Report on Preliminary Study of the Elbe River Floods

September 12, 2002

Infrastructure Development Institute

IFNet Preparatory Unit, “Water in Rivers”

1. Purpose of the study:

(i) Preliminary study of the Elbe River floods in August 2002.

(ii) To introduce and request participation in the International Flood Network.

2. Countries Studied:

(i) The Czech Republic

(ii) The Federal Republic of Germany

3. Study Team Members:

(i) Ryosuke Kikuchi, Director of the Second Research Department, Infrastructure Development Institute, (Director General of "Water in Rivers" Secretariat)

(ii) Akira Sasaki, Second Research Department, Infrastructure Development Institute, (Deputy Director General of "Water in Rivers" Secretariat)

4. Study Schedule

September 3, 2002,	A.M.	Arrival at Praha
	P.M.	Data collection (procurement of maps drawn to scales of 1/50,000, 1/300,000, and 1/500,000)
		Interview with Mr. Tomio Tatsuki, Secretary of the Japanese Embassy in the Czech Republic
September 4	A.M.	Field study from Praha to the Slapy dam located 40 km upstream.
	P.M.	Field study within Praha City
		Travel to Bonn
September 5th	A.M.	Hearing at the Federal Institute of Hydrology in Koblenz.
		Data collection (procurement of maps of Dresden City, etc. drawn to scales of 1/50,000, 1/300,000, and 1/700,000)

5. Study Items and Results

(1) Outlines of the Elbe River

(a) River length 1,170 km (Federal Institute of Hydrology)

(b) Catchment area 148,268 km^2

(c) Outlines of the river basin and the river (See Figure-1)

The river flows in the Czech Republic and Germany with about one third of its entire length in the upper reaches in the Czech Republic and about two thirds in the lower reaches in Germany. The Elbe River originates in the Riesen mountains in the Czech Republic rising around 1,500 m above sea level. Its upper reaches in the Czech Republic form a basin like terrain; the river flows out of the Riesen mountains through the Czech Basin to the west, then turns to the north, joining the Vltava River flowing in from Southern Czech Republic, where Praha is located, and the Ohre River flowing in from Western Czech Republic, and heads for Dresden through gorges across the border of the Czech Republic and Germany. Within the territory of the Czech Republic, the river flows mostly in river channels naturally dug in the ground except for some urban areas, where embankments and dikes to prevent bank washouts have been constructed.

Once the river flows into Germany, it heads northwest and then runs to the north, joining the Elster River from the east downstream of Dresden and the Mulde River from the south in Dessau City. Further north, it joins the Havel River flowing in from Berlin and then through Hamburg to the North Sea.

