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Analysis and Prediction of Poyang Lake's Navigable Conditions under a New Hydrological Regime

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Abstract: Human activities have profoundly changed the hydrological regime and trends of rivers and lakes, which, in turn, has affected the utilization of their navigable conditions. However, few studies have focused on the effects of changes in hydrological regimes and trends of rivers and lakes on navigable conditions. Thus, this study intensively analyzes and investigates the navigable depth at the major control sections in the lake area during the dry season in the period before 2002, when the Three Gorges Reservoir was not yet constructed, and the period from 2003 to 2019, when the Three Gorges Project was put into operation with impoundment based on the dry-season water level curve in the Poyang Lake area since the operation of the Three Gorges Reservoir. This study also further analyzes the influence of the change in the hydrological regime on the navigable depth in the lake area. The results show that the waterway depth and width could meet the navigation requirements before 2002. From 2003 to 2019, whereas the water level with a 98% guarantee rate of duration at the Xingzi Hydrometric Station decreased, that at the Hukou Hydrometric Station increased. The waterway depth and width at both the Hukou and Xingzi hydrometric stations could meet the requirements of the size of Grade II waterways. This study also performs a simulation prediction of the water regime of Poyang Lake under a new hydrological regime using the mathematical model of water and sediment of the Changjiang River Scientific Research Institute. The results reveal that in 2030 and 2050, after the Three Gorges Reservoir has been in operation for 30–50 years, the water levels at the Hukou, Xingzi, and Wucheng hydrometric stations (Hukou) of Poyang Lake will decline by approximately 0.18–0.66 and 0.10–0.24 m, respectively. Although the overall navigable depth can basically meet the navigation requirements for a period of time, the trend of the long-term declining water level may cause unsafe navigation risks.

Keywords: the river–lake relationship; the Poyang Lake navigable conditions; new hydrological regime

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1. Introduction

In recent years, the concept of the river–lake relationship has become increasingly involved in the study of water and sediment exchange between Poyang Lake and Yangtze River [1]. Accordingly, the influence of the change in the river–lake relationship caused by the Three Gorges Project (located 1063 km upstream of Poyang Lake) on Dongting and Poyang lakes in the middle reaches of the Yangtze River has been given increasing attention by academic circles [2–4]. Yangtze River and Poyang Lake join at the Hukou Hydrometric Station (Figure 1), constituting an intricate river–lake relationship, in which the lake water discharges into the river, or the river water flows back into the lake. The water exchange between rivers and lakes is affected by the water from the five rivers in the upper reaches of Poyang Lake and that from the Yangtze River. This enables Poyang Lake to regulate and store the flood water in the Yangtze River and leads to the river evolution and lake erosion–deposition and change in the hydrological regime, as well as the effects of the water resources, environment, and ecology and shipping arising thereof due to the flow and mass energy exchange between Yangtze River and Poyang Lake [5,6].

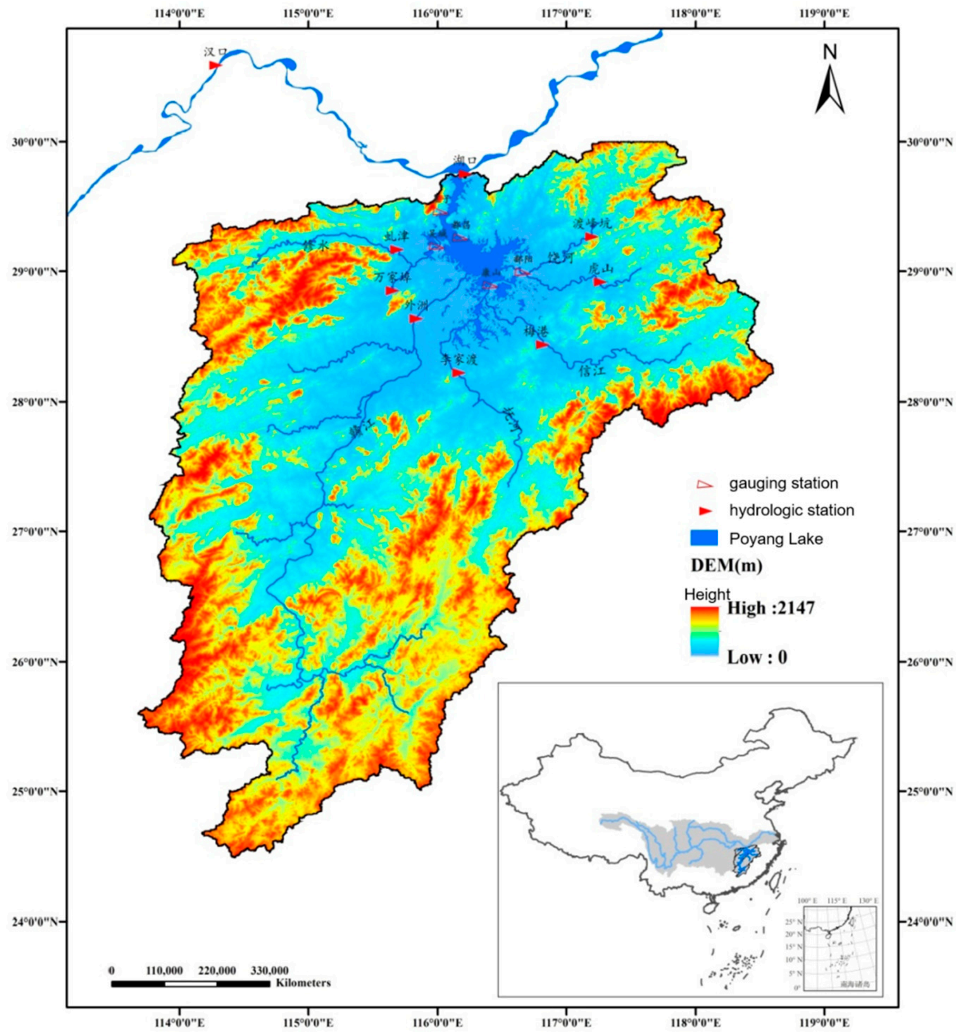


Figure 1. Location of the research area.

