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# MILITARY HYDROLOGY

## RESEARCH & DEVELOPMENT BRANCH

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## ADVANCE COPY

SPECIAL STUDY S-51-5  
DANUBE RIVER LOCK AND DAM SYSTEM  
AT PASSAU, GERMANY  
HYDRAULIC EFFECTS OF REGULATION,  
OPERATIONS, OR POSSIBLE DEMOLITION

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Prepared by  
Military Hydrology R & D Branch  
Engineering Division  
Washington District, Corps of Engineers  
Washington, D. C.  
March 1952

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### 1-03 ARRANGEMENT OF REPORT.

This report is sub-divided as follows:

Section I	Introduction
Section II	Drainage Area Characteristics
Section III	Hydrology
Section IV	Artificial Flood Potentialities
Bibliography	
Exhibits	

### 1-04 EQUIVALENT ENGLISH--METRIC TERMS.

Both English and metric terms are used in this report. The following table presents conversion factors for convenient reference. To reduce A to B, multiply A by F. To reduce B to A, multiply B by G.

Unit A	Factor F	Factor G	Unit B
Miles (Mi.)	1.60935	.62137	Kilometers (Km.)
Meters (M)	3.2808	.30480	Feet (Ft.)
Meters	39.370	.025400	Inches
Cubic Meter (M <sup>3</sup> )	35.3145	.028317	Cubic Feet (Cu.Ft.)
Acre-foot	43560.	.000022957	Cubic Feet
Acre-foot (Ac-ft)	1233.5	.00081071	Cubic Meters (M <sup>3</sup> )
Second-feet (cfs)	1.9835	.50417	Ac-ft per 24 hrs.
Miles per hour	1.4667	.68182	Feet per second
Meters per second	3.2808	.30480	Feet per second
Meters per second	2.2369	.44704	Miles per hour

### 1-05 ABBREVIATIONS AND DEFINITIONS.

The following abbreviations are used in this report: m for meters, km for kilometers, and m<sup>3</sup>/sec. for cubic meters per second. Definitions of terms applicable to stage and discharge are defined on Exhibit 1.

### 1-06 REFERENCES.

All references used in the text and in the exhibits of this report are listed in the bibliography at the end of the text.

## SECTION II

### DRAINAGE AREA CHARACTERISTICS

#### 2-01 GENERAL.

a. References 1, 2, and 3 in the bibliography section of this report present detailed descriptions of the Danube River Basin and its connecting waterways.

b. Detailed description of the Danube River in this report will apply only to the reach of river affected by the operation or demolition of Kachlet Dam. The reach considered, extends from the mouth of the Isar River, Germany to Engelhartzell, Austria.

#### 2-02 TOPOGRAPHY.

a. Exhibit 2 is a map showing the general layout of the Danube River Basin above Passau, Germany, and its connecting waterways. Exhibits 3 and 4 are sketch maps depicting crossings and improvements of the reach of the Danube River influenced by the operation of Kachlet Dam.

b. Drainage areas of the Upper Danube River at the confluence with its major tributaries are as follows:

<u>Danube River</u> <u>below mouth of</u>	<u>Drainage area</u> <u>in square kilometers</u>
Iller	7,471
Lech	19,258
Altmühl	26,214
Regen	35,385
Isar	47,110
Inn	26,604

c. All elevations referred to in this report are in meters above the Adriatic Sea, or "über Adria" datum, which is the old Austrian altitude reference.

d. Distances along the Danube River channel referred to herein, unless otherwise noted, refer to the distance in kilometers upstream from the mouth of the Danube River at Sulina, Rumania, on the Black Sea.

#### 2-03 RIVER CHANNEL CHARACTERISTICS.

a. From the mouth of the Isar River below Deggendorf to Hofkirchen, about 25 kilometers, the Danube River flows through a

wide, flat valley, with low gradients. The river is held in its banks along this reach by the construction of flood-control dikes supplemented by several pumping plants which operate behind the dikes during high stages in the river. Exhibit 4 is a sketch map showing the location of flood-control dikes and pumping plants along this reach.

b. In the reach from Hofkirchen to Kachlet Dam, about 26 kilometers, the Danube River is ponded by the dam. Before construction of Kachlet Dam this section of the river, known as the Bavarian Kachlet, was characterized by a wide, shallow channel, interrupted by outcrops of large, cubical rocks and great changes in slope (from 0.2 m/km to 2.7 m/km). A navigation channel was blasted and dredged through this reach prior to the construction of Kachlet Dam, but the channel remained shallow and treacherous, especially at low flows. Due to the steep gradients of the river channel, "run-of-the-river" regulation, and the low head maintained at Kachlet Dam, there is relatively little sediment deposited in the reservoir. Channel depths in this reach vary from 2.0 to 11.3 meters at mean low discharge and from 5.0 to 11.3 meters at mean high discharge under normal pool conditions. With no control at Kachlet Dam channel depths would be decreased and range from 1.3 to 1.5 meters at mean low discharge and from 2.3 to 4.0 meters at mean high discharges. A profile of this reach is shown in Exhibit 5, and channel widths for the reach are shown in Exhibit 6.

c. The Danube River flows through a narrow, deep channel with high, rocky banks from Kachlet Dam to the mouth of the Inn River, a distance of about five kilometers. From the confluence of the Inn River downstream for approximately 70 kilometers, the Danube River flows through a narrow valley with steep channel gradients, so that little or no ponding occurs at any stage. Channel depths from Kachlet Dam (km 2230.6) to Obernsell (km 2208.9) vary from 2 to 4 meters at mean low stage and from 4 to 7 meters at mean high stage. Exhibit 6 is a table of channel widths for about 30 kilometers below Kachlet Dam, and Exhibit 5 shows river profiles for about 22 kilometers below the dam.

#### 2-04 FLOOD PLAINS.

The only flood plain along the Danube River near Kachlet Dam is located between the mouth of the Isar River and Hofkirchen, from 26 to 52 kilometers above Kachlet Dam. This plain is protected from high water on the Danube River by the construction of flood-control dikes and pumping plants, as mentioned in par. 2-03, a, above. Exhibit 4 is a sketch-map of this area.

#### 2-05 NAVIGATION.

The Danube River is navigable from the mouth at the Black Sea to Ulm, Germany, a distance of 2,594 kilometers. The prime purpose for

constructing Kachlet Dam was to improve navigation conditions of the Danube River through the Bavarian Kachlet between Vilshofer (km 2249.1) and Passau (km 2225.2). With the locks operating at Kachlet Dam it is possible to navigate the Danube River from Passau to Regensburg (km 2383) with 1,000-ton barges loaded to 650 tons. Before construction of Kachlet Dam it was possible to navigate from Passau to Vilshofer only with vessels weighing less than 200 tons. The Danube River at Kachlet Dam freezes solidly enough to impede navigation for an average of 21 days per year. Navigation in the Kachlet pool is impeded by high water about two days per year. Exhibit 7 is a route description for navigation of the river from Passau (km 2225.2) to Irlbach (km 2301). Exhibit 6 shows channel widths of the Danube River from Engelhartzell (km 2200.6) to Hofkirchen (km 2256.7). Exhibit 8 presents flow-duration curves for Hofkirchen and Obernzell. References 1 and 4 present detailed navigation data for the Danube River above Passau. Reference 5 discusses the formation of ice in the Danube River.

#### 2-06 REGULATION OF THE DANUBE RIVER.

a. The only regulation structure existing on the Danube River between Regensburg (km 2383) and Sulina (the mouth), is Kachlet Dam at river kilometer 2230.6. Control structures above Regensburg could not affect the operation of Kachlet Dam, therefore, are not considered within the scope of this report.

b. This dam is a masonry and concrete structure with an over-all length of 400 meters, including the navigation locks and powerhouse. It impounds water to a depth of 11.3 meters above the sill of the weir section at normal pool. The dam was constructed for two purposes: (1) To facilitate the navigation of the Danube River in the Bavarian Kachlet above the dam; and (2) To provide "run-of-the-river" electric power. Kachlet Dam is divided into three main sections: (1) A weir-type spillway section containing six, vertical-lift gates, 25 meters wide and 11.3 meters high, separated by masonry piers 5 meters thick, and having a total discharge capacity of 6,000 m<sup>3</sup>/sec; (2) A powerhouse containing eight turbines with a total discharge capacity of 700 m<sup>3</sup>/sec; and (3) Two navigation locks, each 230 meters long and 24 meters wide, with a maximum lift at low water of 9.2 meters. The Danube River is ponded for a distance of about 26 kilometers by Kachlet Dam. The reservoir formed has a storage capacity of about 30,000,000 cubic meters. References 1 and 6 present details of the construction and operation of Kachlet Dam. Exhibit 9 is a plan drawing of Kachlet Dam, and Exhibit 10 shows elevation and cross-sectional views of the dam.

## SECTION III

### HYDROLOGY

#### 3-01 GENERAL.

The hydrological and hydraulic data presented in this report are pertinent only to the reach of the Danube River influenced by Kachlet Dam. These data are generally presented in graphical form to facilitate their application.

#### 3-02 CLIMATOLOGY.

Climatological data for Southern Germany may be found in References 2 and 7. In general the climate of the Upper Danube River Basin is characterized by frequent periods of sub-freezing temperature and heavy snowfall in the winter, and moderately high temperature in the summer with occasional high-intensity rainstorms.

#### 3-03 STREAM-GAGING STATIONS.

On the reach of the Danube River affected by Kachlet Dam, the only stream-gaging stations that have published discharge records are located at Hofkirchen (km 2256.7) and at Obernzell (km 2208.9), with records since 1901. Gages also exist on the bridges at Wilshofen (km 2249.1) and Passau (km 2226.5). The highest flood of record at Passau was 6,000 m<sup>3</sup>/sec in 1845. Records of Danube River gaging stations in Germany and Austria are tabulated in Reference 8. Exhibit 11 shows discharge and velocity rating curves for Hofkirchen, Passau, and Obernzell.

#### 3-04 RIVER-FLOW CHARACTERISTICS.

a. General. The Danube River above the mouth of the Inn River (km 2225.2), is characterized by an annual, high-water period in May or June, due to snow-melt in the headwater areas, and several, small-volume rises in the summer or fall, due to local rainstorms. In winter the stage is often raised by flooding due to ice-jams in the Danube River above Kachlet Dam. The minimum stage at Hofkirchen is generally recorded in fall or early winter. However, because of climatic and terrain characteristics, the Danube River at Kachlet Dam can have high-water stages almost any time of year. Exhibit 12 shows average monthly stage variations at Hofkirchen (km 2256.7) and Obernzell (km 2208.9), and Exhibit 8 shows discharge-duration curves for Hofkirchen and Obernzell.

b. River Velocities. In the reach above Kachlet Dam (km 2230.6) to Hofkirchen (km 2256.7), average surface velocities vary from 0.6 to 5.5 feet per second at mean low stage and from 3.6 to 7.6 feet per second at mean high stage under normal pool conditions. However, with no control at Kachlet Dam, average surface velocities for this reach would be increased and range from 1.8 to 8.7 feet per second at mean low stage and from 4.0 to 10.0 feet per second at mean high stage. From Kachlet Dam to Obornzell (km 2203.9), average surface velocities vary from 2.8 to 9.9 feet per second at mean low stage and from 7.0 to 12.5 feet per second at mean high stage. Average surface velocities of the Danube River from Hofkirchen to Obornzell are shown on Exhibit 5 for high, mean, and low stages. Stage-velocity-discharge curves are shown for Hofkirchen and Obornzell on Exhibit 8.

## SECTION IV

### ARTIFICIAL FLOOD POTENTIALITIES

#### 4-01 GENERAL.

a. The term "artificial flood" as used in this report applies to any major increase in the extent of flooding, over that normally prevailing with existing developments, that is brought about by manipulation of control structures, breaching of dams, or levees, or temporary damming operations designed to create flooding conditions. In this report the following three types of artificial flooding were considered:

(1) Major flood waves, created by sudden breaching of a dam to release large quantities of impounded water.

(2) Detrimental streamflow variation, in which sudden changes in discharges, depths, velocities, and widths of streams are brought about to increase difficulties of stream-crossing operations or navigation, such as might be accomplished by opening and closing large flood gates intermittently to create cyclical flood waves for limited distances downstream.

(3) Still-water barriers, created by flooding land to form water obstacles or to reduce trafficability, using such means as breaching levees, sandbagging dams, or diverting flow from canals. Still barriers may also be created by draining areas normally flooded by reservoirs so that mud-flats will be formed.

b. There are several reaches of the Danube River and its tributaries in Germany and Austria, where artificial flooding could be applied to military advantage. This report considers only the artificial flood potentialities of the reach of the Danube River influenced by Kachlet Dam, including the effects on this reach caused by the regulation of the Isar River. However, the artificial flood potentialities of the entire Danube River should be considered in planning military operations in Central and Eastern Europe.

c. The following means for creating artificial flooding conditions on the Danube River were considered:

(1) Demolition of Kachlet Dam.

(2) Regulation of Kachlet Dam to create cyclical flood waves downstream.

(3) Possible regulation of the Isar River hydraulic structures to create artificial flooding conditions on the Danube River above Kachlet Dam.

(4) Possible creation of still-water barriers or mud-flats by: (a) raising the pool behind Kachlet Dam by such means as sandbagging the dam, or (b) draining the pool behind Kachlet Dam.

#### 4-02 ARTIFICIAL FLOOD WAVES.

##### a. Flood Wave Created by Demolition of Kachlet Dam.

(1) General. In the determination of conditions under which demolition was considered likely to occur, it was assumed that the weir section of the dam would be the first and most likely section of the dam to be demolished. Demolition of the powerhouse would not increase appreciably the peak discharge of a wave caused by the demolition of the weir section, because of the high backwater effect resulting from the narrowing of the river channel below the dam. In event the navigation lock gates are opened or breached, there would be no effective increase in the peak discharge of a flood wave released by the demolition of the weir section, due to the long, narrow approach channels above and below the lock. Damage to the lock chambers, however, will retard future navigation. The flood wave which was considered to be the most likely to be produced by the demolition of Kachlet Dam was based on the assumption that only the weir section of the dam would be breached, leaving the powerhouse and locks structurally intact. With the reservoir water surface at normal stage of 299.5 m above sea level, the wave caused by breaching the six gates on the weir section of the dam would have a peak discharge of 6,000 m<sup>3</sup>/sec. The duration and effects of this wave would be tempered by the base flow in the Danube River at the time of the breach. This wave would equal the highest flood of record in 1845. Considerable damage to the waterfront section and to railroad tracks in Passau would be caused by this flood wave. Sections of Passau adjacent to the Danube River would be flooded by about 4 meters of water for a short time by a flood wave of 6,000 m<sup>3</sup>/sec. at Kachlet Dam. Below the mouth of the Inn River, the flood wave would be rapidly reduced by the wide river channel. The following table is a summary of data pertinent to artificial flood waves created by the demolition of the weir section of Kachlet Dam:

Station	Distance km.	Base flow		Peak		Time from dam breach to:		
		Stage Elev. M	Disch. m <sup>3</sup> /sec	Stage Elev. M	Disch. m <sup>3</sup> /sec	Start of rise Hours	Peak disch. Hours	End of rise Hours
Kachlet D	0	-	a 280	299.5	6000	0	0	9
Passau	5.1	289.5	a 280	294.4	2600	0.1	0.5	10
Obernzell	21.7	281.5	a 600	283.8	1800	0.2	2.0	12
Kachlet D	0	-	b 620	299.5	6000	0	0	7
Passau	5.1	291.0	b 620	294.8	3000	0.1	0.5	8
Obernzell	21.7	283.3	b 1400	285.0	2600	0.2	2.0	10
Kachlet D	0	-	c 1700	299.5	6000	0	0	6
Passau	5.1	293.5	c 1700	295.7	3800	0.1	0.4	7
Obernzell	21.7	286.7	c 4000	287.6	4900	0.2	1.5	9

- a Mean low discharge
- b Mean discharge
- c Mean high discharge

Hydrographs of flood waves created by the breaching of Kachlet Dam with various base flows in the Danube River are shown on Exhibit 13, together with the resultant flood hydrographs at Passau (km 2230.6) and Oberrzell (km 2208.9). The hydrographs at Passau and Oberrzell were determined by routing the breaching wave, using various base flows in the Danube River at the time of the breach.

