in Flood Plains or Wetlands of the Mun River between the River and FPD

Lat	Lon	WSL, m MSL	EC, mS/m	Distance from the dam, km	River name
15.3626	103.9982	117.90	22.9	23.0	M
15.3776	104.0120	117.90	23.5	21.0	M[1]
15.3861	103.9837	117.90	24.8	26.0	M[1]
15.3720	103.9688	117.90	10.3	26.2	M[1]
15.3749	103.9660	117.90	22	26.1	M[1]
15.3776	104.0120	117.90	26.5	30.0	M[1]
15.3961	103.9431	117.90	83.6	34.0	M
15.3749	103.9660	117.53	49.2	26.1*	M[1]
15.4365	103.9588	116.35	53.6	36.1	M[1]
15.3720	103.9688	116.32	200.5	26.2*	M[1]
15.3749	103.9660	116.32	202.2	26.1*	M[1]
15.3961	103.9431	116.32	267.5	34.0*	M

Note *Repeat Measurement and [1] is in the Wetland.

Table 4. Group D: EC value in other Areas with some are in Floodplains and outside Flood Protection Dikes

Lat	Lon	WSL, m MSL	EC, mS/m	Distance from the dam, km	River name
15.4284	103.8950	117.90	119.7	43.0	M
15.4570	103.9203	117.90	22.8	43.1	M
15.4213	104.1056	117.89	10.7	22.4	NK
15.5150	104.0424	117.50	17.1	35.0	LS[1]
15.5256	104.0748	117.50	11.5	38.5	LS
15.4408	103.7711	117.89	22.2	72.5	PP
15.4305	103.8705	117.53	54.4	53.0	M
15.3998	103.8283	117.53	30.2	67.0	M
15.3904	103.7880	117.53	28.6	90.0	M[1]
15.4407	103.7534	117.53	36.6	75.1	PP
15.4229	103.8551	116.32	87.8	56.0	M
15.4142	104.1259	116.32	152.8	25.5	NK
15.4366	103.9587	116.35	25.9	36.0	M
15.4284	103.8950	116.32	869.0	43.0*	M

Note *Repeat Measurement and [1] is in the Wetland

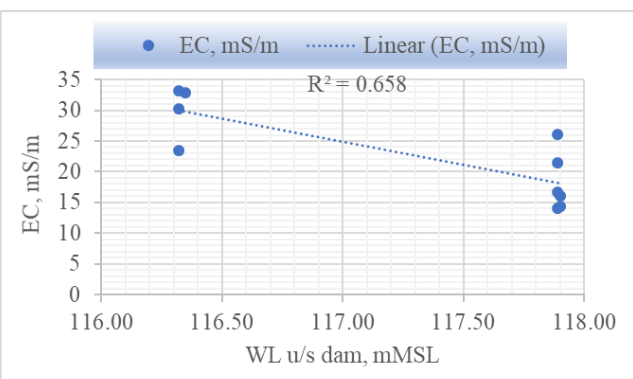

Fig. 5. Relationship of EC and Water Levels of Group A.

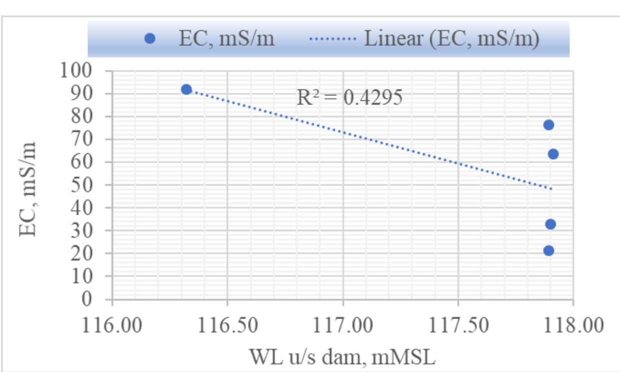

Fig. 6. Relationship of EC and Water Levels of Group B.

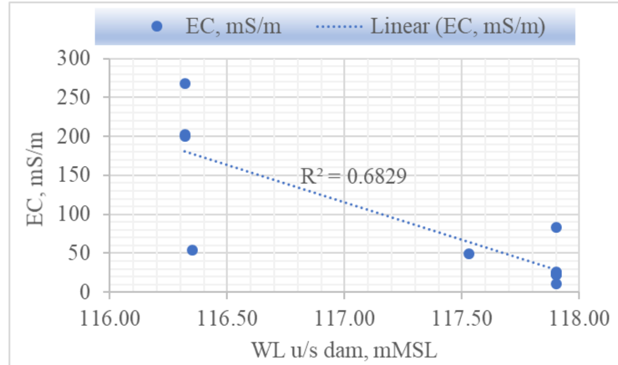

Fig. 7. Relationship of EC and Water Levels of Group C.