1.1. The Impact of Human Activities on River-Lake Relations

The water regime of the main stream of the Yangtze River directly affects the interaction between the Yangtze River and the Poyang Lake [7,8]. Hu et al. performed a quantitative analysis of the state, intensity, and annual variation characteristics of the water exchange between rivers and lakes using various parameters (e.g., the net change rate of the lake flow) and analyzed the influence of the river–lake relationship on the water level of Poyang Lake from 1960 to 2003. The results show that the water coming from the Poyang Lake basin plays a leading role in Poyang Lake's water level and flood disaster, whereas the backwater of the Yangtze River plays a secondary role in Poyang Lake. Zhang et al. [9] showed that since 1990, the occurrence frequency of Yangtze River inpouring into Poyang Lake has significantly decreased and has an intermittent feature, which is in good correspondence with the temporal variation of rainfall. The analysis of the inflow and outflow water and sediment regime in Poyang Lake shows that the runoff at the Wuhe and Hukou hydrometric stations of Poyang Lake since 2003 was less than that before 2000. Moreover, the sediment discharge into the lake at the Wuhe hydrometric station significantly decreased, whereas the average annual sediment discharge at the Hukou hydrometric station markedly increased [10,11]. Natural factors, such as the significant decrease of the sediment in Poyang Lake, climate change, tectonic subsidence, soil erosion, sediment deposition, and Yangtze River regime change, led to a change in the river–lake relationship, but human activities since the 20th century have accelerated the adjustment of this relationship [12–14].

Before the flood season, the reservoir will increase the discharge to reserve flood control storage capacity. After the flood season, the reservoir will reduce the discharge to save water. Thus, the water regime of Poyang Lake significantly changed [15–17], especially before the flood season and at the end of this season. Zhang et al. [18] used a generalized additive model to simulate and verify that the impoundment operation of the Three Gorges Project caused a 5% average loss of the inflow from the Yangtze River, and that the impoundment period at the end of the flood season slowed down the backwater effect of Yangtze River on Poyang Lake, thereby aggravating the drought in Poyang Lake in autumn. Liu et al. [19] used multitemporal satellite remote sensing data from 1973 to 2011 to collect the water surface information of Poyang Lake based on its water balance analysis. The results showed that the change in the river–lake relationship between the Yangtze River and Poyang Lake caused by the impoundment operation of the Three Gorges Project is one of the main control factors of the sudden change of the water level at the end of the flood season in Poyang Lake in recent years.

The impoundment operation of the Three Gorges Project reduced the main stream discharge under the dam during the flood season and increased it under the dam during the dry season, leading to a silt discharge decrease in the Yangtze River. The change of the water regime in the main stream of the middle reaches of the Yangtze River changed the interaction between the Yangtze River and the two lakes [20–23]. Human activities and climate change have dramatically changed the evolution process and trend of the hydrology and geomorphology of rivers and lakes. With the completion and operation of reservoirs in the upper and middle reaches of the Yangtze River, the relationship between the rivers and lakes in the middle and lower reaches of the river underwent dramatic changes, which affected the utilization of its navigable depth. The change in the river–lake relationship is an important factor affecting the hydrological and sediment environments of Poyang Lake, which has a bearing on the safety of shipping in the lake area. Based on the analysis of the navigability and characteristics of the navigation-obstructing shoals in the Raohe Lake area, Yang [24] employed mathematical models to calculate the key parameters of the dredging depth of the navigation channels in each shoal section of the lake waterway. He also analyzed the change in the hydrodynamic conditions and the velocity variations at the channel section after the project.

1.2. The Impact of Hydrological Regime Changing on Navigability of the Yangtze River

The navigability of the Yangtze River supports the economic and social developments along it. By 2020, the water volume of the Yangtze River was 30.6×10^8 t, accounting for 78.6% of the total water volume in China's inland rivers [24]. Affected by sand mining in the lake area and the operation of the upstream Three Gorges Reservoir, the hydrological regime of the two lakes changed, and the change of the hydrological regime in the lake area may bring about some adverse effects on the navigability of the two lakes in the future [25–28]. However, existing studies paid little attention to the influence of the river–lake relationship and the change of the hydrological regime in the river–lake intersection area [29], especially in terms of the development and utilization of deep-water resources in the main channel of the Yangtze River. The correct understanding and adequate regulation of the change of the river–lake relationship are keys to realizing safe navigation in the rivers and lakes in the Poyang Lake area [30–33]. With the change in the relationship between the hydrological regime and the rivers and lakes in the main stream of the Yangtze River, defects, such as insufficient consistency and sequence length of data, were found in the existing hydrological observation data, making it difficult to ensure safe navigation in Poyang Lake under the new hydrological regime. The existing research often ignores the influence of the Three Gorges Reservoir on the hydrological regime. As a result, the simulation results are far from the actual situation. To solve the abovementioned problems, this study simulates and predicts the navigable depth in the Poyang Lake area based on the water level curve analysis of Poyang Lake since the operation of the Three Gorges

Reservoir by analyzing the hydrological regime and the water level curve and simulating and predicting the navigation safety of Poyang Lake.

2. Overview of the Study Area

The Poyang Lake water system is a convergent water system, with Poyang Lake as its convergence center. It is composed of the Ganjiang, Fuhe, Xinjiang, Raohe, and Xiushui rivers and other rivers directly flowing into Poyang Lake from the area around it. The Poyang Lake basin is high in the south and low in the north. The basin is surrounded by mountains and gradually slopes towards Poyang Lake on all sides, forming a basin-like terrain with Poyang Lake as the bottom. The water from all the rivers that gather in Poyang Lake is stored in Hukou, Jiangxi Province, before being discharged into the Yangtze River. The Poyang Lake basin is located on the right bank of the middle and lower reaches of the Yangtze River, covering an area of 162,200 km^2 and accounting for approximately 9% of the Yangtze River basin area. The Poyang Lake is densely covered with rivers and lakes. Its navigation involves the five water systems of the Ganjiang, Fuhe, Xinjiang, Raohe, and Xiuhe rivers. The water from these five rivers comes from the confluence of the Chuxi Estuary 20 km downstream of Wucheng and flows into the Yangtze River via Xingzi. Poyang Lake has 99 navigable rivers or routes and 5 major water system basins with a navigable mileage of 5525 km, including 310 km of grade III and above waterways. The Grade III waterways in the lake area were required to be (2.0~2.4 m) × (90~110 m) × 550 m. The Ganjiang and Xinjiang River waterways are the main waterways in the lake area. Ganjiang River is also the major water transport artery in Jiangxi. Figure 2 depicts a schematic diagram of the main waterways in the Poyang Lake area.