(2) Consideration was given to the possibility that the weir section of Kachlet Dam might be demolished at such a time when the water surface is raised by sandbagging to induce surcharge storage or to cause flooding upstream. It is not considered structurally feasible to raise the pool more than about 3 meters above normal by blocking the outlets and sandbagging between the overflow sections of the dam. As the pool would be constantly overflowing, an inflow discharge exceeding middle high discharge of 1,700 m<sup>3</sup>/sec. would be required to raise the pool 3 meters, making the possibility of accomplishing this operation very infrequent. However, if demolition of the weir section of the dam should occur when the pool elevation is 3 meters above normal, the resulting flood wave would have a peak discharge about 2,000 m<sup>3</sup>/sec. greater than a peak resulting from demolition occurring with normal pool. A flood wave created by demolition of the weir section of Kachlet Dam under these conditions would cause a maximum stage at Passau over one meter higher than a flood wave created by demolition under normal conditions. However, this flood wave would cause no significant amount of damage greater than the damage caused by a flood wave created at normal pool elevation, because the more important sections of the city are situated on high ground, beyond the reaches of flood waters.

### (3) Effects on Bridging.

(a) Permanent Bridges. Highway and railroad bridges across the Danube River below Kachlet Dam would not likely fail from the action of a breaching flood wave, as they are constructed high enough to clear navigation traffic. However, if ice conditions are such as to cause jams at piers or approaches, bridges could be damaged and bridge traffic would be suspended at least temporarily. The only bridge upstream from Kachlet Dam that is considered within the scope of this report is at Vilshofen (km 2249.1). This bridge would not be damaged by any condition existing at Kachlet Dam. Locations of permanent bridges are shown on Exhibit 3.

(b) Temporary Military Bridges. Any floating bridges constructed across the Danube River below Kachlet Dam (km 2230.6) as far as Oberrzell (km 2208.9), would be damaged or possibly destroyed by a breaching flood wave, unless constructed to withstand average surface velocities greater than 12 feet per second. Floating bridges constructed across the Danube River upstream from Kachlet Dam (km 2230.6) to Vilshofen (km 2249.1), would also be adversely affected by the draining of the pool resulting from demolition of the dam. In this reach backwater

normally keeps river velocities low, but permanent draining of the pool would increase average surface velocities at some points to as much as 9 feet per second at main discharge. Therefore, floating bridges would be difficult to maintain in the reach from Kachlet Dam to Vilshofen. Danube River profiles and surface velocities from Hofkirchen (km 2256.7) to Obernzell (km 2208.9) are shown on Exhibit 5.

(4) Effects of Crossings and Banks.

(a) Ferries. In the reach of the Danube River below Kachlet Dam (km 2230.6), all ferry operations would be impossible during breaching floods as far as the Inn River (km 2225.2), and difficult as far as Obernzell (km 2208.9). Approaches to ferries located downstream from the dam would not likely be permanently damaged. Upstream from Kachlet Dam to Vilshofen (km 2249.1), ferry traffic would be damaged by the draining of the reservoir, and the resultant increased stream velocities. Ferries operating near Kachlet Dam would sustain considerable damage by the draining of the pool, as their approaches and docks would be left high and dry, except during flood stages on the Danube River. Locations of ferries are shown on Exhibit 3.

(b) Military Ferrying Operations. In that the Danube River is too deep to ford in any reach within the scope of this report, consideration has been given only to the effects of artificial flooding of military ferrying operations. It should be noted that on several occasions, the Danube River has frozen solidly enough above Kachlet Dam to support very heavy vehicles. This freezing was largely caused by loss of velocities due to Kachlet Dam, and continuous efforts are made to prevent and break up ice formation of the Danube River (Reference 5). Military ferrying operations of the Danube River from Kachlet Dam (km 2230.6) downstream to Obernzell (km 2208.9), would be made impossible or extremely difficult by a breaching wave released from Kachlet Dam, due to increased velocities and stages. In the reach of the Danube River above Kachlet Dam to Vilshofen (km 2249.1), military ferrying operations would be hindered by the increased velocities resulting from the draining of the pool after breaching. Exhibit 6 shows channel widths from Engelhartzell (km 2200.6) to Hofkirchen (km 2256.7).

(c) Bank Conditions. Below Kachlet Dam there would be no great damage to river banks caused by a breaching wave flood, mainly because there would not be enough water stored behind the dam to make a flood of long duration. As far as the mouth of the Inn River (km 2225.2), the banks are steep and rocky, and below the Inn River the flood would be contained within the banks, so that damage to the banks would not be great at any place below Kachlet Dam. In the reach of the Danube River upstream from Kachlet Dam (km 2230.6) to Hofkirchen (km 2256.7), the water would recede from the banks after the breaching of Kachlet Dam. In this reach the banks are generally

steep and are often rocky, so that no serious bank erosion and no large mud flats would be created by the draining of the pool. Exhibit 6 is a table of Danube River channel widths from Engelhartzell (km 2200.6) to Hofkirchen (km 2256.7).

(5) Effects on Navigation.

(a) General. After demolition of the weir section of Kachlet Dam, it would not be possible to use the navigation locks to pass large vessels either up or downstream, due to the loss of head-water. However, it would be possible to pass small vessels, displacing less than 200 tons, through the south lock, providing the head and tail-water conditions produce no currents and stages adverse to navigation.

(b) Below Kachlet Dam. In case Kachlet Dam is breached, all navigation below the dam to Obernsell (km 2208.9), would be hazardous during the crest of the flood. Navigation structures at Passau would be severely damaged by the high water. The demolition of Kachlet Dam would hinder navigation below the dam only for the duration of the crest of the flood wave, or for about four hours.

(c) Above Kachlet Dam. In the reach of the Danube River from Kachlet Dam (km 2230.6) to Vilshofen (km 2249.1), navigation would be permanently reduced and remain hazardous after demolition of the dam. This reach of the river would return to conditions similar to those that existed before construction of the dam. Due to the rock outcrops and deposited sediment in the river channel, only small vessels weighing less than 200 tons could navigate this reach, and only during infrequent periods when stages and velocities are favorable. Navigation above Hofkirchen (km 2256.7) would not be affected by the demolition of Kachlet Dam because backwater effects resulting from the dam are negligible above that point.

b. Flood Waves Created by Regulation of Kachlet Dam.

(1) General. It would be possible to release artificial flood waves from Kachlet Dam by the regulation of the weir gates with supplemental aid of locks and turbines. The magnitude, duration, and frequency of the waves created depend on the discharge in the Danube River and backwater resulting from the Inn River which enters the Danube River about five kilometers below Kachlet Dam. An artificial flood wave created by the sudden opening of the weir gates, locks, and turbines, with the reservoir at normal elevation of 299.5 meters above sea level, would have a peak discharge of 5,000 m<sup>3</sup>/sec. and the flood would last about two hours. Waves could be repeated, depending on the Danube River discharge at the following intervals:

- 20 hours at mean low water,
- 12 hours at mean water,
- 5 hours at mean high water.

4-02b(1)

An artificial flood wave of 5,000 m<sup>3</sup>/sec. would approach the largest flood of record, of 6,000 m<sup>3</sup>/sec, in 1845, and would cause considerable damage to the lower sections of Passau. Below the mouth of the Inn River (km 2225.2) the effects of the wave would be greatly reduced by the wide river channel. Velocity changes will be greatest if the wave is released during a period of low flow in the Danube River. Exhibit 11 shows stage-discharge-velocity curves for Passau and Obernzell.

(2) Effects on Bridging.

(a) Permanent Bridges. Artificial flood waves created by the manipulation of the gates at Kachlet Dam would have approximately the same effects on permanent bridges across the Danube River as a flood wave created by breaching the weir section of the dam, as discussed in par. 4-02, a, (3)(a).

(b) Temporary Military Bridges. Floating military bridges across the Danube River would be damaged to about the same extent by the release of large, regulated flood waves from Kachlet Dam, as by a wave created from the breaching of the dam, as discussed in par. 4-02, a, (3)(b); except that bridges constructed upstream from the dam would be difficult to maintain only during periods of drawdown in the reservoir after large releases.

(3) Effects on Crossings and Banks.

(a) Ferries. Large, artificial flood waves released from Kachlet Dam would cause about the same amount of damage to Danube River ferries as the breaching flood wave discussed in par. 4-02, a, (4)(a). However, since the pool behind the dam would not be drained for long periods by flood-releasing operations, ferries located above Kachlet Dam would not be permanently damaged.

(b) Military Ferrying Operations. The damage to military ferrying operations created by a large, artificial flood wave released from Kachlet Dam, would be about the same as damage caused by a flood wave resulting from breaching the weir section of the dam, as discussed in par. 4-02, a, (4)(b). The wave could be repeated at interval as indicated in par. 4-02, b, (1) above. No permanent hindrance to crossing the Danube River above the dam would result from the release of artificial flood waves however, because the reservoir would not likely be drained for long periods by cyclical operations.

(c) Bank Conditions. Releases of large, artificial flood waves from Kachlet Dam would have approximately the same effect on bank conditions and approaches to crossings as a flood wave resulting from the breaching of the dam; see par. 4-02, a, (4)(c).

(4) Effects on Navigation.

(a) General. Any plan to release cyclical flood waves from Kachlet Dam would make the use of the navigation locks extremely difficult, if not impossible during build-up and release periods. Plans for releasing the largest waves possible would call for the opening of the lock gates to supplement releases from the weir section. Repeated use of the locks for this purpose would cause permanent damage to the locks.

(b) Below Kachlet Dam. Regulation of Kachlet Dam to create large artificial flood waves would cause stage variation and river velocities so great that navigation would be impossible between Kachlet Dam (km 2230.6) and the mouth of the Inn River (km 2225.2), and hazardous downstream to Obernzell (km 2208.9), for a period of about two hours after the release of each wave. Navigation facilities in Passau would be severely damaged by the action of flood waves of 5,000 m<sup>3</sup>/sec. originating at the dam.

(c) Above Kachlet Dam. During periods of flood-wave releases at Kachlet Dam and for several hours later, drawdown in the pool above the Dam would cause increased stream velocities and decreased channel depths so that navigation would be temporarily suspended from Kachlet Dam (km 2230.6) to Vilshofen (km 2249.1). No serious damage to navigation structures would be likely in this reach, resulting from any regulation of Kachlet Dam.

c. Flood Waves Created by Regulation of the Isar River.

(1) General. Hydraulic studies conducted by the German Government (Reference 3) show that it is possible to create artificial floods on the Isar River by using several different plans of regulation. Only regulation plans which caused high water at the mouth of the Isar River (Danube River km 2282.0) were considered in this report. To determine the flow in the Danube River below the mouth of the Isar River, flood waves released at Hofham Lock on the Isar River, located 81.3 kilometers above the mouth, were routed down the Danube River to Kachlet Dam, using various base flows in both rivers. Regulations of hydraulic structures on the Isar River are discussed in detail in Reference 3. Exhibit 14 shows artificial flood wave releases from Hofham Lock and their resultant flood hydrographs below the mouth of the Isar River and at Kachlet Dam.

(2) Plan A.

(a) General. This scheme for releasing artificial flood waves on the Isar River is based on the manipulation of the weir gates, canals, and locks at Oberfoehring, Saaptflut, Uppenborn, and Hofham, to produce the highest possible flow in the Isar River below Hofham Lock. A detailed discussion of this scheme is presented in Reference 3, together with its effects on the Isar River Basin.

4-02c(2)(a)

The maximum effective wave produced by this plan would occur if the wave were released during a period of mean discharge on the Isar River. This wave would have a peak discharge of about 1,200 m<sup>3</sup>/sec. at Hofham Lock, which would cause a peak discharge of 970 m<sup>3</sup>/sec. in the Danube River below the mouth of the Isar River, and 930 m<sup>3</sup>/sec. at Kachlet Dam. Data pertinent to artificial flood waves created at Hofham Lock using Plan A are shown in the following table:

Station	Distance from Hofham Lock	Base flow <sup>a</sup>	Peak discharge	Time from release of wave to:		
				Start of rise	Peak discharge	End of rise
	<u>Km.</u>	<u>m<sup>3</sup>/sec</u>	<u>m<sup>3</sup>/sec</u>	<u>Hours</u>	<u>Hours</u>	<u>Hours</u>
Hofham Lock	0	160	1200	0	0	69
Below mouth, Isar R.	81.3	620	<sup>b</sup> 970	2	11.5	<sup>c</sup> 80
Kachlet D.	132.7	620	930	6	18.0	<sup>c</sup> 90

<sup>a</sup> Mean discharge.

<sup>b</sup> Rise in stage of about 0.8 meter.

<sup>c</sup> Approximate time. Rise is negligible after time indicated.

(b) Effects on the Danube River. An artificial flood wave created on the Isar River by using Plan A would hinder all navigation and amphibious crossing of the Danube River between the mouth of the Isar River (km 2282.0) and Kachlet Dam (km 2230.6), during the crest of the flood or about six hours. This flood probably would have an adverse effect on any floating military bridges; however, river banks and permanent bridges would suffer little damage from this flood wave. Exhibit 4 is a sketch map of the Danube River from above the mouth of the Isar River to below Hofkirchen (km 2256.7).

### (3) Plan B.

(a) General. In carrying out this plan for creating artificial flood waves on the Isar River, supplemental water would be obtained from Walchen Lake, and from the manipulation of weir gates, canals, and locks at Icking, Muelital, Hoellriegelskreuth, and Grosshesselohs, and by drawing water from the city of Muenchen and the Great Amper Power Works; thereby augmenting the water obtained in Plan A. Reference 3 presents a detailed discussion of this plan and its effects on the Isar River Basin. A flood wave produced by this plan, if released during a period of mean discharge on both the Isar and Danube Rivers, would have a peak discharge of about 1,800 m<sup>3</sup>/sec. at Hofham Lock, causing a peak discharge of 1,100 m<sup>3</sup>/sec. in the Danube River below the mouth of the Isar River (km 2282.0), and 1,000 m<sup>3</sup>/sec. peak at Kachlet Dam (km 2230.6).