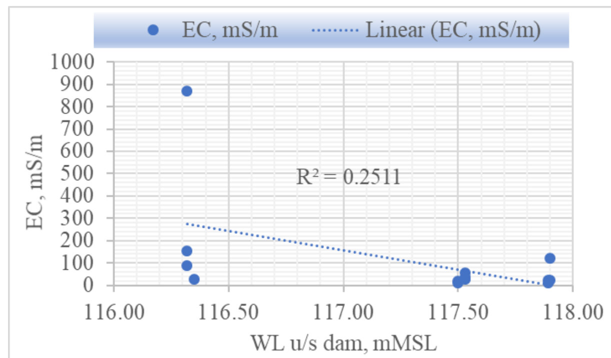

Fig.8. Relationship of EC and Water Levels of Group D.

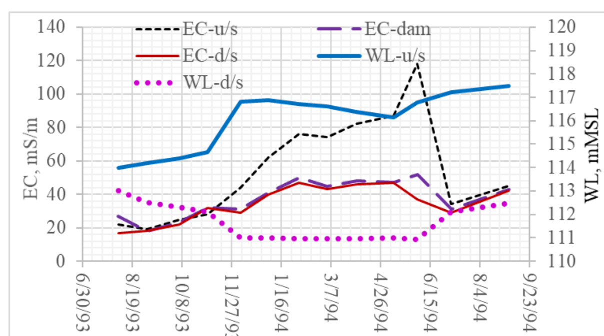

Fig. 9. Monthly EC Records in the Mun River at 10 km Upstream (u/s) Dam, at the Dam and at 10 km Downstream (d/s) Dam from August 1993 to October 1994 (adapted from an original map [11]).

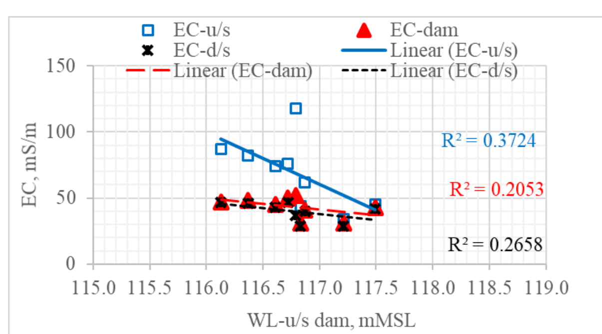

Fig. 10. Correlation of Monthly EC Values and u/s Dam, at Dam and d/s Dam from August 1993 to October 1994 [11].

In keeping with the historical measurements only in the Mun River or Reservoir, the EC values of Group A and Group B are combined. The results are shown in "Figure 11". The correlation was relatively low at 0.17, with the EC mean and standard deviation of 34.3 and 23.7 mS/m, respectively. In comparing the past and present analysis results between "Figure 10" and "Figure 11", it was found that the two EC values were inversely proportional to the water level in the same pattern. The EC jump in "Figure 11" may be due to different environmental conditions, such as land-use changes from wetlands and rain-fed agricultural systems to reservoirs and irrigation systems since 1994 [13, 14].

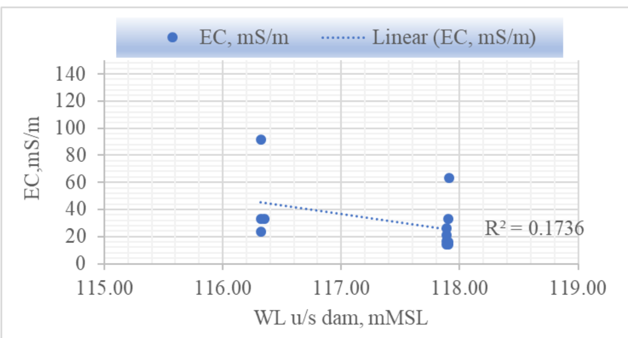

Fig. 11. Relationship of EC and Water Levels u/s the Dam combined from Group A and Group B.

Some EC values selected from Table 1 to Table 4 for specific measurement points located in wetlands (M[1], NK[1], LS[1], PP[1], and TT[1]) were re-analyzed. It was found that the group's EC was inverse correlation with water level, with a good correlation of 0.49 and standard deviation of 58.1 mS/m, as shown in "Figure 12".