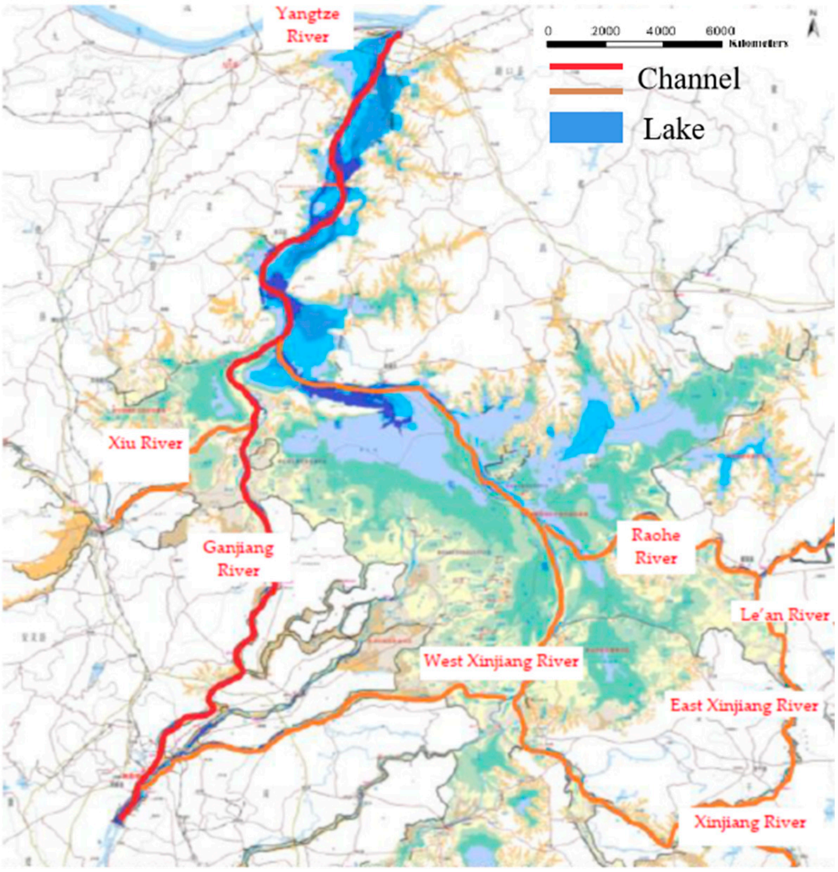


Figure 2. Schematic diagram of the main waterways in the Poyang Lake.

3. Water Level Curve Analysis in the Poyang Lake Area during the Dry Season since the Operation of the Three Gorges Reservoir

In this section, the water level curves in the lake area before and after the construction of the Three Gorges Reservoir were compared and analyzed using the observation data collected from the Xingzi hydrometric station, which was selected as the lake stage gauging station, and the Hukou hydrometric station, which was chosen as the outlet gauging station, in the Poyang Lake area before (from 1960 to 2002) and after (from 2003 to 2019) the Three Gorges Reservoir operation.

3.1. Mean Water Level Variation in the Poyang Lake Area during the Dry Season (from September to October) since the Operation of the Three Gorges Reservoir

Since the operation of the Three Gorges Reservoir, the monthly average water level of all the stations in the lake area generally showed a downward trend from October to March, except for the Hukou hydrometric station, where the monthly average water level showed a downward trend from January to March. The specific analysis of the water levels at the Hukou and Xingzi hydrometric stations is described below.

3.1.1. Analysis and Discussion of Water Level Variation at Hukou Hydrometric Station

After 2003, the average water level at the Hukou hydrometric station decreased from October to December and increased from January to March. Compared with that for the period from 1960 to 2002, the average water level from 2003 to 2019 decreased by 2.56, 1.65, and 0.43 m in October, November, and December, respectively, and increased by 0.57, 0.56, and 0.80 m in January, February, and March, respectively. The water level in the dry season also came earlier than usual. According to statistics, the 12, 11, and 10 m water levels were advanced by approximately 31, 32, and 8 days, respectively. Consequently, the deep-water channel in the middle flood period in the lake area became the dry season channel. Moreover, the duration of the deep-water channel in the mid-flood period was reduced by approximately 8%. The vessels operating in the lake area can travel with a full load in the mid-flood period, whereas in the dry season, the load of goods is generally reduced to ensure safe navigation. Therefore, the advanced occurrence of the dry season in the lake area inhibited the development of merchant shipping to some extent.

Figure 3 shows the water level variation at the Hukou Hydrometric Station during the dry season. Figure 4 presents the analysis results of the early occurrence of the low water level in the dry season. After the operation of the Three Gorges Project, the variation of the water level at Hukou Station in the dry season showed obvious seasonal characteristics. Affected by the flood control operation of the Three Gorges Reservoir, the water level of Hukou Station decreased from October to December and increased from January to March. At the same time, the average occurrence time of the low water level (11 m, 12 m) at Hukou Station was significantly advanced. However, the average occurrence time of the extremely low water level (10 m) at Hukou Station had little change due to the minimum discharge requirements of the Three Gorges Reservoir.

3.1.2. Analysis and Discussion of Water Level Variation at Xingzi Hydrometric Station

After 2003, the average water level at the Xingzi hydrometric station decreased from October to March. Compared with that in the period from 1960 to 2002, the average water level in October, November, and December in 2003 and January, February, and March in 2019 decreased by 2.56, 1.72, 0.70, 0.12, 0.52, and 0.08 m, respectively. The water level at Hukou increased from January to March due to the influence of water replenishment during the dry season of the upper reaches of the Three Gorges Reservoir and other reservoirs. At the Xingzi reach, the water replenishment effect of the upstream reservoir was insignificant. The water level of the Xingzi reach in the dry season also showed a downward trend overall due to the influence of sand mining and river regulation measures. Moreover, the water level in the dry season came earlier than usual. Statistics revealed that the 13, 12, 11, and 10 m water levels were advanced by approximately 30, 32, 35, and 11 days, respectively.

Figure 5 illustrates the water level variation at the Xingzi hydrometric station in the dry season. Figure 6 shows the analysis results of the early occurrence of the water level in the dry season. After the operation of the Three Gorges Project, the variation of the water level at Hukou Station in the dry season showed obvious seasonal characteristics. Affected by the flood control operation of the Three Gorges Reservoir, the average water level of Xingzi Station significantly decreased from October to December, and slightly from January to March. Meanwhile, the average occurrence time of the low water level (13, 11, 12 m) at Xingzi Station was significantly advanced. However, under the influence of the minimum discharge requirements of the Three Gorges Reservoir, the average occurrence time of the extremely low water level (10 m) at Xingzi Station had little change.