4-02c(3)(a)

The following table presents data pertinent to artificial flood waves created at Hofham Lock under Plan B:

Station	Distance from Hofham Lock	Base flow <sup>a</sup>	Peak discharge	Time from release of wave to:		
				Start of rise	Peak discharge	End of rise
	Km.	m <sup>3</sup> /sec	m <sup>3</sup> /sec	Hours	Hours	Hours
Hofham Lock	0	160	1800	0	0	69
Below mouth, Isar R.	81.3	620	<sup>b</sup> 1100	2	11	<sup>c</sup> 80
Kachlet D.	132.7	620	1000	6	17	<sup>c</sup> 90

<sup>a</sup> Mean discharge.

<sup>b</sup> Rise in stage of about 1.0 meter.

<sup>c</sup> Approximate time. Rise is negligible after time indicated.

(b) Effects on the Danube River. A flood wave released under Plan B would result in peak water-surface elevations at the following stations above Hofkirchen (km 2256.7), the point above which there is little backwater effect from Kachlet Dam:

Station	Kilometers above Sulina	Plan B	
		Peak elevation* in meters above sea level	Mean high water stage in meters above sea level
Hofkirchen	2256.7	303.7	304.8
	2260.0	304.6	305.7
	2265.0	306.0	307.1
	2270.0	307.4	308.5
Nieder Alteich	2275.7	309.0	310.1
Mouth of Isar R.	2282.0	310.5	311.6

\*Assuming that flood-control dikes in the reach are not breached and that pumping plants are in operation.

A flood wave of 1,100 m<sup>3</sup>/sec. would make navigation and amphibious crossing of the Danube River difficult between the mouth of the Isar River (km 2282.0) and Kachlet Dam (km 2230.6), for a period of about six hours and might damage any floating bridges constructed across the Danube River in this reach. River banks, dikes, and approaches to crossings would be little damaged by this flood, and no permanent bridges would be damaged.

#### (4) Plan C.

(a) General. This plan utilizes the same operations of hydraulic installations of the Isar River as Plan B, but the flood wave would be released from Hofham Lock during a period of mean high discharge on both the Isar and Danube Rivers.

4-02c(4)(a)

The peak discharge released from Hofham Lock would also be about 1,800 m<sup>3</sup>/sec., but would cause a peak discharge of 2,000 m<sup>3</sup>/sec on the Danube River below the mouth of the Isar River (km 2282.0), and a peak of 1,900 m<sup>3</sup>/sec. at Kachlet Dam. A summary of data pertinent to artificial flood waves released at Hofham Lock using Plan C are presented in the following table:

Station	Distance from Hofham Lock	Base flow <sup>a</sup>	Peak discharge	Time from release of wave to:		
				Start of rise	Peak discharge	End of rise
	Km.	m <sup>3</sup> /sec	m <sup>3</sup> /sec	Hours	Hours	Hours
Hofham Lock	0	667	1800	0	0	15
Below mouth, Isar R.	81.3	1700	<sup>b</sup> 2000	2	10	24
Kachlet D.	132.7	1700	1900	6	16	32

<sup>a</sup> Mean high discharge.

<sup>b</sup> Rise in stage of about 0.2 meter.

(b) Effects on the Danube River. Peak water-surface elevations for the Danube River, resulting from a flood wave released from Hofham Lock under Plan C, are shown in the following table for various stations above Hofkirchen, above which there is little backwater effect from Kachlet Dam:

Station	Kilometers above Sulins	Plan C	
		Peak elevations* in meters above sea level	Mean high water stage in meters above sea level
Hofkirchen	2256.7	305.0	304.8
	2260.0	305.9	305.7
	2265.0	307.3	307.1
	2270.0	308.7	308.5
Nieder Alteich	2275.7	310.3	310.1
Mouth of Isar R.	2282.0	311.8	311.6

\*Assuming that flood-control dikes in the reach are not breached and that pumping plants are operating.

A flood wave of 2,000 m<sup>3</sup>/sec. would have approximately the same effect on navigation, amphibious crossings, and bridging of the Danube River as a flood wave released under Plan B, described in 4-02, c, (3)(b) above. Continuous repetition of this flood wave would cause severe bank erosion between the mouth of the Isar River (km 2282.0) and Hofkirchen (km 2256.7).

#### 4-03 STILL-WATER BARRIERS.

a. General. Investigations of the reach of the Danube River considered within the scope of this report, show that it is not possible

to create any still-water barriers below Kachlet Dam by any plan of regulation or breaching of the dam, because of the narrow width and steep gradients of the river valley below the dam. Consequently, only the possibilities of causing still-water barriers upstream from Kachlet Dam are presented in this report. The following methods of producing still-water barriers above Kachlet Dam were investigated: (1) Drain the reservoir behind Kachlet Dam to create mud-flats on areas covered by deposited sediment from normal inundation; (2) Raise the reservoir stage by sandbagging to create flooding conditions upstream; and (3) Breach flood-control dikes below the mouth of the Isar River in conjunction with the release of artificial flood waves from the Isar River.

b. Created by Draining Kachlet Reservoir. Due to the steep gradients and narrow, rocky, river valley from Kachlet Dam (km 2230.6) to Hofkirchen (km 2256.7), no significant mud-flats would be created by draining the reservoir, even during low flow. There is no backwater effect from Kachlet Dam above Hofkirchen at low flows, and the backwater effect is not nearly that far during high flows. Profiles of the Danube River, with and without Kachlet Dam regulation, are shown in Exhibit 5.

c. Created by Raising the Stage at Kachlet Dam. It is considered feasible to raise the stage at Kachlet Dam by sandbagging the dam and power house, up to about elevation 302.5 meters above sea level. With all weir gates, locks, and turbines closed, the unregulated overflow of the crest gates and lock gates at this stage would have a discharge of about 1,800 to 2,000 m<sup>3</sup>/sec., which is above mean high discharge. Any higher raising of the stage is considered impractical and would probably result in structural failure of the dam. It was determined that with the stage at Kachlet Dam raised to elevation 302.5 meters above sea level, and with an overflow discharge of 2,000 m<sup>3</sup>/sec., there would be no appreciable increase of backwater effect above Hofkirchen (km 2256.7); therefore, it would not be possible to create any mud-flats in the reach above Hofkirchen by induced backwater from raising Kachlet Dam. Plans of Kachlet Dam are presented in Exhibits 9 and 10, and Danube River profile showing induced backwater effect is shown in Exhibit 5.

d. Created by Breaching of Flood-Control Dikes and by Regulation of the Isar River. Study of the reach of the Danube River below the mouth of the Isar River, showed that still-water barriers could be created between the mouth of the Isar River (km 2282.0) and Hofkirchen (km 2256.7). This reach of river is characterized by low gradients and a wide, flat river valley, making it ideal for use as a still-water barrier. Flood-control dikes and pumping plants have been constructed on both sides of the Danube River along this reach to confine the flow to the main river channel. Breaching of these dikes would cause the flooding of flat, lowland areas and create a formidable barrier to military crossing operations, if made during a stage of middle high water in the Danube River.

Due to the lack of sufficient data on the flood-control dikes, it is not possible to select exact points to breach the dikes to produce the most effective flooding conditions. A topographic survey of the area between Deggendorf (km 2284.5) and Hofkirchen (km 2256.7) is needed to determine the location of points on the flood-control dikes which, if breached, would cause the most rapid and effective artificial flooding conditions. By releasing an artificial flood wave from Hofham Lock on the Isar River under Plan B, described in par. 4-02, c, (3) above, the stage in this reach could be raised over one meter during a period of mean discharge. If either Plan B or Plan C were carried out at a time when the flood-control dikes are breached, water barriers in the form of mud-flats would be created on both sides of the Danube River from the mouth of the Isar River (km 2282.0) to Hofkirchen (km 2256.7). A still-water barrier created by breaching of the flood-control dikes would be effective for a length of time depending on: (1) The natural flow in the Danube River, (2) The ability to release future artificial flood waves from the Isar River, and (3) The ability of the enemy to repair the dikes. The time required to create still-water barriers depends on: (1) The stage in the Danube River; (2) The location of the breaches; and (3) The size of the breaches. A more detailed topographic map of the area and a more detailed physical description of the flood-control dikes are needed before reasonably accurate time schedules could be prepared. However, preliminary examination of the area between the mouth of the Isar River and Hofkirchen, indicates that the most effective places to breach the flood-control dikes probably would be: (1) Directly opposite the mouth of the Isar River; (2) At Nieder Alteich; and (3) At Thundorf. It appears that flooding would not be effective unless the Danube River is higher than mean stage. Rises in the river higher than mean stage last from two weeks in the fall and winter to two months in the spring and early summer. No form of regulation, raising the stage, or breaching of Kachlet Dam would have any effect on the reach of the Danube River above Hofkirchen (2256.7), due to the narrow valley and steep river gradients below Hofkirchen. Exhibit 4 is a sketch-map showing the location of the river channel, flood-control dikes, and pumping plants on the Danube River from above the mouth of the Isar River (km 2282.0) to below Hofkirchen (km 2256.7).

#### 4-04 CONCLUSIONS.

The following are conclusions reached regarding the hydraulic effects of regulation, operations, and possible demolition of Kachlet Dam:

1. Navigation and military ferrying operations on the Danube River would be made extremely hazardous for a distance of about 25 kilometers below Kachlet Dam for a period of two to four hours during floods created by releasing large, artificial flood waves from Kachlet Dam or by a flood wave created by demolition of the dam.

2. Waterfront structures in Passau would be severely damaged by any large artificial flood waves released from Kachlet Dam.

3. Any regulation operations or demolition of Kachlet Dam would cause little significant damage to railroad and highway bridges, or to river banks and approaches to crossings below Kachlet Dam.

4. Demolition of Kachlet Dam would severely restrict navigation between Passau (km 2225.2) and Vilshofen (km 2249.1) due to the draining of the Bavarian Kachlet reach of the Danube River.

5. Navigation and military ferrying operations on the Danube River would be made hazardous between the mouth of the Isar River (km 2282.0) and Kachlet Dam (km 2230.6) for a period of about six hours during floods caused by releasing large, artificial flood waves from Hofham Lock on the Isar River.

6. Large, artificial flood waves released from Hofham Lock on the Isar River would cause little significant damage to river banks or approaches to crossings along the Danube River, as long as the flood-control dikes between the mouth of the Isar River and Hofkirchen are not breached.

7. No significant still-water barriers can be created by Kachlet Dam, either by raising the water stage above normal at the dam or by draining the reservoir behind the dam.

8. Still-water barriers can be created on the Danube River from the mouth of the Isar River (km 2282.0) to Hofkirchen (km 2256.7), by breaching the flood-control dikes along this reach. The barriers created could be enlarged by the release of artificial flood waves from Hofham Lock on the Isar River.

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- | <u>Reference<br/>Number</u> | <u>Document</u>  |
|-----------------------------|--|
| 1                           | Engineer Research Office Report No. 172, "The Danube River above Passau and Connecting Waterways," Vol. 1, published by Office Chief of Engineers, U. S. Army, April 1945.   |
| 2                           | "Germany," Vol. 1, "Physical Geography," published by the British Naval Intelligence Division, January 1944.   |
| 3                           | "Stromgebiet der Donau, Einwirkung auf die Wasserfuehrung," a military geography document, published by the German VII Army Corps, Munich, in 1937.  |
| 4                           | "Schiffahrtskarte der Donau von Kelheim bis Pressburg," published by the German Ministry of Traffic, Berlin, 1941.   |
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| 7                           | "Report on Flood Control in Germany," by Capt. W. W. Wanamaker, C. E., in February 1938.   |
| 8                           | "Jahrbuch fur die Gewasserkunde des Deutschen Reichs," Abflussjahr (Wateryear) 1938, published by the German Government, Berlin 1942.  |
| 9                           | "Der Hochwasserschutz an der Donau in Bayern," by Erwin Marquardt, published in Munich in 1929.  |
| 10                          | Strategic Engineering Study No. 128, "Navigable Waterways of Germany," Vol. 1, published by Office, Chief of Engineers, U. S. Army, August 1944.   |

## LIST OF EXHIBITS

<u>Exhibit Number</u>	<u>Title</u>
1	Hydrologic Terms and Abbreviations from European Literature
2	Basin Map above Passau, Germany*
3	Danube River, Deggendorf to Engelhartzell
4	Sketch Map, Metten to Pleinting*
5	Profiles and Surface Velocities, Hofkirchen to Obernzell
6	Channel Widths, Engelhartzell to Hofkirchen
7	Danube River, Route Description (3 pages)*
8	Flow-Duration Curves, Hofkirchen and Obernzell**
9	Plan of Kachlet Dam*
10	Kachlet Dam, Elevation and Cross-Section*
11	Stage-Velocity-Discharge Curves
12	Average Monthly Stage, Hofkirchen and Obernzell**
13	Kachlet Dam Flood-Wave Hydrographs
14	Hofham Lock Flood Wave Hydrographs

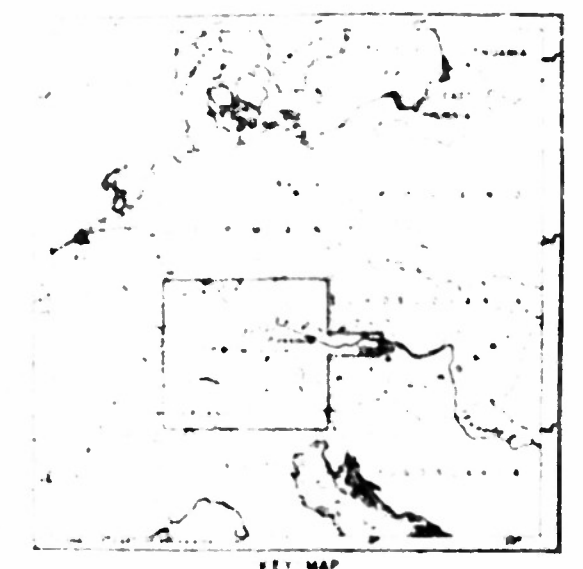
\* From Engineer Research Office Report No. 172 (ERC-172), Vol. I, "The Danube River above Passau and Connecting Waterways," published by Office, Chief of Engineers, April 1945.

\*\* From "Jahrbuch für die Gewässerkunde des Deutschen Reichs," the German Hydrological Yearbook, for 1938.