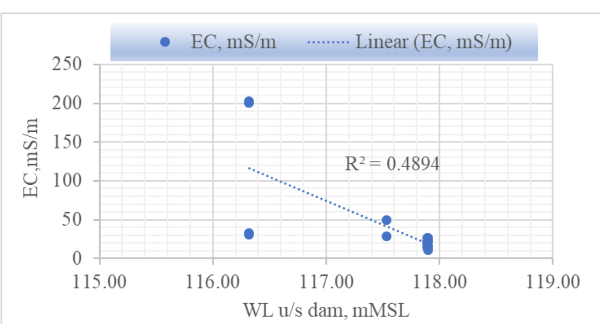

Fig. 12. Relationship of EC and Water Levels in Wetlands (M[1], NK[1], LS[1], PP[1] and TT[1]) of the Mun River.

Based on past and current analyzes above, it can be confirmed that EC is inversely proportional to water levels in water bodies and reservoirs, indicating the salinity of marsh water. However, if there is an old salt source near the water source, it will greatly degrade the quality of the water source. For example, if the dam's water level control should not be lower than 117 m MSL, it may be better to inhibit the spread of saline soil to water bodies.

Operation of the Dam and Its Effects

For the management of dam gate operations, the authors applied the RAS [12] and Lidar DEM in case of low and high river flow rates. In the model, 29 cross-sections of rivers spanning the floodplain were entered into the menu of geometric data in RAS and overlaid on the Lidar DEM map. The model's upstream boundary began at M.4 (sta. 108.6) passes through the Rasi Salai Dam (sta. 9.5) and ends as the downstream boundary of the model at M.5 (sta. 0.2) as shown in "Figure 13".

The river flow rate was considered as the upstream boundary condition at M.4, the lateral boundaries where the various tributaries meet with the Mun River as well. In the simulation of gate control during zero or low flow rates during the dry season. Three cases were considered in the model assuming the retention levels of 116, 117.5, and 119 m MSL, respectively. The model results show that the water surface profile along the river reach has a flat slope with the inundated in floodplain and wetlands at 0, 1230, and 7585 ha, respectively. Moreover, the suggestion from model that most openings should be completely sealed to maintain water levels in such cases. However, during the average water inflow or very high flow in the rainy season and flooding, if the reservoir water level tends to be above 118.5 m MSL, the model suggests that all gates should be opened. Moreover, if the water level is higher than 119 m MSL, the gates should be fully lifted above the water surface. An example of a result from RAS with a low inflow rate and retention water level of 118.5 m MSL is shown in "Figure 14". It can be seen that the u/s water level causes the backwater almost to the middle reach of the river at the bridge (sta. 55.5) approx. 46 km measured from the dam. However, if the river flow rate becomes approx. 700 m^3/s with the gates partially opened and retained water level u/s dam at 118.5 m MSL, the water level retraces back to a distance of approx. 80 km from the dam and overbank flowing into floodplains and wetlands as shown in "Figure 15 ". In addition, the simulation results show that during the river's high flow rate, although the water level in front of the dam is approx. 118.5 m MSL as well, there is a much larger inundated area than when the river is low in flow.

The example of the simulation above illustrates the water level at any location in the river to the floodplains and wetlands based on the flow rate and retained water levels in a dam by gate-controlled. The RAS results show the impact of different reservoir levels from dam operations. It can be concluded that the water in the Mun River and the upstream dam tributaries can flow through those natural sources as shown in the elevation maps of the floodplain and wetlands of the Mun River. However, overflowing the bank or flowing along a channel from the Mun River through various water bodies in this simulation is not considered obstructions that block the flow, such as levees or local roads in a riverbank area.