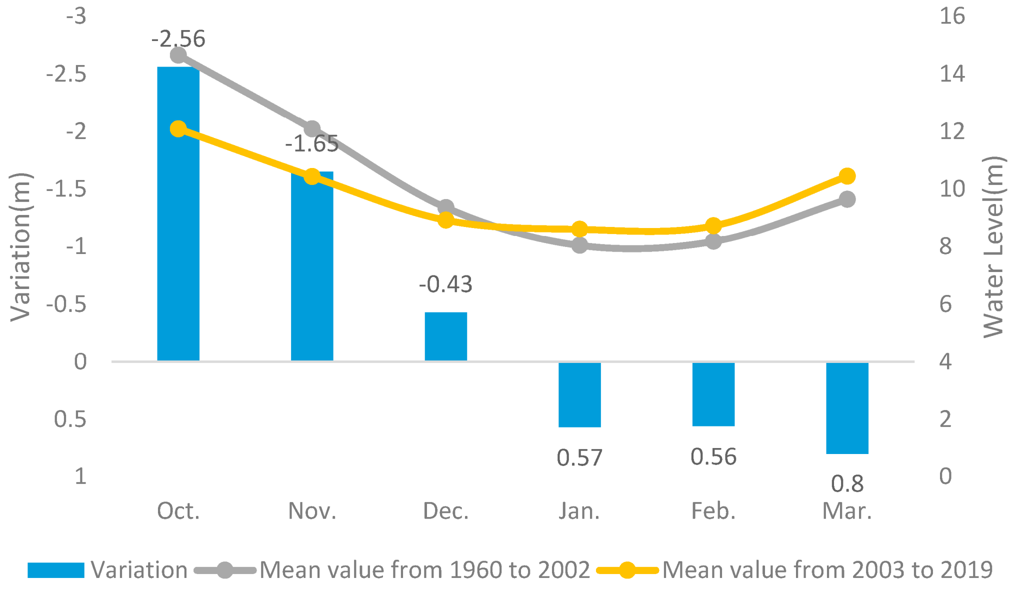


Figure 3. Water level variation and water level curve of the Hukou hydrometric station during the dry season.

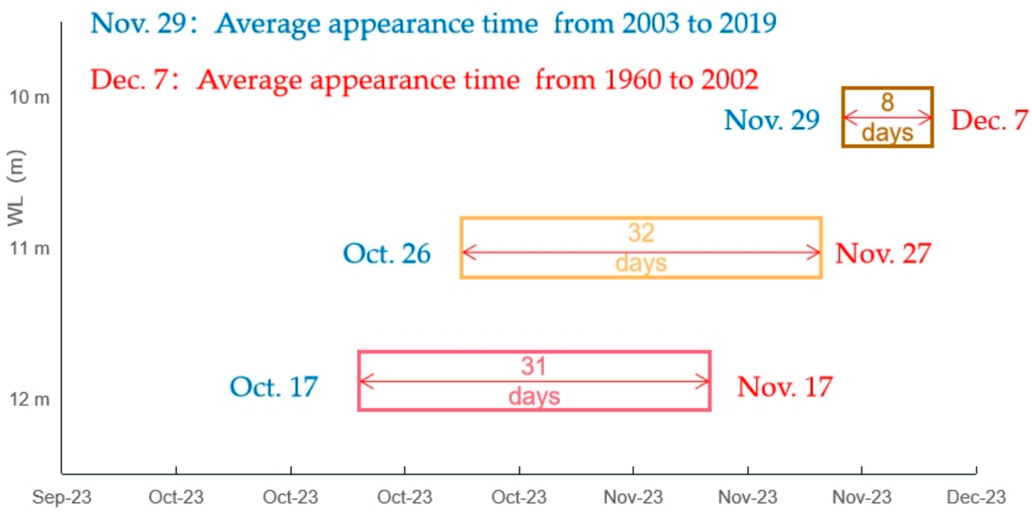


Figure 4. Comparison of average appearance times of different water levels at the Hukou hydrometric station before and after operation of the Three Gorges Project.

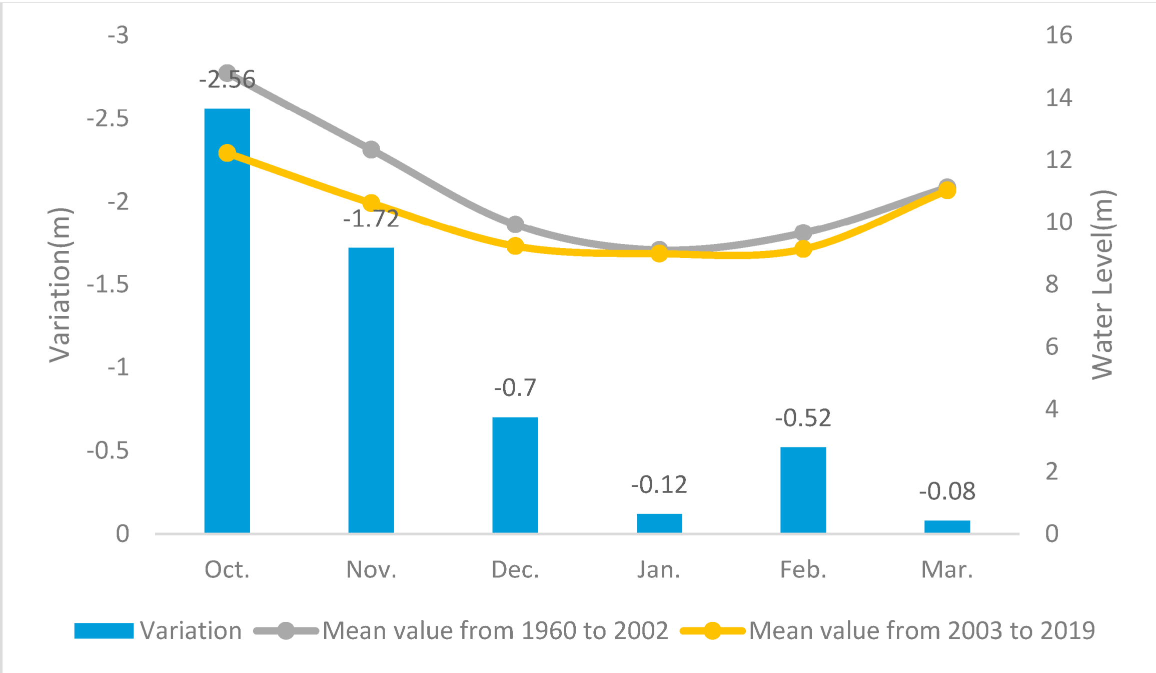


Figure 5. Monthly variation of the average water level at the Xingzi hydrometric station during the dry season (unit: m).