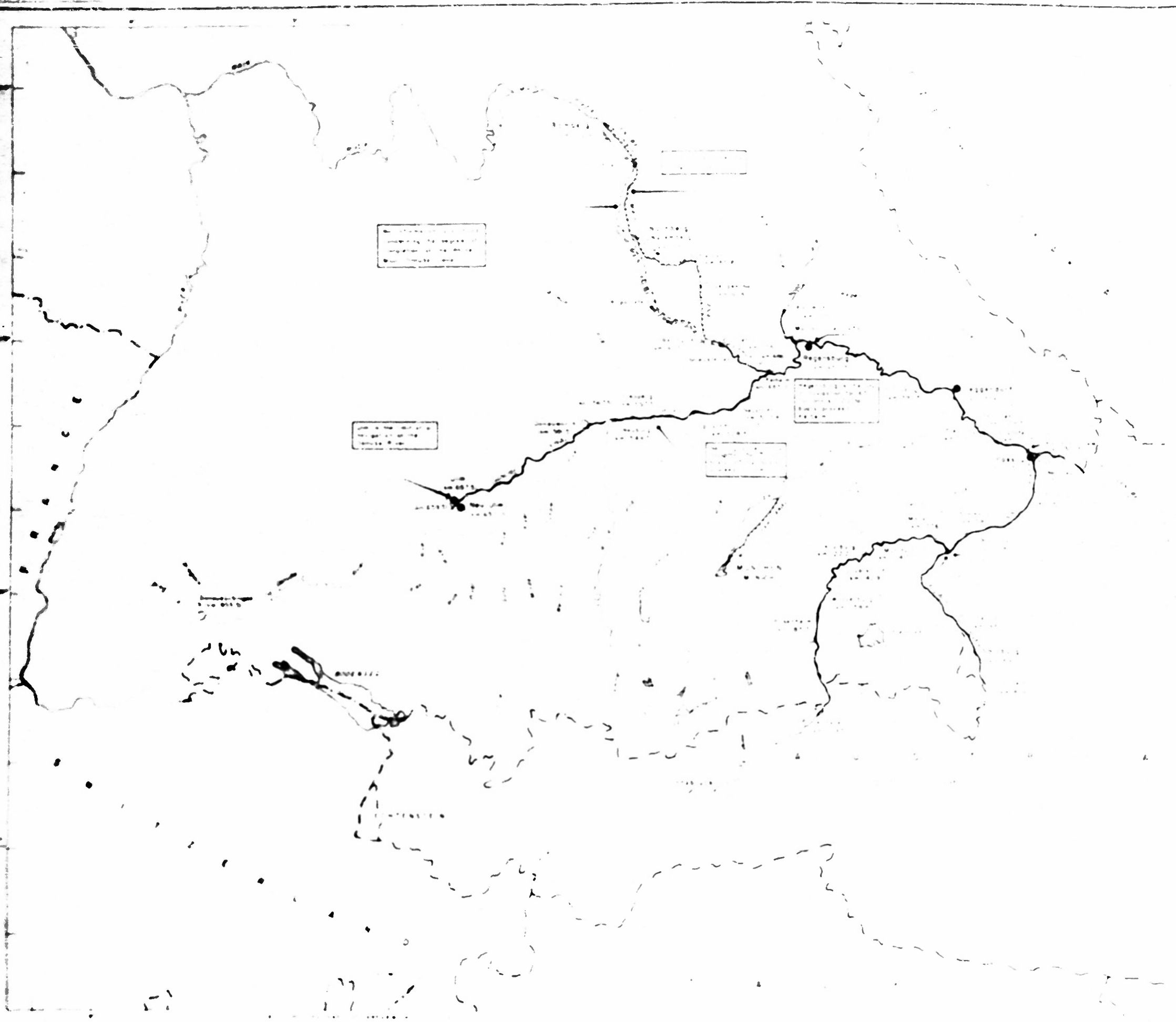
	Water levels as given in				Other	Remarks
	Observations	As High Water	As Low Water	As Mean Water		
	(1)	(2)	(3)	(4)	(5)	(6)
a. The highest high water (HH) ever known or anticipated. (The absolute extreme.)	100	100w	100w	100	100	100
b. The highest value (H) encountered in the course of time covered.	90	90w	90w	90	90	90
c. The mean high range (MR) in the course of time covered.	100	100w	100w	100	100	100
d. The mean value (M) [average] in the course of time covered.	90	90w	90w	90	90	90
e. The mean low value (ML) (and minimum) in the course of time covered.	100	100w	100w	100	100	100
f. The lowest value (L) encountered in the course of time covered.	90	90w	90w	90	90	90
g. The lowest low value (LL) ever known or anticipated. (The absolute minimum.)	100	100w	100w	100	100	100

1. The highest low water (LL) ever known or anticipated in the course of time covered. For example, 100 is the highest low water range value that has ever been observed at any low water.
2. The highest low water (L) ever known or anticipated in the course of time covered. For example, 90 is the highest low water range value that has ever been observed at any low water.
3. The mean high range (MR) is the range of water levels between the highest high water (HH) and the lowest low water (LL) in a given period of time. For example, if the HH is 100 and the LL is 100, the MR is 0. If the HH is 100 and the LL is 90, the MR is 10. If the HH is 90 and the LL is 90, the MR is 0. The MR is the range of water levels between the HH and the LL in a given period of time. For example, if the HH is 100 and the LL is 100, the MR is 0. If the HH is 100 and the LL is 90, the MR is 10. If the HH is 90 and the LL is 90, the MR is 0.
4. The mean value (M) [average] is the average of all the observations in a given period of time. For example, if the observations are 100, 90, 100, 90, 100, the M is 96.7. Another example: if the observations are 100, 90, 100, 90, 100, 100, the M is 98.3.
5. The mean low value (ML) (and minimum) is the lowest value in a given period of time. For example, if the observations are 100, 90, 100, 90, 100, the ML is 90. Another example: if the observations are 100, 90, 100, 90, 100, 100, the ML is 90.
6. The lowest value (L) ever known or anticipated in the course of time covered. For example, if the observations are 100, 90, 100, 90, 100, the L is 90. Another example: if the observations are 100, 90, 100, 90, 100, 100, the L is 90.
7. The lowest low value (LL) ever known or anticipated in the course of time covered. For example, if the observations are 100, 90, 100, 90, 100, the LL is 100. Another example: if the observations are 100, 90, 100, 90, 100, 100, the LL is 100.
8. Refer to explanation in column 1.
9. Refer to explanation in column 1.
10. Refer to explanation in column 1.

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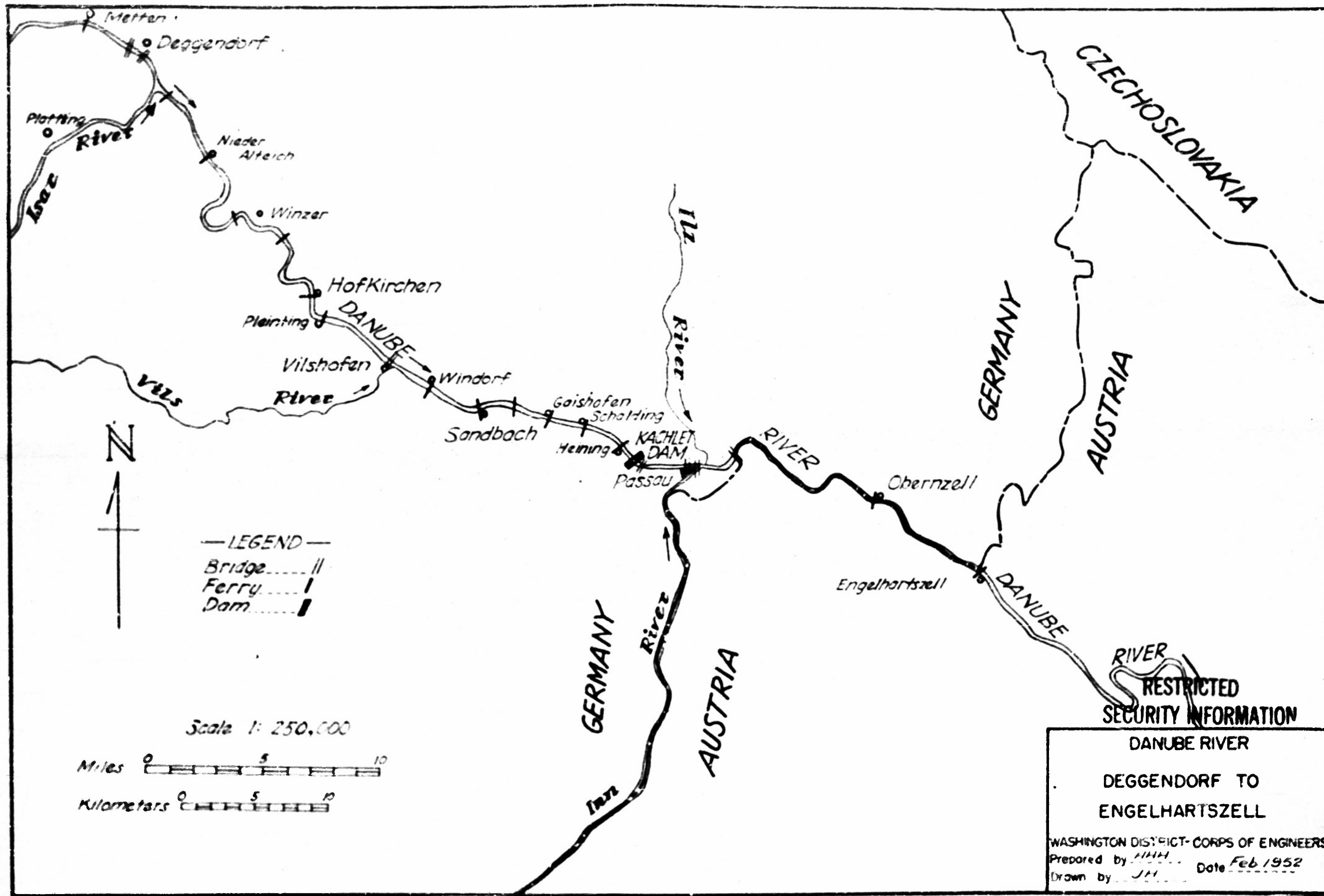


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Research Office Report N-172  
(E R O - 172)



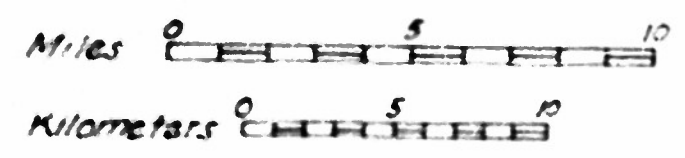
- LEGEND
- Main Danube and Inn and Isar above Passau
  - Main Danube according to I.M.S. M.S. and I.M.S. M.S. above Passau
  - Main Danube
  - Main Danube with weir, dam, canal, etc.
  - Main Danube weir, dam, canal, etc.
  - Main Danube weir, dam, canal, etc.
  - Main Danube weir, dam, canal, etc.

DANUBE RIVER  
BASIN MAP  
ABOVE  
PASSAU, GERMANY.  
WASHINGTON DISTRICT CORPS OF ENGINEERS  
Date 5-25-52



— LEGEND —  
 Bridge .....  
 Ferry .....  
 Dam .....

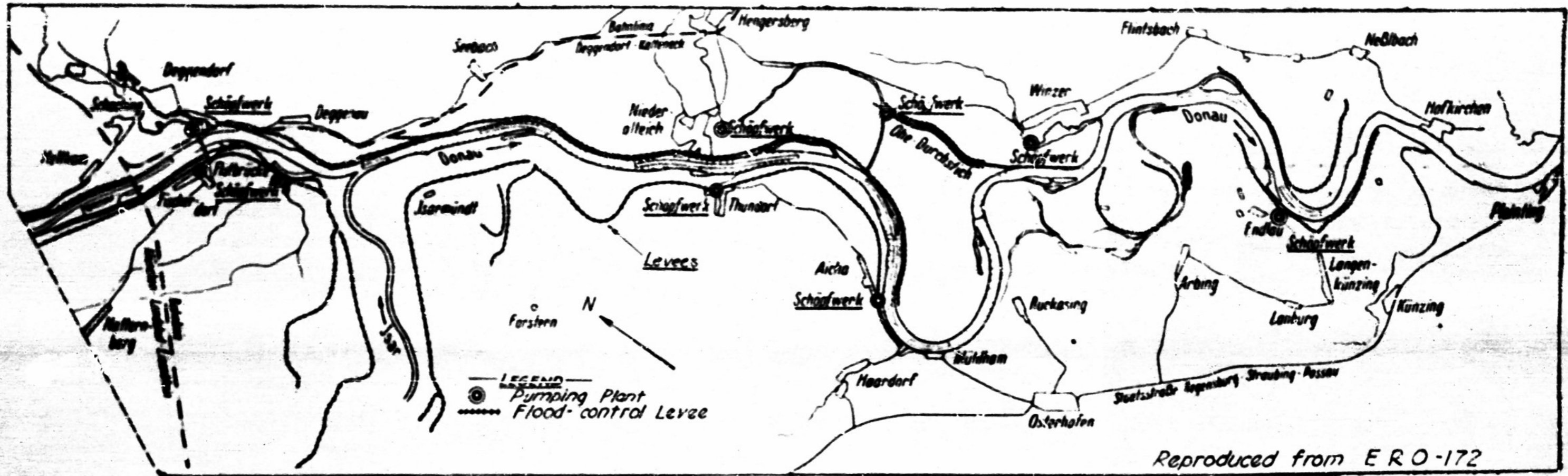
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**DANUBE RIVER**  
**DEGGENDORF TO**  
**ENGELHARTSZELL**

WASHINGTON DISTRICT-CORPS OF ENGINEERS  
 Prepared by *JHH* Date *Feb 1952*  
 Drawn by *JH*



Sketch Map of the Danube River Between Metten  
 and Pleinting Showing Locations of Pumping Plants