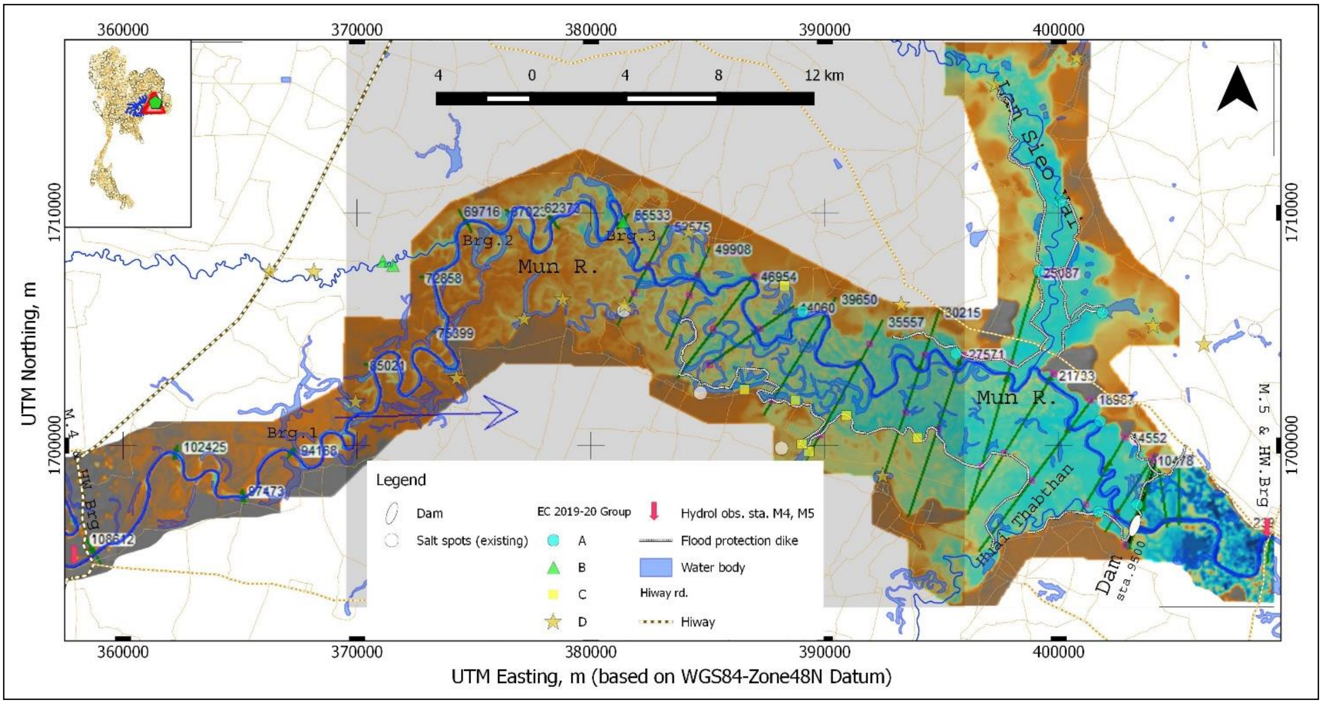

Fig. 13. Map showing Location of Cross-Sectional Profiles of a River Reach in RAS from M.4 to M.5, through the Rasi Salai Dam, and Water Bodies in Floodplains/Wetlands of the Mun River overlaid on the Lidar DEM Map, and the Light Blue is Water Storage Area at the Level in the Reservoir approx. 119 m MSL (the dam is at Sta.9.5)