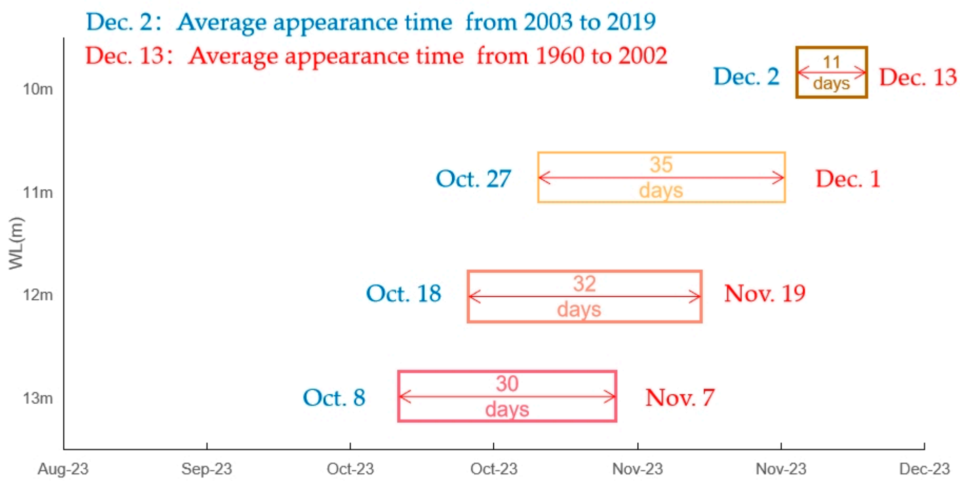
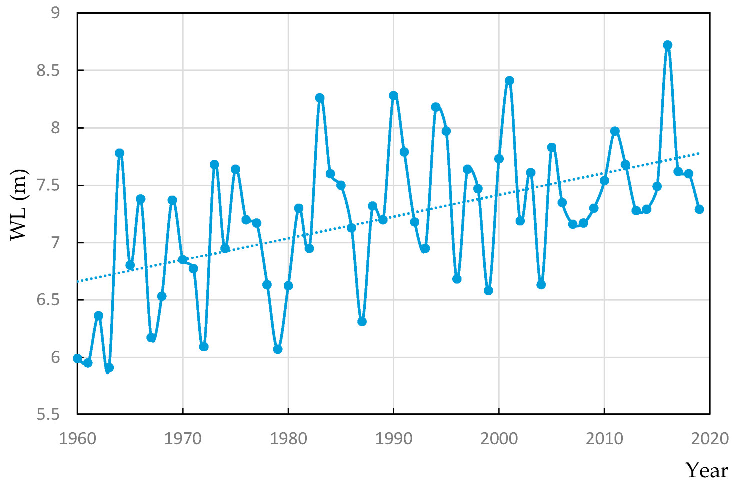


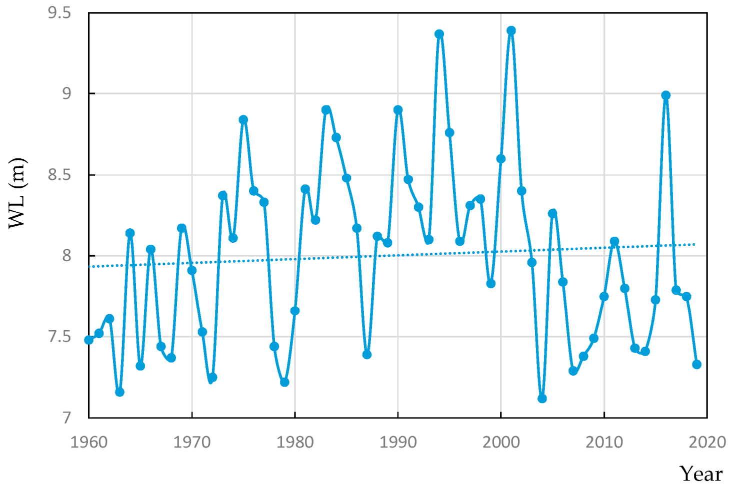
Figure 6. Comparison of average appearance times of different water levels at the Xingzi hydrometric station before and after operation of the Three Gorges Project.

3.2. Variation of the Annual Lowest Water Level in the Lake Area since the Operation of the Three Gorges Project

Figure 7 displays the annual lowest water level at the Hukou and Xingzi hydrometric stations from 1960 to 2019. The annual lowest water level at the Hukou hydrometric station showed a slight upward trend, whereas that at the Xingzi and Poyang hydrometric stations depicted no obvious change. The main reason for these results is that the Three Gorges Reservoir increased the water supply to the middle and lower reaches of the Yangtze River during the dry period, resulting in the rise of the annual lowest water level at the Hukou hydrometric station.



(**a**) Hukou Hydrometric Station



(**b**) Xingzi Hydrometric Station

Figure 7. Annual lowest water level curve of each hydrometric station in the Poyang Lake area over the years.

4. Influence of the Change of the Hydrological Regime on the Navigable Depth of the Waterways in the Lake Area

This study intensively analyzed and investigated the dry-season navigable depth at the major control sections of the Hukou and Xingzi hydrometric stations in the lake area during the period before 2002, when the Three Gorges Reservoir had not yet been constructed, and the period from 2003 to 2019, when the Three Gorges Project was put into operation with impoundment. This work also analyzed the navigable depth at the Wuchen and Tangyin stations and other hydrometric stations in the lake area.

4.1. Analysis and Discussion of Change of the Water Level with the Guaranteed Navigation Rate

The major waterways in the lake area are generally classified into Grades II and III, with a guaranteed navigation rate of 98%. The Grade II waterways in the lake area were required to be 2.8 × 90 × 550 m, whereas the Grade III ones were required to be (2.0–2.4 m) × (90–110 m) × 550 m. As an important technical parameter for navigation in the lake area, the change of the water level with a 98% guarantee rate of duration has a material impact on the safe navigation in this area. Based on the analysis results of the statistical data of the water level before 2002 and from 2003 to 2019, this study examined the change of the water level with a 98% guarantee rate of duration at the main hydrometric stations of Hukou, Xingzi, Wucheng, and Tangyin (Figure 8).

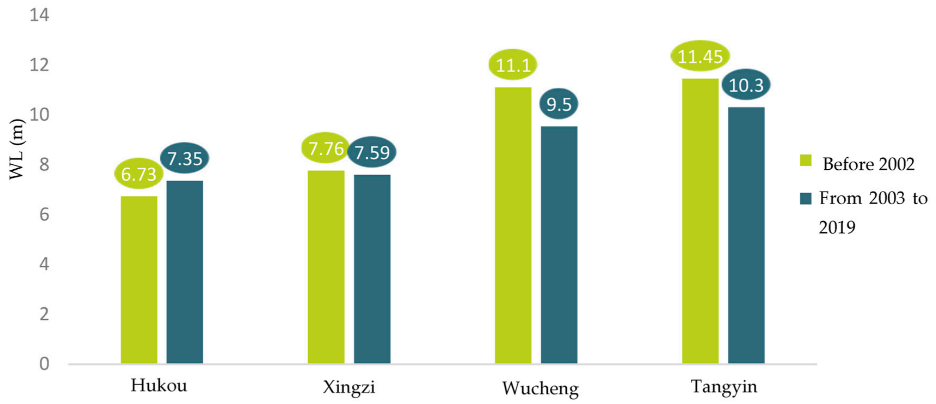


Figure 8. Change of the water level with a 98% guarantee rate of duration at the main hydrometric stations in the lake area in different periods.