GERMANY - 1935

**GERMAN**

Bahnlinie  
 Durchstich  
 Schöpfwerk  
 Staatsstrasse

**ENGLISH**

Railroad  
 Out-off Canal  
 Pumping Plant  
 State Highway

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ELEVATION IN METERS

300  
295  
290  
285  
280  
20  
15  
10  
5  
0

AVERAGE SURFACE VELOCITY  
IN METERS PER SECOND

FEET PER SECOND

RESERVOIR NORMAL WATER  
SURFACE EL 289.5m

CHANNEL BOTTOM

Hofkirchen Ferry  
Hofkirchen Gage

Deimling Ferry

Island

Vilshofen Highway  
Bridge & Gage  
Vils River

Windorf Ferry

Sandbach Ferry

Seestetten Ferry

Gaishofen Ferry

Schalding Ferry

2260

2255

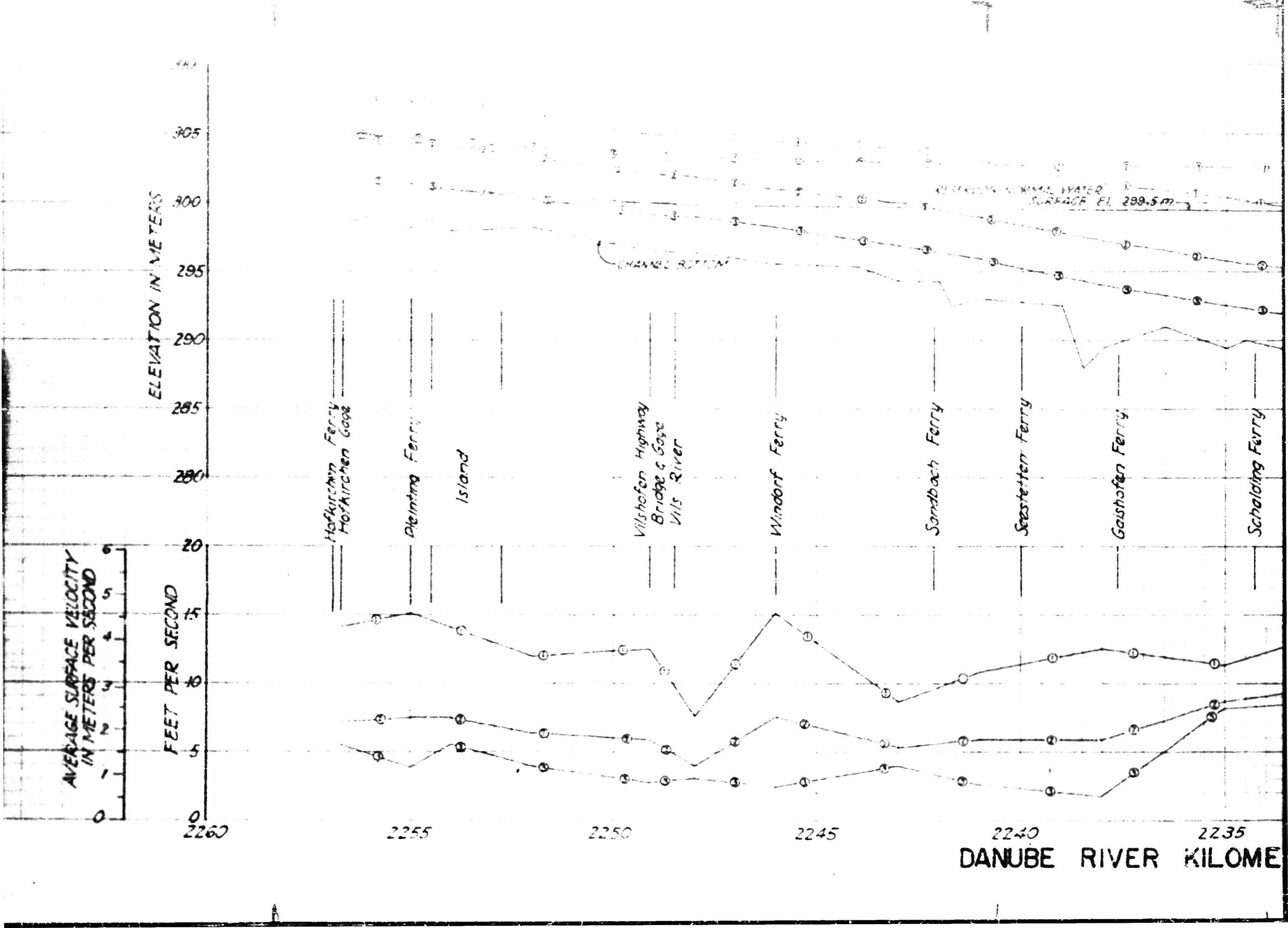
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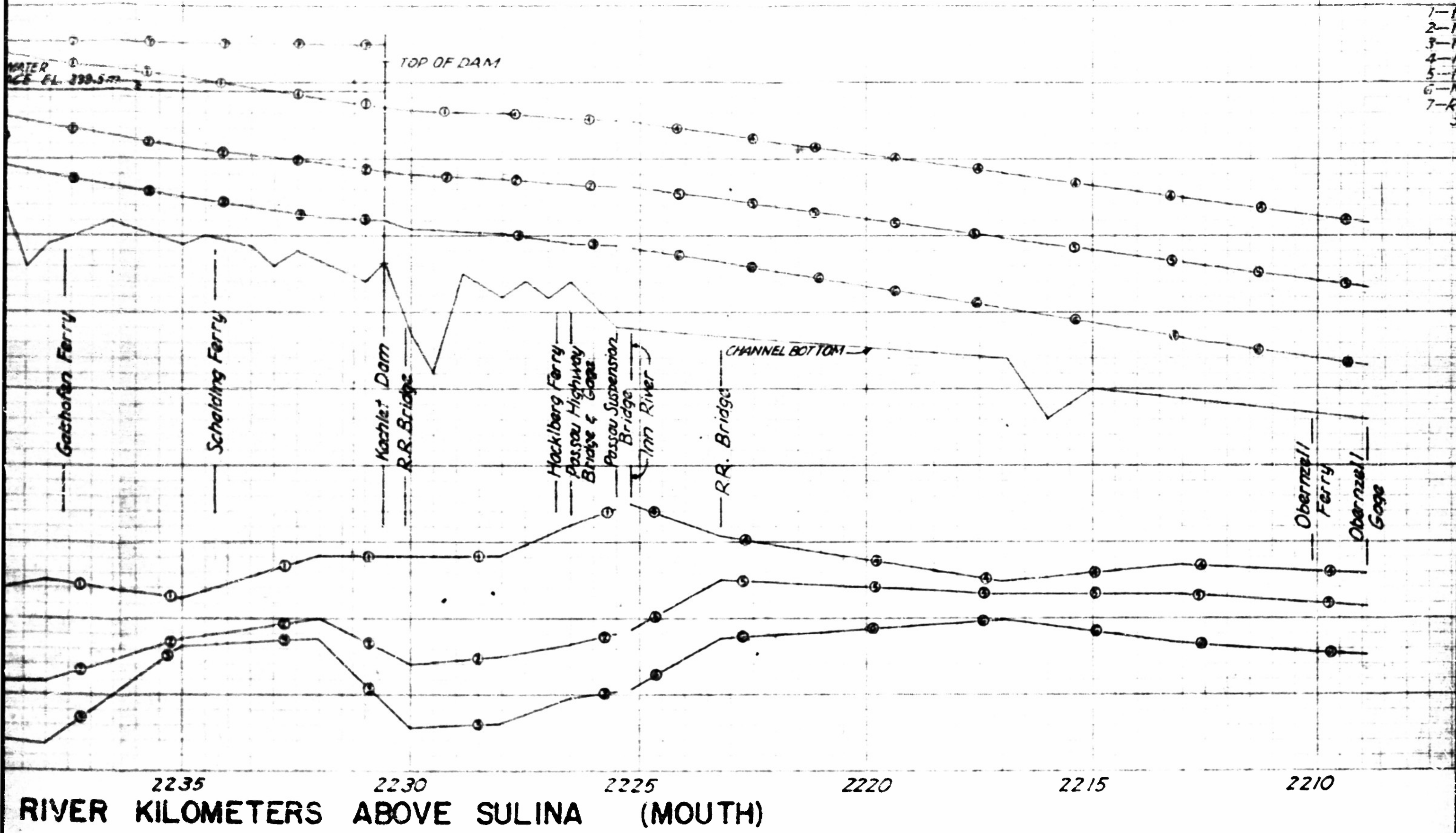
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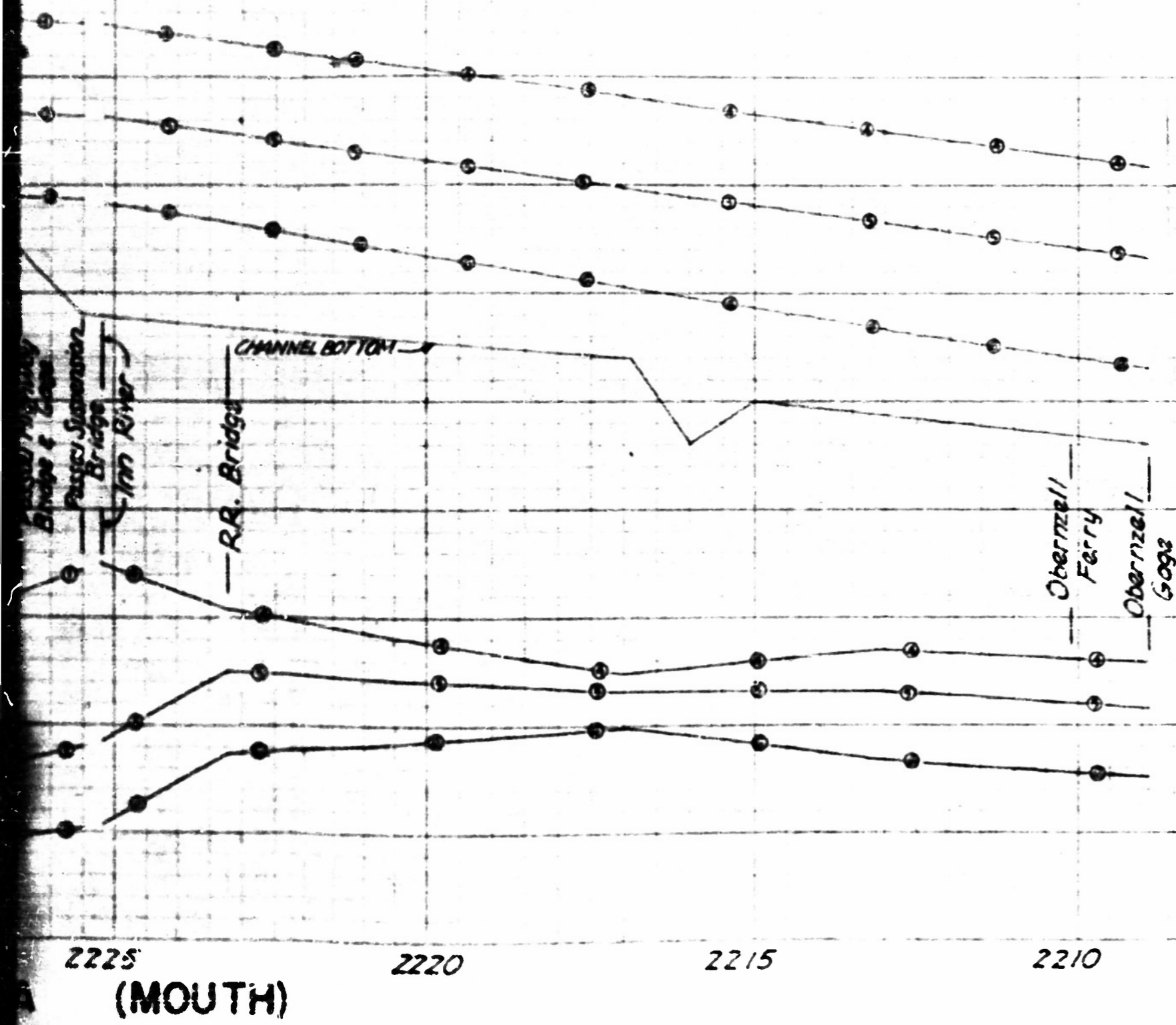
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DANUBE RIVER KILOMETER





- LEGEND -----
- 1- High High Water (1845) 5000 Cubic Meters Per Second
  - 2- Mean High Water 1700 Cubic Meters Per Second
  - 3- Mean Low Water 280 Cubic Meters Per Second
  - 4- High High Water (1899) 8200 Cubic Meters Per Second
  - 5- Mean High Water 4000 Cubic Meters Per Second
  - 6- Mean Low Water 620 Cubic Meters Per Second
  - 7- Reservoir water surface with dam raised to Elevation 302.5 meters. (Discharge 2000 Cubic Meters Per Second)



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**DANUBE RIVER  
 PROFILES &  
 SURFACE VELOCITIES  
 HOFKIRCHEN TO OBERNZELL**

WASHINGTON DISTRICT CORPS OF ENGINEERS  
 Prepared by H.H.H. Date/25, 1952  
 Drawn by J.L.M.

EXHIBIT 5

DAUBHE RIVER CHANNEL WIDTHS

FROM ENGELHARTZELL TO HORNZELL  
(River km 260.6 to 250.7)

Elevation above Gullna (meters)	Mean low water		Channel width at mean high water		High high water with vachlet		Description
	With vachlet Dam	Without vachlet Dam	With vachlet Dam	Without vachlet Dam	With vachlet Dam	Without vachlet Dam	
2600.6	240	260	270	270	300	300	Engelhartzell dam
2603.0	150	150	230	230	250	250	Lochenstein
2608.9	200	200	260	260	280	280	Hornzell dam
2613.0	140	140	230	230	250	250	
2617.0	150	150	290	290	300	300	
2623.2	130	130	260	260	260	260	
2625.5	100	100	130	130	140	140	H. R. Bridge
2626.5	130	130	160	160	170	170	Passau suspension bridge
2628.0	120	120	160	160	170	170	Passau Highway bridge and dam
2630.1	100	100	160	160	170	170	H. R. Bridge
2630.6	-	-	-	-	-	-	Vachlet for dam dam
2632.0	290	150	200	230	230	280	Schalding
2635.0	300	150	300	240	310	310	
2638.0	180	150	180	170	200	200	
2641.0	270	200	240	230	260	260	
2643.0	150	220	350	350	370	370	
2646.0	100	150	180	180	210	210	Aldorf ferry - State Channel
2648.0	320	240	320	320	400	400	Pro Channel - Verpfe approach cut
2648.0	400	250	480	430	500	500	Wilsberg - River bridge
2649.1	270	230	250	250	270	270	
2650.0	230	210	250	240	300	300	
2652.0	160	160	220	220	260	260	Island - State Channel
2654.0	250	250	350	350	420	420	Island (State)
2655.0	160	160	200	200	230	230	Wilsberg dam
2656.7	130	130	250	250	260	260	Wilsberg dam

SECURITY INFORMATION

**SAMUEL RIVER ROUTE DESCRIPTION**  
From KRO 172

The material is arranged in this table in eight columns as follows:

Column 1 - Distances, in km, of the places listed in Column 2 from the lower terminal point of the waterway. Two km distances given for the same place indicate the upper and lower limits of this place on the river. For instance: 266.6) Dortmund.  
267.1)

Column 2 - In this column are listed the localities and facilities situated on the waterway. Places of importance with docking facilities are underscored with a solid line. Junctions and deviations of waterways are underscored with dashed line.

Column 3 - Km station, if it has been established for the waterway, from source to mouth. This distance is not necessarily the complement of that in Column 1, as it is not computed on the same basis.

Column 4 - Gauge readings for water levels referred to zero point of the appropriate gauge.

Column 5 - Depth of navigation channel at indicated water level.

Column 6 - Useful length and width of locks.

Column 7 - Number of bridge spans usable for navigation, width of bridge span or spans accommodating the navigation passage and the vertical clearance under bridge at highest navigable water, unless otherwise specified.

Column 8 - Information on places listed in Column 2, also information added to the table from recent sources (underscored).