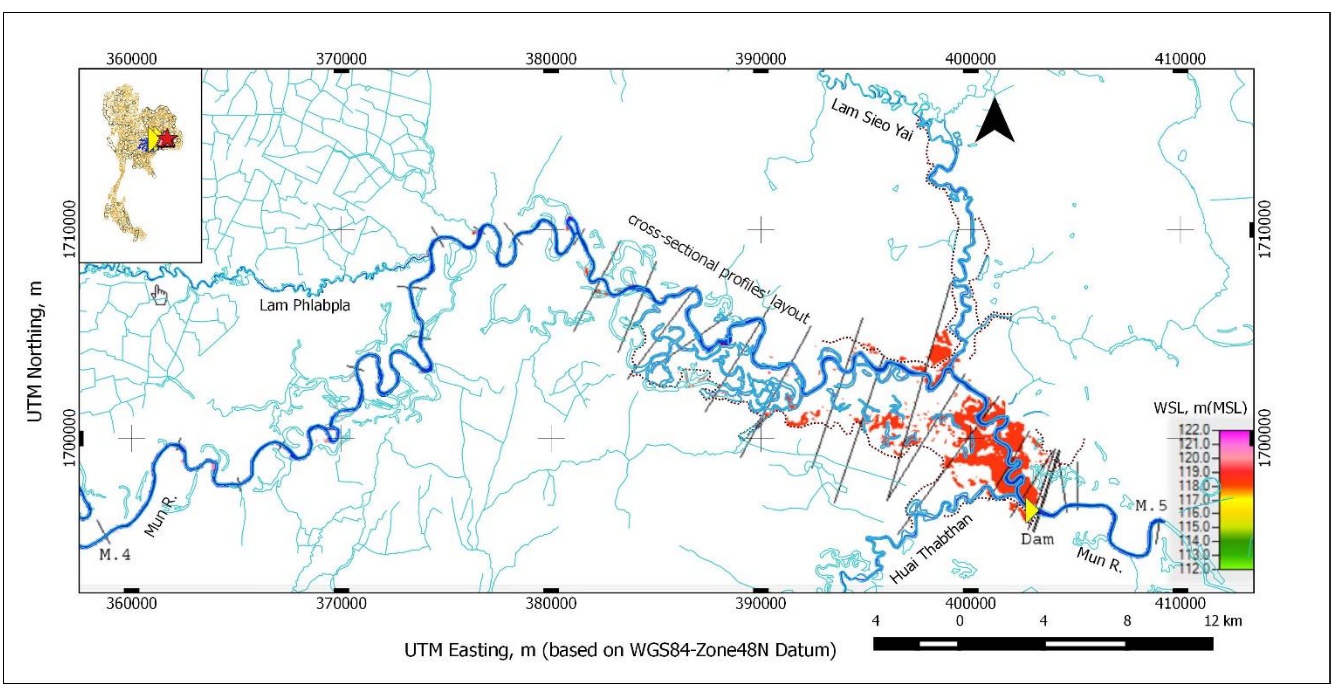

Fig. 14. Map showing the Simulated WSL in the Floodplain/Wetlands based on Lidar DEM Map with Low River Flow Rate and Retention Water Level at the Dam approx. 118.5 m MSL with Gates almost Completely Closed on August 22, 2011

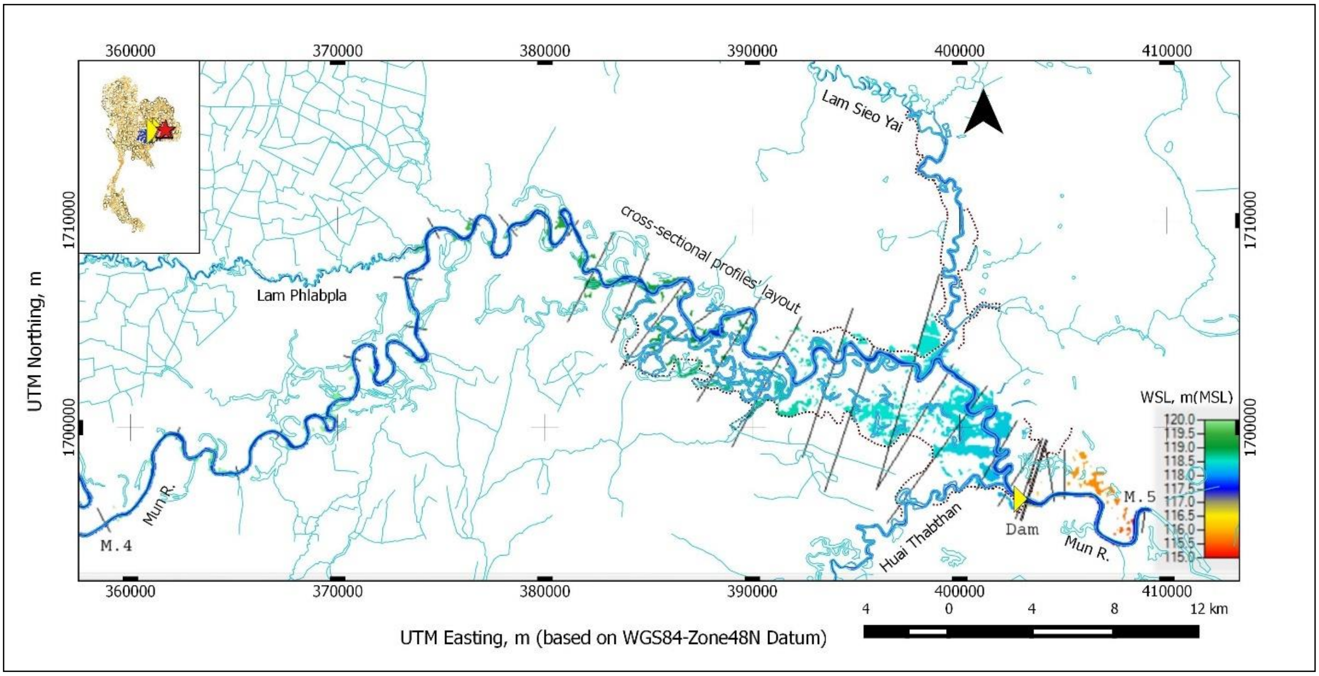

Fig. 15. Map showing the Simulated WSL in the Floodplain/Wetlands with Mean River Flow Rate during Wet Season and WSL at the Dam of +118.5 m MSL with Gate Partially Opened on October 1, 2011.