Affected by the water replenishment of the reservoirs in the upper reaches of the Yangtze River during the dry season, the water level with a 98% guarantee rate of duration at the Hukou hydrometric station increased by approximately 0.62 m from 2003 to 2019, compared with that before 2002. The water level at the Xingzi hydrometric station mainly affected by sand mining and waterway regulation was approximately 0.17 m lower. The water level with a 98% guarantee rate of duration at the Wucheng and Tangyin hydrometric stations in the lake area basically showed a downward trend. For example, the water level with a 98% guarantee rate of duration at the Wucheng hydrometric station in the Ganjiang Waterway dropped by approximately 1.57 m, whereas that of the Tangyin hydrometric station in the Xinjiang Waterway decreased by approximately 1.15 m.

According to the analysis of all the previous annual water levels with a 98% guarantee rate of duration at the Hukou, Xingzi, Wucheng, and Tangyin hydrometric stations, that at the Hukou hydrometric station showed an upward trend, whereas those at the Xingzi, Wucheng, and Tangyin hydrometric stations presented downward trends.

Figure 9 illustrates the variation of all the previous annual water levels with a 98% guarantee rate of duration at the main hydrometric stations in the Poyang Lake area.

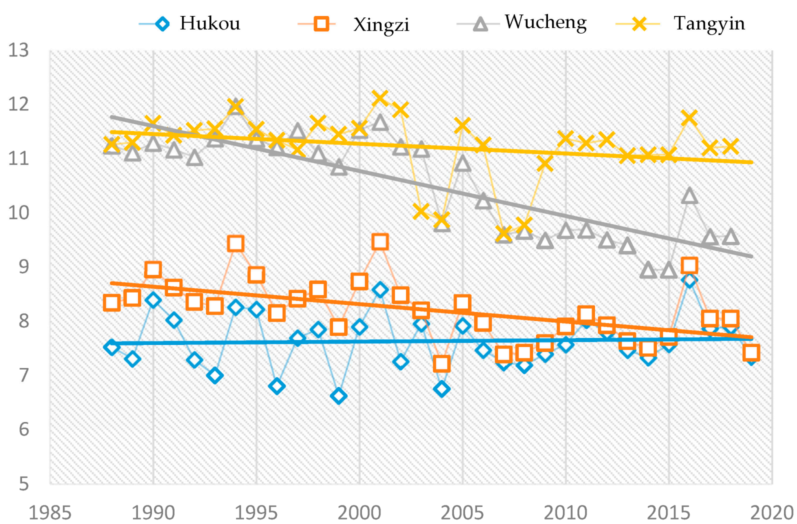


Figure 9. Variation of all the previous annual water levels with a 98% guarantee rate of duration at the main hydrometric stations in the Poyang Lake area.

4.2. Analysis and Discussion of the Channel Dimension Variation

The main waterways in the lake area were classified into Grades II and III. To evaluate if the navigable depth of the river reach was satisfactory, the waterway depth was analyzed based on the calculated water level, with a 98% historical guarantee rate of duration at the typical sections in each lake area. The Hukou and Xingzi sections were selected as the typical sections in the Poyang Lake area and depicted in Figures 10 and 11, respectively.

Figure 10. Navigable depth analysis of the Hukou section.

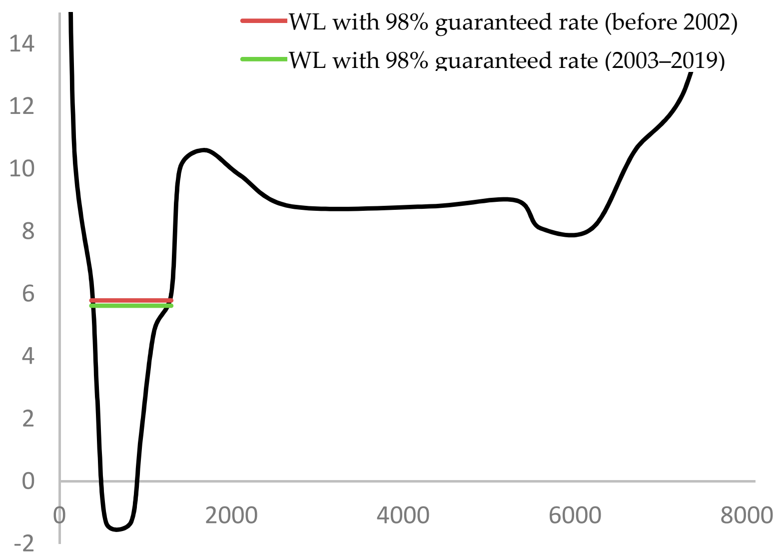


Figure 11. Navigable depth analysis of the Xingzi section.

The typical section analysis results for Hukou and Xingzi in Poyang Lake demonstrated that the waterway depth and width could meet the navigation requirements before 2002. From 2003 to 2019, the water level with a 98% guarantee rate of duration at Hukou increased, and the waterway depth and width met the dimension requirements of the Grade II waterway (2.8 × 90 × 550 m). Although the water level with a 98% guarantee rate of duration at Xingzi decreased, the waterway depth and width still met the dimension requirements of the Grade II channel (2.8 × 90 × 550 m).

5. Simulation and Prediction of Navigation Safety in Poyang Lake under the New Hydrological Regime

5.1. Model Building

The mathematical model of the river water and the sediment established by the Changjiang River Scientific Research Institute was used to simulate and predict the water regime of Poyang Lake under the new hydrological regime [34]. For the one-dimensional (1D) river channel, the model utilized a four-point implicit scheme for the 1D unsteady flow to find a solution by the difference method. For the two-dimensional (2D) lakes, a high-performance water–sediment algorithm with a limited control volume was employed. The connection between the 1D and 2D modules was realized through the transfer of state variables, including water level and flow rate, on the common boundary nodes or sections between the modules. The state variables at the connection points were also explicitly exchanged. The control section around the model for the model simulation calculation was selected as follows:

- The main stream section of the Yangtze River: The upper control section was Yichang, whereas the lower section was Datong, which join in the Qingjiang, Juzhang, Lushui, Hanjiang, and Jiangbei Shishui Rivers. The section with hydrological stations was the control section.
- Two-dimensional module of the Poyang Lake: A 2D calculation module of the lake sediment erosion and deposition, that took the amount of the water and sediment of the five rivers entering the lake as the condition of the water and sediment entering Poyang Lake and the water level at the Hukou section of Poyang Lake as the lower boundary. Poyang Lake was divided into 3064 quadrilateral grid elements. The minimum side length of the main trough grid element was 350 m. The maximum side length of the beach was 3500 m.