The following abbreviations are used in the table -

HNW - Highest navigable water  
MLW - Mean low water  
MW - Mean water  
R.R. - Railroad  
R.R.Sta. - Railroad station

SECURITY INFORMATION

THE DANUBE RIVER (DONAU)

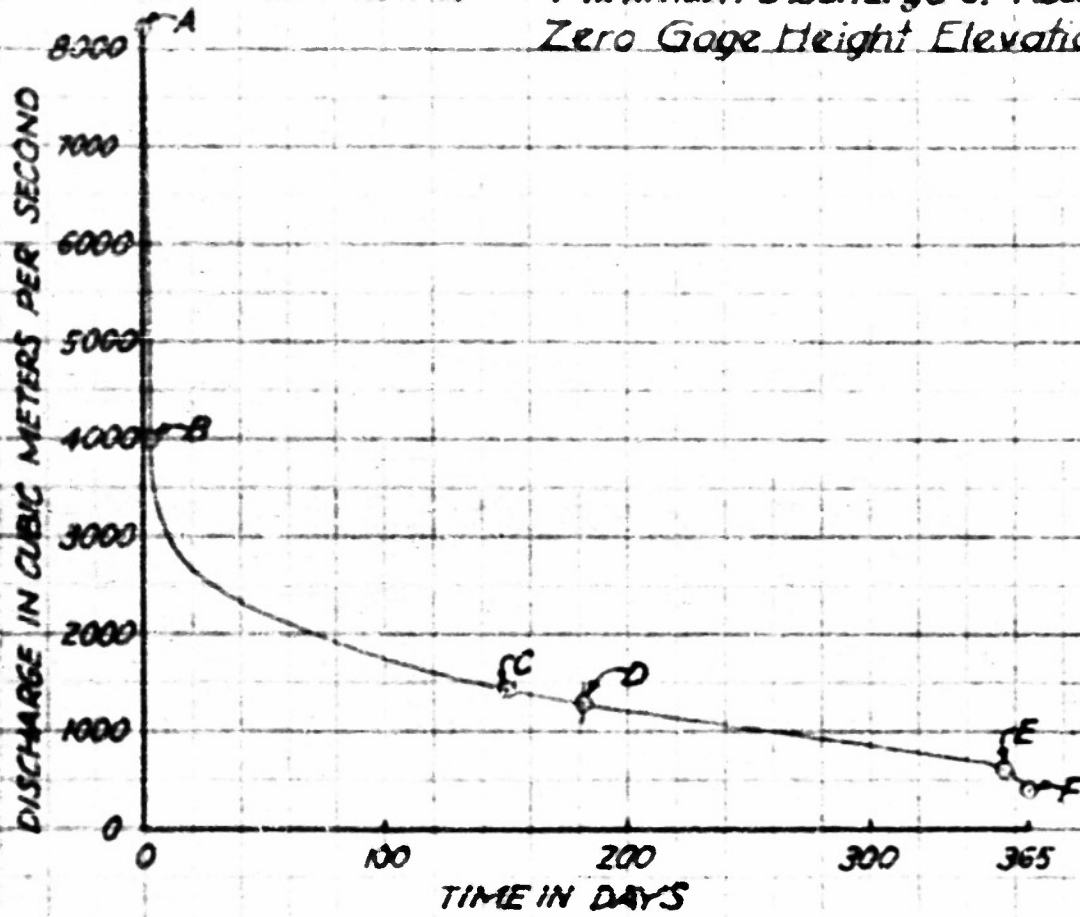
ITEM NO.	MILE POINT	LOCALITIES AND FACILITIES	ELEVATION IN FEET	WATER LEVEL ON GAGE AT		CHANNEL DEPTH AT		LOCK USEFUL LENGTH WIDTH		BRIDGES NAVIGATION SPANS WIDTH CLEARANCE		REMARKS
				M.W.	H.W.	M.W.	H.W.	NO.	M.W.	H.W.	NO.	
1	0870.0	Description of the Danube river gives in this column										
2	201.1	Feeder canals	367.2			1.43	2.40					
3	207.0	Mouth of the JOE river	342.0									
4	207.0	Feeder, Fort, etc.	362.0	1.50	2.40							
5	207.0	Feeder, Substation bridge	362.0									
6	207.0	Feeder, Highway bridge	362.0									
7	207.0	Feeder, etc.	362.0									
8	207.0	Feeder, etc.	362.0									
9	207.0	Feeder, etc.	362.0									
10	207.0	Feeder, etc.	362.0									
11	207.0	Feeder, etc.	362.0									
12	207.0	Feeder, etc.	362.0									
13	207.0	Feeder, etc.	362.0									
14	207.0	Feeder, etc.	362.0									
15	207.0	Feeder, etc.	362.0									
16	207.0	Feeder, etc.	362.0									
17	207.0	Feeder, etc.	362.0									
18	207.0	Feeder, etc.	362.0									
19	207.0	Feeder, etc.	362.0									
20	207.0	Feeder, etc.	362.0									
21	207.0	Feeder, etc.	362.0									
22	207.0	Feeder, etc.	362.0									
23	207.0	Feeder, etc.	362.0									
24	207.0	Feeder, etc.	362.0									
25	207.0	Feeder, etc.	362.0									
26	207.0	Feeder, etc.	362.0									
27	207.0	Feeder, etc.	362.0									
28	207.0	Feeder, etc.	362.0									
29	207.0	Feeder, etc.	362.0									
30	207.0	Feeder, etc.	362.0									
31	207.0	Feeder, etc.	362.0									
32	207.0	Feeder, etc.	362.0									
33	207.0	Feeder, etc.	362.0									
34	207.0	Feeder, etc.	362.0									
35	207.0	Feeder, etc.	362.0									
36	207.0	Feeder, etc.	362.0									
37	207.0	Feeder, etc.	362.0									
38	207.0	Feeder, etc.	362.0									
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40	207.0	Feeder, etc.	362.0									
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47	207.0	Feeder, etc.	362.0									
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52	207.0	Feeder, etc.	362.0									
53	207.0	Feeder, etc.	362.0									
54	207.0	Feeder, etc.	362.0									
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93	207.0	Feeder, etc.	362.0									
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95	207.0	Feeder, etc.	362.0									
96	207.0	Feeder, etc.	362.0									
97	207.0	Feeder, etc.	362.0									
98	207.0	Feeder, etc.	362.0									
99	207.0	Feeder, etc.	362.0									
100	207.0	Feeder, etc.	362.0									

THE DANUBE RIVER (DONAUI(COAR))

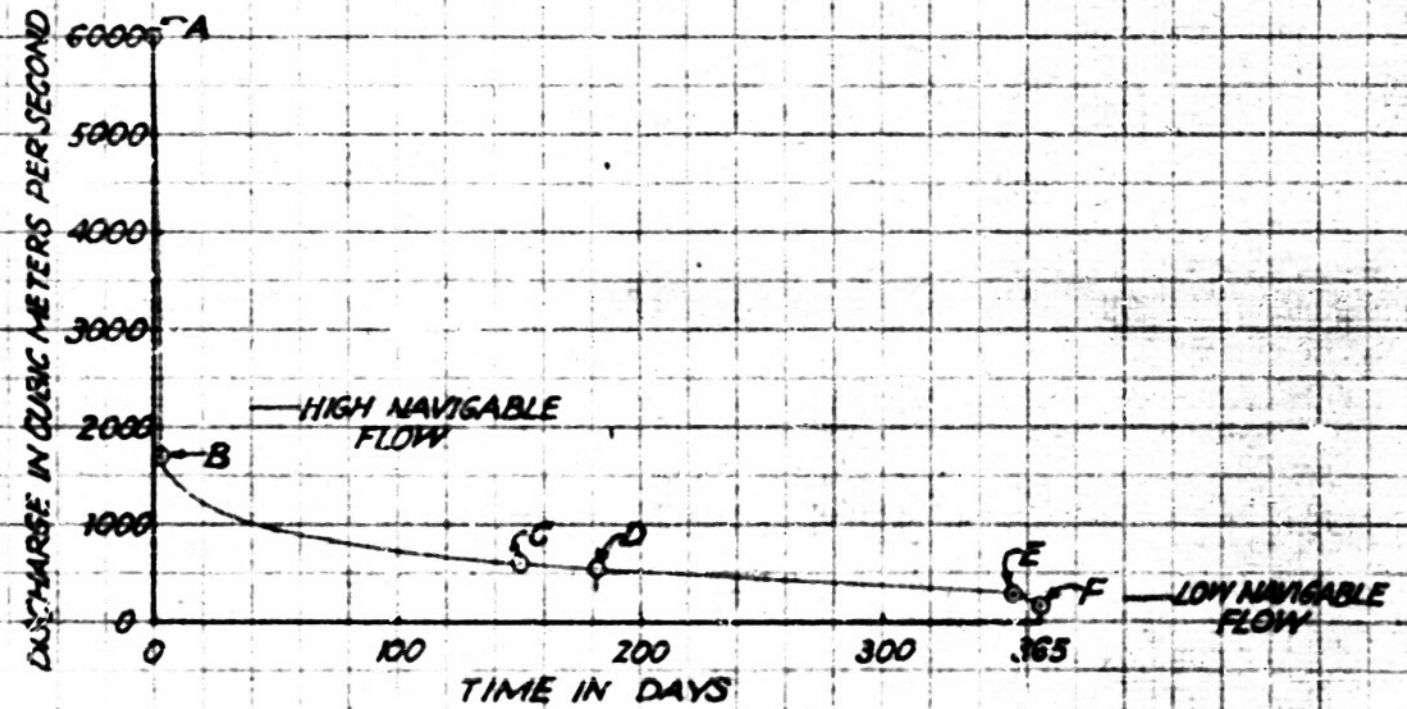
ITEM NO	STATION NO	LOCALITIES AND FACILITIES	ELEVATION IN METERS	WATER LEVEL ON GAGE		CHANNEL DEPTH		USEFUL LENGTH	SPAN		REMARKS
				M/W	M/H	M/W	M/H		NO	WIDTH	
16	312.0	Landau, g.s. Ste.	247.0	-	-	-	-	-	-	-	Ferry
17	313.0	Landau	247.0	-	-	-	-	-	-	-	Ferry
18	322.0	South of the Tuller River	238.0	-	-	-	-	-	-	-	Ferry
19	323.0	Wienau, g.s. Ste.	237.0	-0.00	2.20	-	-	-	42.00	4.10	Ferry
20	324.0	Wienau, g.s. Ste.	236.0	-	-	-	-	-	-	-	Ferry
21	325.0	Wienau, g.s. Ste.	235.0	-	-	-	-	-	-	-	Ferry
22	326.0	Wienau, g.s. Ste.	234.0	-	-	-	-	-	-	-	Ferry
23	327.0	Wienau, g.s. Ste.	233.0	-	-	-	-	-	-	-	Ferry
24	328.0	Wienau, g.s. Ste.	232.0	-	-	-	-	-	-	-	Ferry
25	329.0	Wienau, g.s. Ste.	231.0	-	-	-	-	-	-	-	Ferry
26	330.0	Wienau, g.s. Ste.	230.0	-	-	-	-	-	-	-	Ferry
27	331.0	Wienau, g.s. Ste.	229.0	-	-	-	-	-	-	-	Ferry
28	332.0	Wienau, g.s. Ste.	228.0	-	-	-	-	-	-	-	Ferry
29	333.0	Wienau, g.s. Ste.	227.0	-	-	-	-	-	-	-	Ferry
30	334.0	Wienau, g.s. Ste.	226.0	-	-	-	-	-	-	-	Ferry
31	335.0	Wienau, g.s. Ste.	225.0	-	-	-	-	-	-	-	Ferry
32	336.0	Wienau, g.s. Ste.	224.0	-	-	-	-	-	-	-	Ferry

PERIOD OF RECORD 1901-1938

	OBERNZELL	HOFKIRCHEN
A - Peak Discharge of Record	(gauge height 915cm)	(gauge height 590cm)
B - Mean High Discharge	( " " 505cm)	( " " 270cm)
C - Mean Discharge	( " " 165cm)	( " " 103cm)
D - Discharge Exceeded 50% of Time	( " " 145cm)	( " " 90cm)
E - Mean Low Discharge	( " " -15cm)	( " " 16cm)
F - Minimum Discharge of Record	( " " -105cm)	( " " -20cm)
	Zero Gauge Height Elevation (281.65 Meters)	(301.60 Meters)



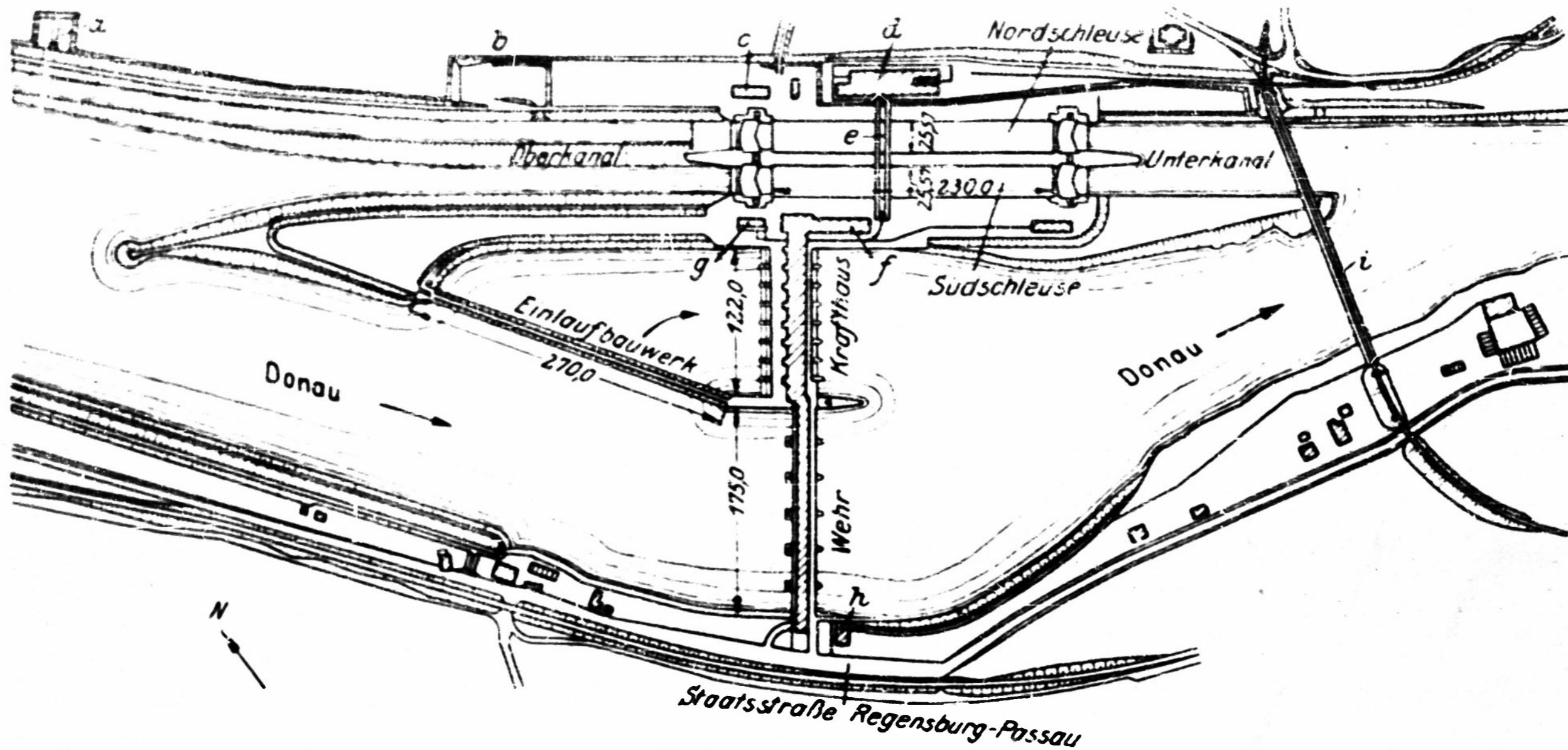
OBERNZELL  
(2208.9 Km ABOVE SULINA)



HOFKIRCHEN  
(2256.7 Km ABOVE SULINA)

**RESTRICTED**  
**SECURITY INFORMATION**  
 DANUBE RIVER  
 FLOW DURATION CURVES  
 HOFKIRCHEN & OBERNZELL

WASHINGTON DISTRICT - CORPS OF ENGINEERS  
 Prepared by H.M.H. Date FEB 52  
 Drawn by J.J.H.