4. RECOMMENDATIONS

Due to the time limitations of this study, it is only to answer the facts of part of the villagers who believe that the operation of the Rasi Salai Dam has many effects, especially the diffusion of salinity. The study therefore made repeated measurements only at some certain points of the water source that the villagers were interested in. Therefore, the number of samples used for analysis may not yet be a good representative for all water bodies throughout the study area. From the above study, it can be seen that if the water level in the Mun River falls below the bank level or the level at which it can overflow the banks into water bodies located on the floodplain and wetlands. Those water sources are vulnerable to an increase in salinity. But after using the Rasi Salai Dam to control the water level as a reservoir, some of the original water sources in the floodplain and wetlands were submerged under the dam's reservoir. This may be beneficial to inhibit the spread of salinity. However, for water bodies in the area between the reservoir and the tidal influence zone of the dam operation and the flood influence may be adversely affected. Especially if the water level in a river or reservoir in the dry season is lower than the bottom level of those water sources. This will affect water bodies near the old salt-making areas, further worsening the quality of the water.

Therefore, further studies of continuous field EC observation should be undertaken near salting sites in both reservoirs and swamps, in floodplains and wetlands of Mun River. The recommendation is to collect the water samples from the water sources during the season according to the project's cultivation calendar. The results of this study should then be compared with the historical results recorded monthly in 1993 to 1994 by the DEDP. Land use surveys around water bodies should also be explored, especially in areas that are diffused from saline water bodies as well. In addition, the gate operation of the Rasi Salai dam during opening or closing to maintain the water retention of the dam should be careful of the impact on salinity. As this study found that salinity increases if the water retention level decreases below +117 m MSL. Stagnant zones should be defined or restricted salting areas to prevent the spread of salinity into water bodies. If the area is not controlled, there could be further conflicts between farmers and salt-makers in the future.

Furthermore, if the project's water allocation officer continues to apply the RAS model to assist in dam management, the efficiency of water level and water quality control in various water bodies will be improved. However, the accuracy of the model results depends on the number and results of cross-sectional surveys along the river and flood plains in the field, but also on their expertise and experience in their application. Project staff should continue to expand the findings of the use of this model to aid in decision-making for effective action in maintaining water levels in reservoirs and dam gates operation. The above recommendation is to ensure that the analysis results of the project are reliable and acceptable to local people living in the study area without the effects of increasing salinity, water damaging agricultural production.

5. CONCLUSION

The results of surveys and analyzes of water quality in the rivers and water bodies on floodplains and wetlands of the Mun River were measured from late-2019 to mid-2020. Some water bodies have been affected by old salt-making facilities in the neighborhood. This causes the water quality to be quite salty as the water level in the water source decreases. However, from the above studies it was found that fluctuating water levels in the Mun River influence changes in water quality in such bodies. If the water level falls to its lowest during the dry season, for example from late April to early August, some of the salty soil will flow back to the water body and increase the salinity in the area and the river. On the other hand, during the flood season, from early September to October or early November, the water in the river floods and retains its water bodies, especially in the lowlands and wetlands. It results in better water quality as well. The results of comparing the EC values in this study with the original data only in the Mun River from 1993 to 1994 after the dam was built by DEDP, concluded that the water quality of the current Mun River has not changed much from the past recorded. However, no reports have been found on the water quality of the water bodies in the floodplains and wetlands of the Mun and its tributaries. But in this study, it was found that the water quality in the water source was inversely proportional to the reservoir level of the Rasi Salai Dam due to the influence of dam gate control. The results of this water quality monitoring were consistent with past reports recorded by the DEDP.

The application of the RAS model in conjunction with Lidar DEM can be used to efficiently manage the dam gate operations. In addition, water levels and depths can also be determined at various locations along the river's cross-section, both in floodplains and wetlands. The accuracy of the simulation results from the RAS model depends on the number of cross-sections of the surveyed rivers, as well as floodplains and wetlands. The size of the other water-control structures in the floodplain irrigation system is also necessary to include in the model. The use of this model will be a tool to confirm the effect of dams forcing water levels to flow in and out of the water bodies on the floodplain and wetlands area. Therefore, the salinity of water in some water bodies near the old salt source could also benefit from this dam if the retention water level in the dam is maintained properly.

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