The hydrological measured data of the main stations from 1 January to 31 December 1998 were used for the model parameter calibration. Figure 12 presents the obtained results. The calibration results showed that compared with the measured water level process at Hukou and Xingzi of Poyang Lake, the simulation results better reflected the water level curve of each station with a peak–valley correspondence, a consistent fluctuation, and a good coincidence of the flood peak water level. The calculation error of the water level was mainly distributed between −0.13 and 0.15 m, ensuring good calculation accuracy.

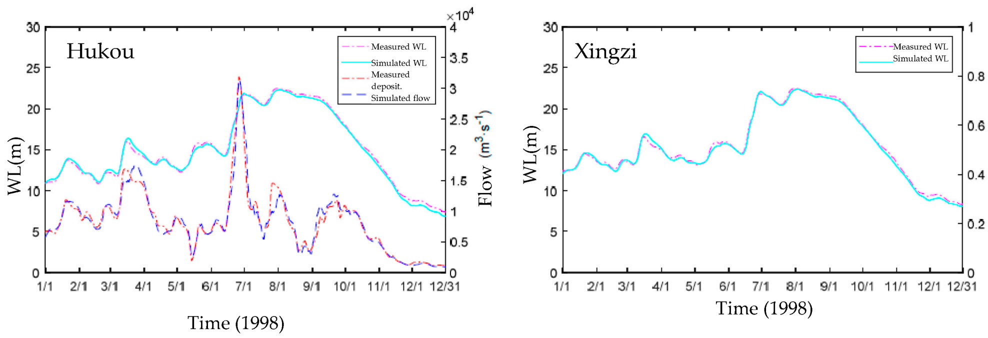


Figure 12. Calibration diagram of the water level and discharge of Poyang Lake in 1998.

5.2. Forecast and Analysis of the Water Regime Variation in the Lake Area

The monthly average water level and its monthly average difference in Poyang Lake in 2030 and 2050 in different typical years were simulated using the simulation model established in the previous section. The incoming water conditions adopted in 2030 and 2050 were the conditions after the Three Gorges' dispatching in different typical years.

(1) Analysis of the water level curve in the dry season (from October to March of the following year)

The water level curve of the main hydrometric stations in the lake area in 2030 and 2050 during the dry season from October to March of the following year are described below.

The Poyang Lake area is represented by the Hukou and Xingzi hydrometric stations. According to the preliminary analysis, compared with the average water level from 2003 to 2019, the predicted water levels at the Hukou and Xingzi hydrometric stations in 2030 and 2050 showed a gradual downward trend. The predicted water level at these stations in 2030 will decrease by 0.38–0.45 and 0.38–0.44 m, respectively. In 2050, the predicted water level at both stations will drop by 0.60–0.80 and 0.58–0.77 m, respectively.

Figure 13 presents the water level curve at the Hukou hydrometric station during the dry season. Figure 14 shows the water level curve at the Xingzi hydrometric station during the same season.

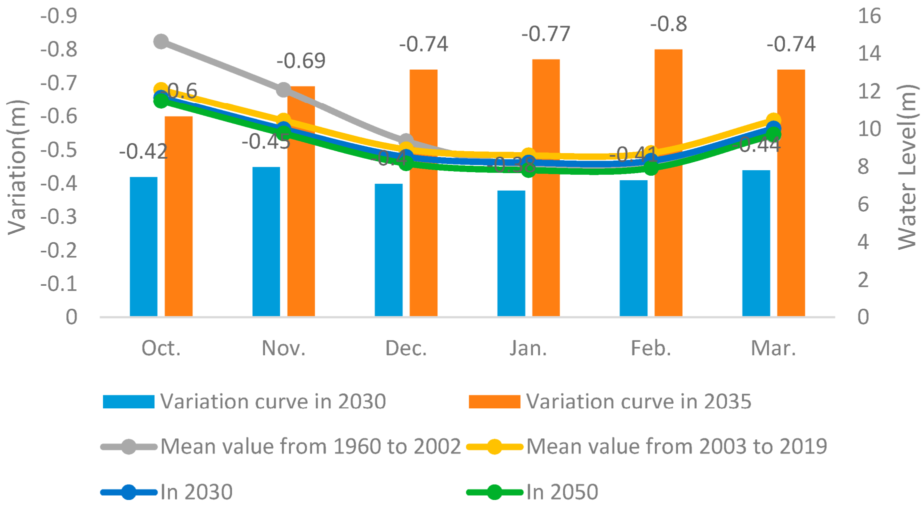


Figure 13. Analysis of the monthly variation curve of the average water level at Hukou hydrometric station during the dry season.

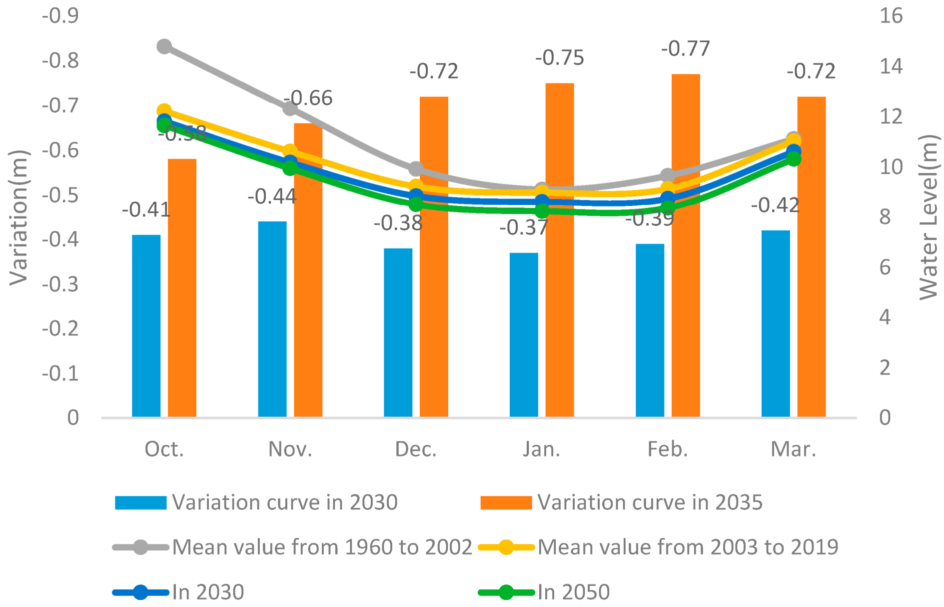


Figure 14. Analysis of the monthly variation curve of the average water level at the Xingzi hydrometric station during the dry season (unit: m).

(2) Dependable water level analysis

The results of the silt erosion and deposition prediction demonstrated that the water level of the main control stations is predicted based on the predicted topographic changes in the scouring and silting evolution in 2030 and 2050. The water level at the Hukou, Xingzi, Wucheng, and Tangyin stations was statistically analyzed using the diachronic method. Table 1 and Figure 15 illustrate the statistical analysis results of the water level variation with a 98% guarantee rate of duration.