PLAN OF THE YACHT DAM ON THE DANUBE RIVER ABOVE PASSAU  
from ERC 170

GERMAN

Einlaufbauwerk  
Krafthaus  
Nordschleuse  
Oberkanal  
Staatsstrasse  
Sudschleuse  
Unterkanal  
Wehr

ENGLISH

Intake Structure  
Powerhouse  
North Lock  
Upper Approach Channel  
State Highway  
South Lock  
Lower Approach Channel  
Weir

Legend

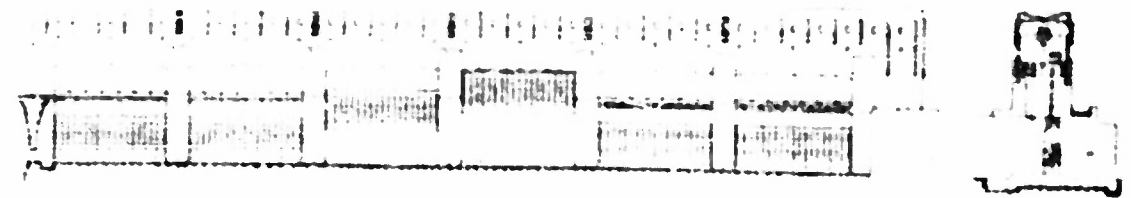
- |   |                                  |
|---|----------------------------------|
| a. Pumping plant                            | f. Transformer station           |
| b. Stop for recess                          | g. Reservoir (Klarbecken)        |
| c. Lock superintendent's quarters           | h. Dam superintendent's quarters |
| d. Transformer                              | i. Railroad bridge               |
| e. Cable duct with sidewalk and crane track |                                  |

**RESTRICTED**  
SECURITY INFORMATION



Cross Section of the Kachlet Dam on the Danube River  
Near Passau

GERMANY - 1928



Elevation of the Kachlet Dam Near Passau  
on the Danube

GERMANY - 1928

**RESTRICTED**  
**SECURITY INFORMATION**

*Reproduced from Engineer Research  
Office Report No 172 (ERO-172)*

GERMAN

Dammbauwerk  
Kran  
Oberwasser  
Schütze  
Steg  
Unterswasser  
Windwerk

ENGLISH

Stop-logs  
Crane  
Head-water  
Gate  
Walk  
Tail-water  
Lift Mechanism

DANUBE RIVER

**KACHLET DAM  
ELEVATION AND  
CROSS SECTION**

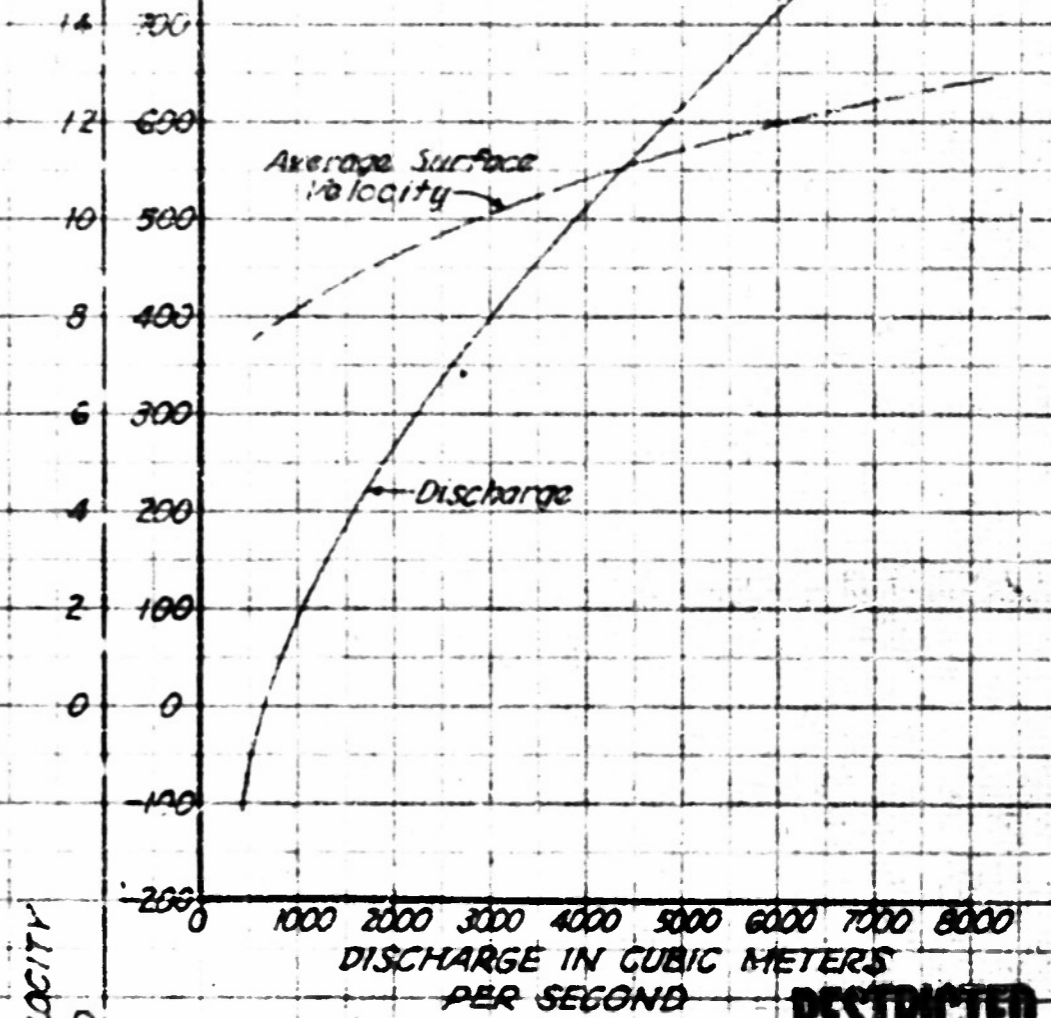
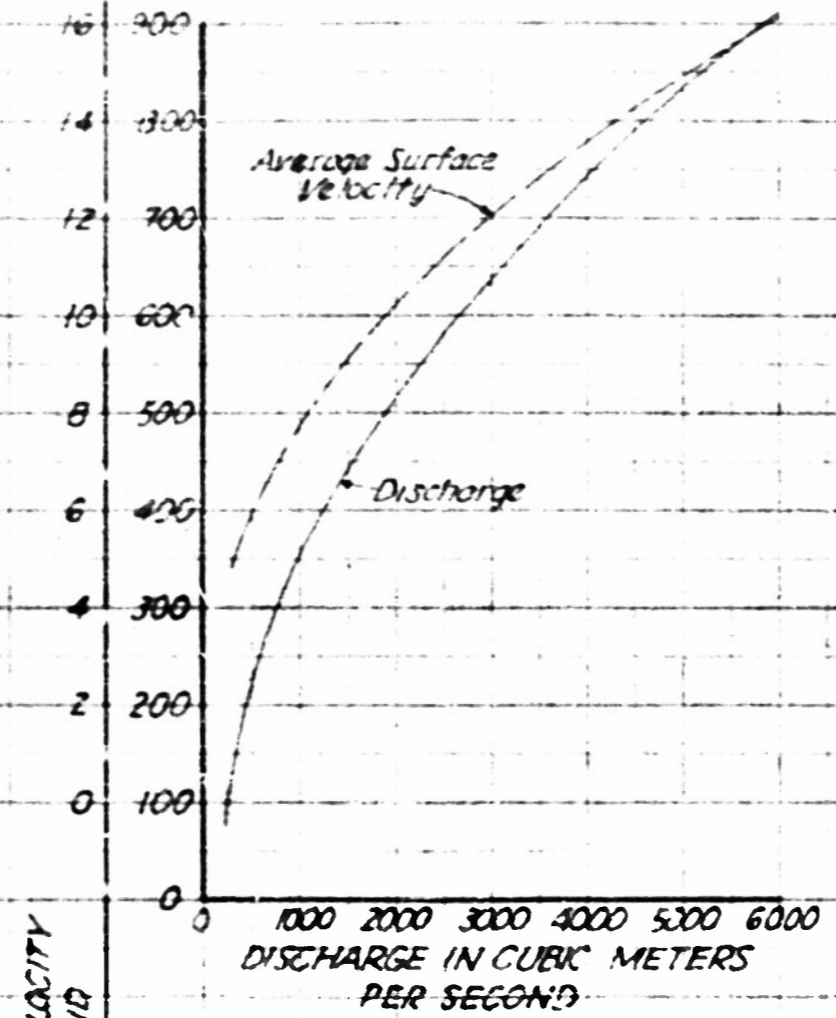
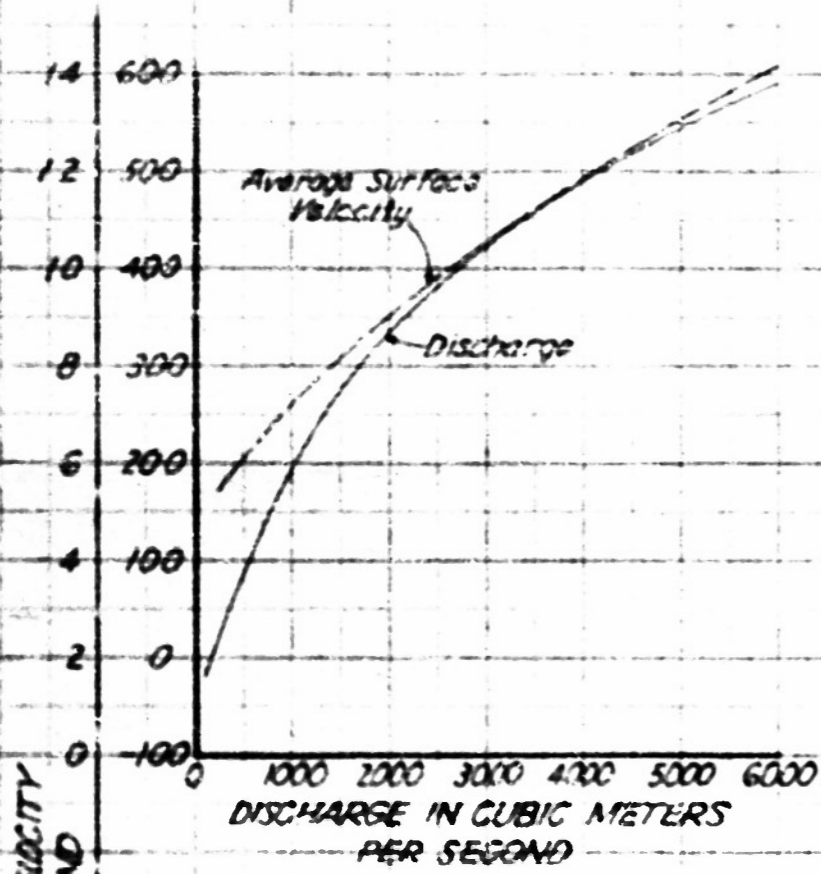
WASHINGTON DISTRICT CORPS OF ENGINEERS

Date Feb. 52

ZERO GAGE HEIGHT 301.60 METERS ELEVATION

ZERO GAGE HEIGHT 256.167 METERS ELEVATION

ZERO GAGE HEIGHT 281.65 METERS ELEVATION

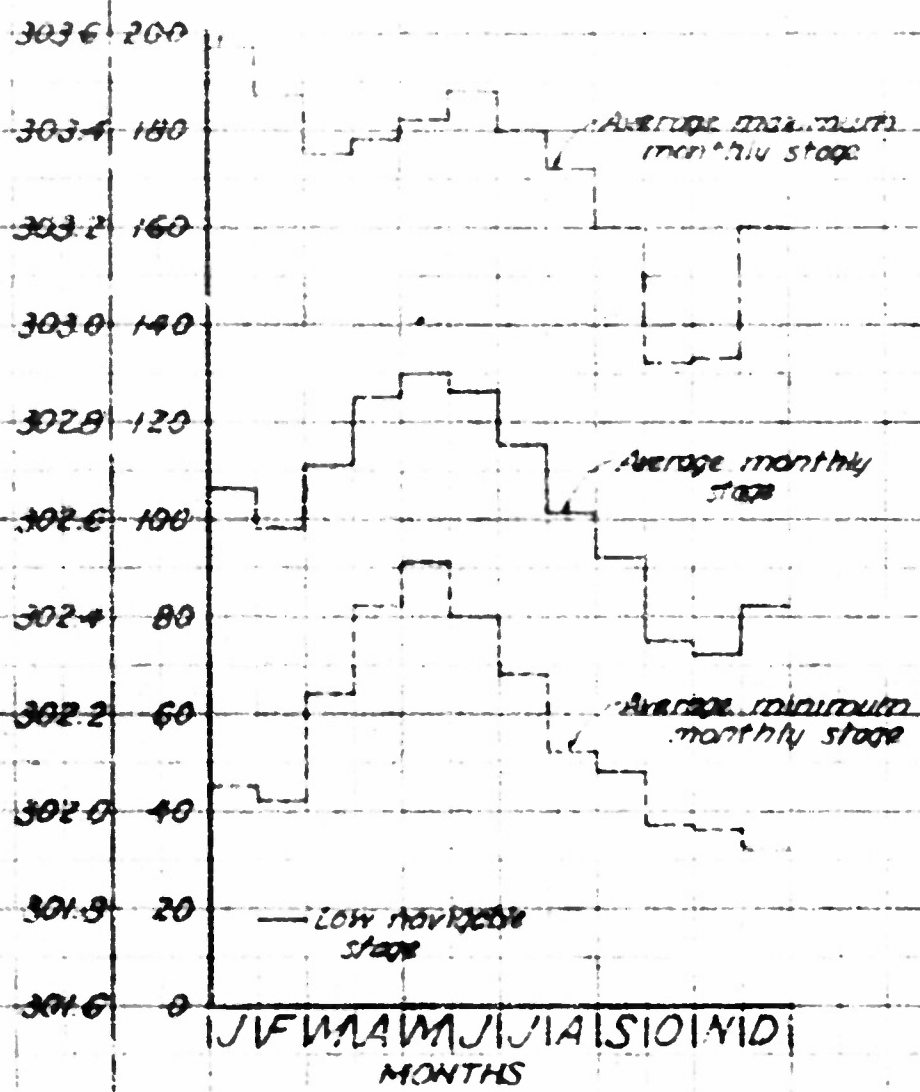


**RESTRICTED SECURITY INFORMATION**

**DANUBE RIVER**  
**STAGE VELOCITY DISCHARGE CURVES**  
WASHINGTON DISTRICT CORPS OF ENGINEERS  
PREDICTED BY H.H.H. DATE: MAR 1957  
DRAWN BY J.J.H.