Table 1. Analysis of the navigation dependable water level in Poyang Lake (unit: m).

Item	Period	Hukou	Xingzi	Wucheng	Tangyin
Measured data	Before 2002	6.73	7.76	11.1	11.45
	2003–2019	7.35	7.59	9.50	10.30
After Three Gorges' dispatching	2030	7.17	7.49	9.04	10.28
	2050	6.69	7.35	8.86	10.25

Figure 15. Water level variation at the main hydrometric stations in Poyang Lake.

In 2030 and 2050, the water level with a 98% guarantee rate of duration at the Hukou, Xingzi, and Wucheng hydrometric stations of Poyang Lake will decrease to varying degrees. That at the Hukou hydrometric station will decrease by approximately 0.18–0.66 m, that at the Xingzi hydrometric station will decline by approximately 0.10–0.24 m, and that at the Wucheng hydrometric station will drop by approximately 0.09–0.13 m.

5.3. Analysis of the Navigable Depth Variation at the Main Sections

The main typical sections were selected as the representative sections for the navigable depth analysis. The Hukou, Xingzi, and other hydrometric stations were chosen for Poyang Lake. The safe navigable depth was measured based on the 2.8 × 90 × 550 m dimension of the Grade II channel based on the calculated value of the water level with a 98% guarantee rate of duration at each station. The analysis results of the typical sections of Hukou and Xingzi in Poyang Lake showed that the navigable water level with a 98% guarantee rate of duration at the Hukou and Xingzi hydrometric stations decreased in 2030 and 2050 (Figures 16 and 17), but the waterway depth and width of the typical sections still met the requirements for the Grade II waterway dimension (2.8 × 90 × 550 m).

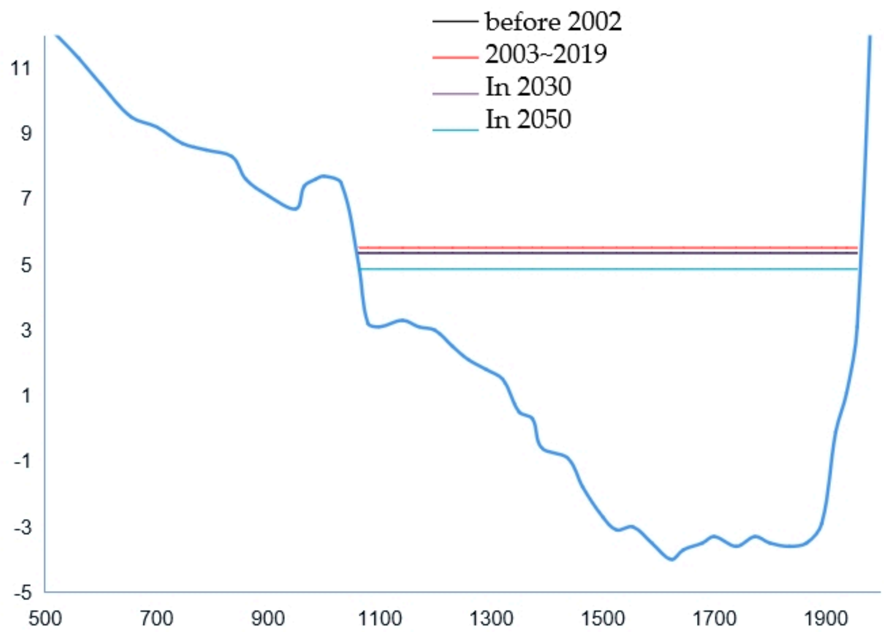


Figure 16. Analysis of the navigable depth (WL with 98% guaranteed rate) at the Hukou section.

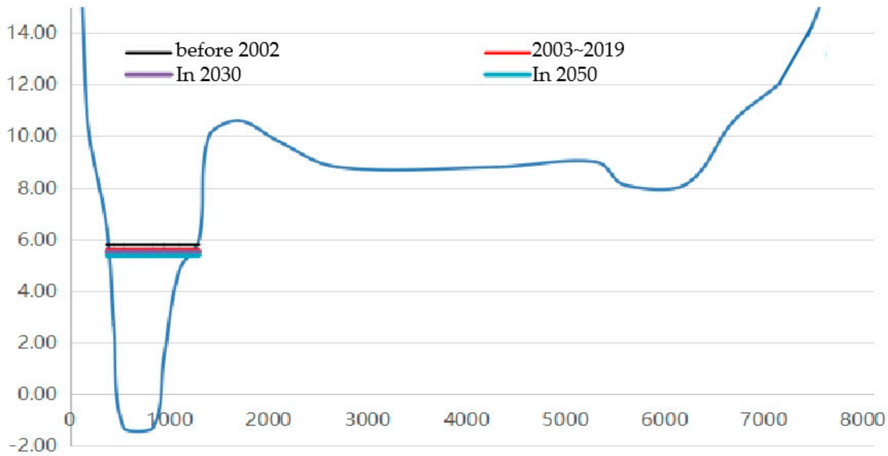


Figure 17. Analysis of the navigable depth (WL with 98% guaranteed rate) at the Xingzi section.

6. Conclusions and Discussion

Since the operation of the Three Gorges Reservoir, the water level at Hukou had been rising from January to March due to the influence of the water replenishment during the dry season of the upper reaches of the Three Gorges and other reservoirs. The Xingzi reach was not affected by the water replenishment of the upstream reservoir, and its water level showed a downward trend in the dry season. The minimum water level of Hukou Station and Xingzi Station in the dry season appeared 8~31 days earlier than that before the Three Gorges was used. The dry water level of Poyang Lake usually occurs from December to February. After the operation of the Three Gorges Project, the water level of the main stream increased due to the replenishment of the upstream reservoir in the dry period. However, it had a limited effect on the lake area and the lake water level increase was not obvious. Therefore, since the operation of the Three Gorges, the navigation safety problems in the lake area are mainly concentrated from December to February of the next year.

The calculation results showed that the hydrological regime variation has a certain impact on the navigable depths of the waterway in the lake area. Moreover, the waterway depth and width could meet the navigation requirements before 2002. From 2003 to 2019, the navigable water level with a 98% guaranteed rate at Hukou increased, and the waterway depth and width met the requirements for the Grade II waterway dimensions. Although the navigable water level with a 98% guaranteed rate at the Xingzi hydrometric station decreased, the waterway depth and width still met the dimension requirements of Grade II channels. With the completion and operation of the upstream controlled reservoirs, the water level in the Poyang Lake area will continue to decline during the dry season. Furthermore, the water level with a 98% duration guarantee rate at each hydrometric station in the lake area will be reduced to the safe water level of the waterway. The navigable water depth of some river sections does not meet the requirements, adversely affecting navigation safety.

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