PERIOD OF RECORD 1901-1938

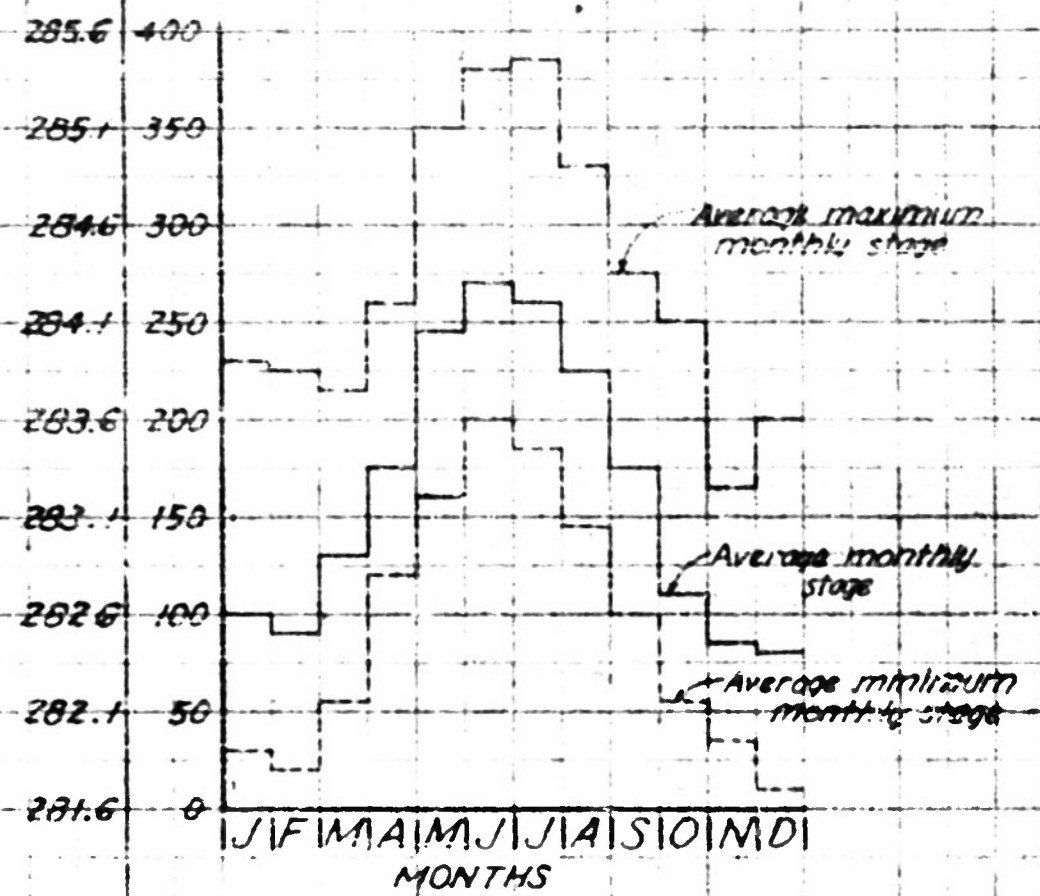
High stages in winter due to ice



ELEVATION IN METERS

GAUGE HEIGHT  
CENTIMETERS

**HOFKIRCHEN**  
(2256.7 km ABOVE SULINA)



ELEVATION IN METERS

GAUGE HEIGHT  
CENTIMETERS

**OBERNZELL**  
(2208.9 km ABOVE SULINA)

**RESTRICTED**

SECURITY INFORMATION

DANUBE RIVER  
AVERAGE MONTHLY STAGE  
HOFKIRCHEN & OBERNZELL  
WASHINGTON DISTRICT CORPS OF ENGINEERS  
Prepared by *HHH* Date *Feb. 1952*  
Drawn by *JH*

- ① High Flow - Mean Low Discharge (250 M<sup>3</sup>/s at Kachlet Dam & Passau) (650 M<sup>3</sup>/s at Oberzell)
- ② Base Flow - Mean Discharge (625 M<sup>3</sup>/s " " " (1400 M<sup>3</sup>/s " " )
- ③ Rise Five Mean High Discharge (1700 M<sup>3</sup>/s " " " (4050 M<sup>3</sup>/s " " )

DISCHARGE IN CUBIC METERS PER SECOND

TIME IN HOURS  
DISCHARGE FROM KACHLET DAM  
(2200.6 KM ABOVE SULINA)

TIME IN HOURS  
DISCHARGE AT PASSAU  
SUSPENSION BRIDGE  
(2225.5 KM ABOVE SULINA)

TIME IN HOURS  
DISCHARGE AT OBERZELL GAGE  
(2208.9 KM ABOVE SULINA)

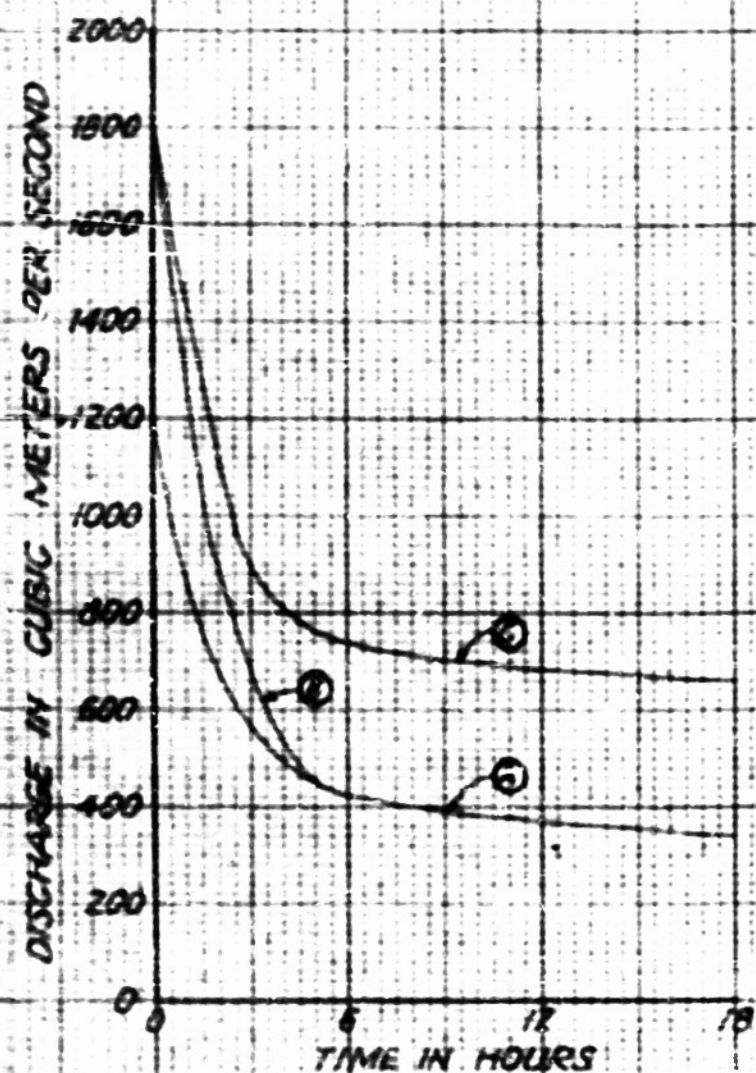
**CONFIDENTIAL**  
SECURITY INFORMATION

**DANUBE RIVER  
KACHLET DAM  
FLOOD WAVE HYDROGRAPHS**

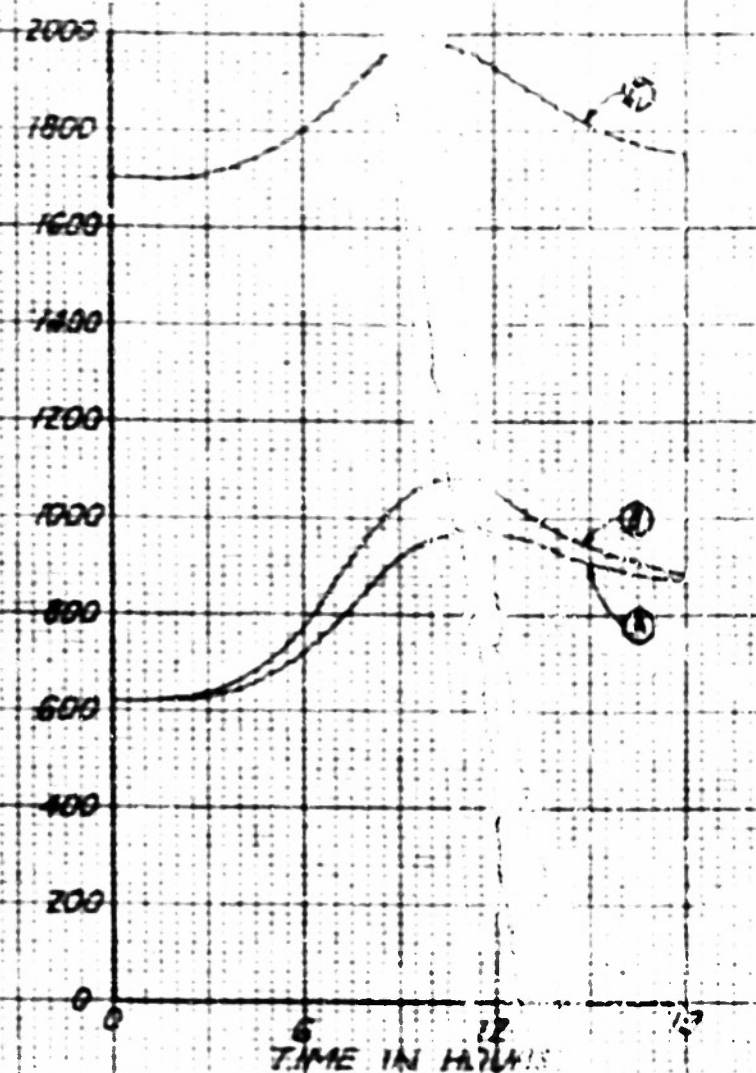
WASHINGTON DISTRICT CORPS OF ENGINEERS  
Prepared by 255 Date Feb. 51  
Drawn by J.M.P.

# ISAR RIVER REGULATION PLANS

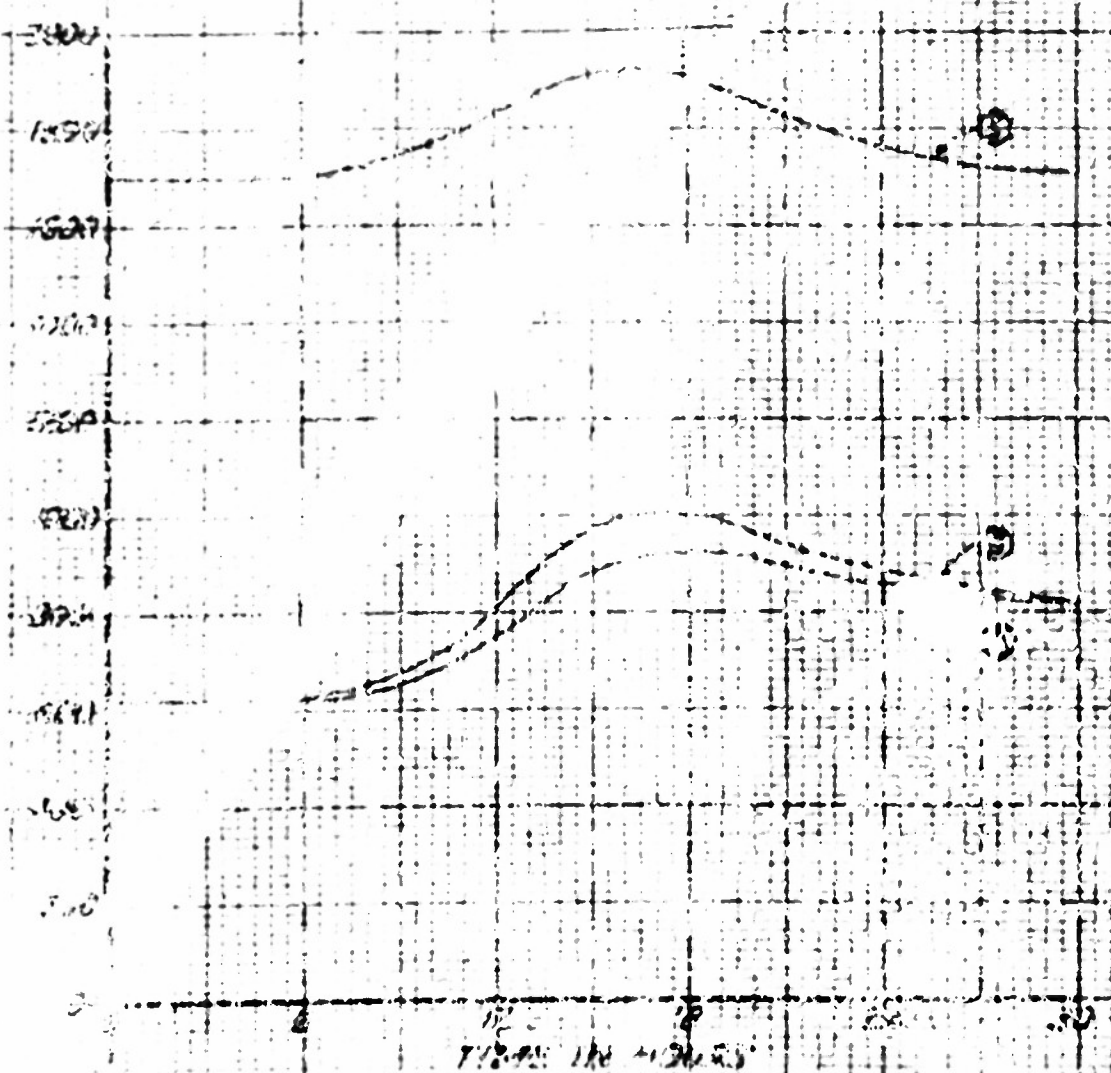
- ① Base Flow = Mean Discharge (150 M<sup>3</sup>/s at Hofham Loch, 150 M<sup>3</sup>/s at Dinkow River)
- ② Base Flow = Mean Discharge (150 M<sup>3</sup>/s at Hofham Loch, 150 M<sup>3</sup>/s at Dinkow River)
- ③ Base Flow = Mean High Discharge (150 M<sup>3</sup>/s at Hofham Loch, 150 M<sup>3</sup>/s at Dinkow River)



DISCHARGE ON ISAR RIVER AT HOFHAM LOCH (813 km. ABOVE MOUTH)



DISCHARGE ON DANUBE RIVER BELOW MOUTH OF ISAR RIVER (2282 km. ABOVE VIENNA)



DISCHARGE ON DANUBE RIVER AT KAMMLET DAM (2235 km. ABOVE VIENNA)

**NOTES:**

1. Hydrographs ① result from the manipulation of the main water control works at Hofham Loch to produce flood waves on the Lower Isar River.
2. Hydrographs ② & ③ result from the same operations as ① but with supplement of water obtained from the Danube River.

CONFIDENTIAL

DANUBE RIVER

HOFHAM LOCH

PLANNED WATER HYDROGRAPH

Prepared by [unclear] [unclear] [unclear]  
 Date [unclear]