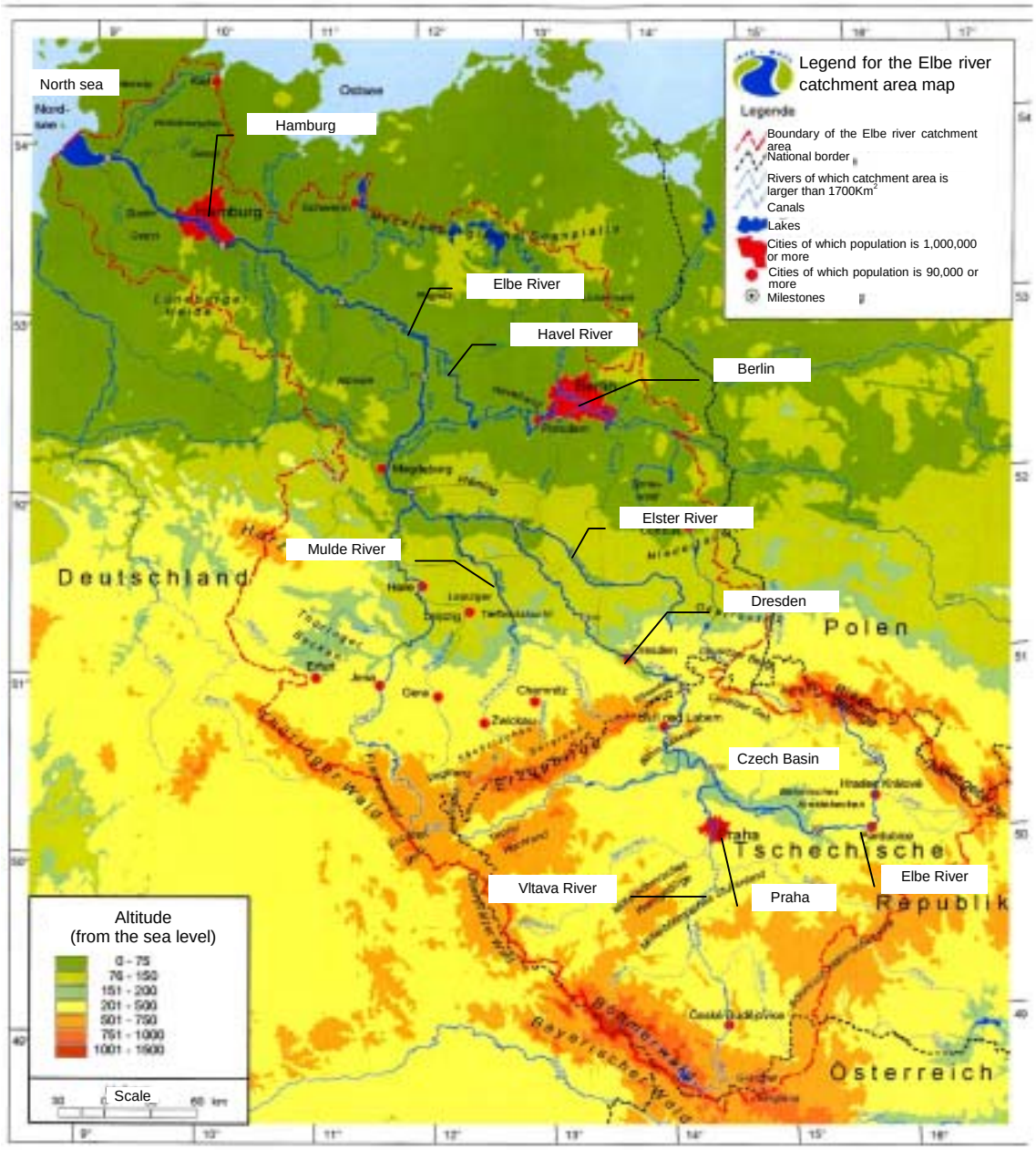


Figure 1: Topographical map of the entire Elbe river basin

Data source: Data source: Federal Institute of Hydrology (BIG) (Koblenz)

Czech Hydrometeorological Institute (CHMU) (Praha)

International Commission for Protection of the Elbe (IKSE) (Magdeburg)

As a 1:1000,000 digital topographical model, DKM1000 is available from Federal Agency of Cartography and Geodesy

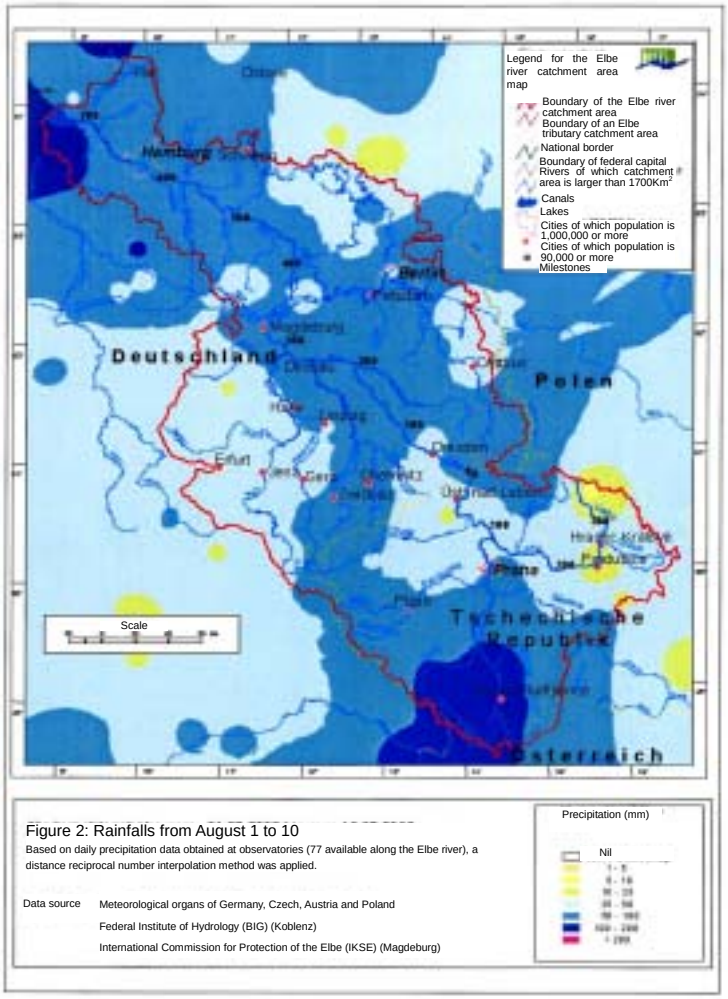
When the Elbe River passes Dresden's urban area, its valley widens, and it begins to flow within the confines of an embankment, including tributaries flowing into it. Most of embankments were constructed without any consistent standard. As a result of

arbitrary embankment construction after each disaster by the state governments, the embankments are now estimated to be constructed based on the preventive criterion of 100 - 200 year probability

(2) Case of the flood in August 2002

(a) Precipitation

The recent rains of 50 mm or more in a ten-day period fell widely in the catchment area from August 1st to 10th, immediately preceding the rains on August 11th through 13th, which were the direct cause of the flood. Southern Czech Republic, in particular, had rainfalls of 100 to 200 mm, which are almost equivalent to the capacity of the region's forests to retain water, which is estimated at 150 mm to 200 mm. (See Figure-2)



Explanation of Figure 2
Rainfall from August 1 to 10

Light blue:	25-50 mm
Blue:	50-100 mm
Dark blue:	100-200 mm
Red line:	Line dividing catchment areas

During the three days from August 11 through 13, the heavy rains in excess of 100 to 200 mm or even over 200 mm in some places fell in the middle and upper reaches of the Elbe River, particularly in Southern Czech Republic and the mountainous area stretching along the Czech-German border. (See Figure-3)

In a district in which the average rainfall in August ranges between 30 and 120 mm, the rain fell two to four times as much as the monthly average in only three days. (See Figure-4)

Average Monthly Precipitation at Praha and Dresden

	Jan.	Feb	Mar.	Apr	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec	total
Dresden	44	42	68	93	102	116	105	87	79	69	80	63	948
Praha	22	20	30	38	78	73	70	72	40	30	30	22	525

(mm)

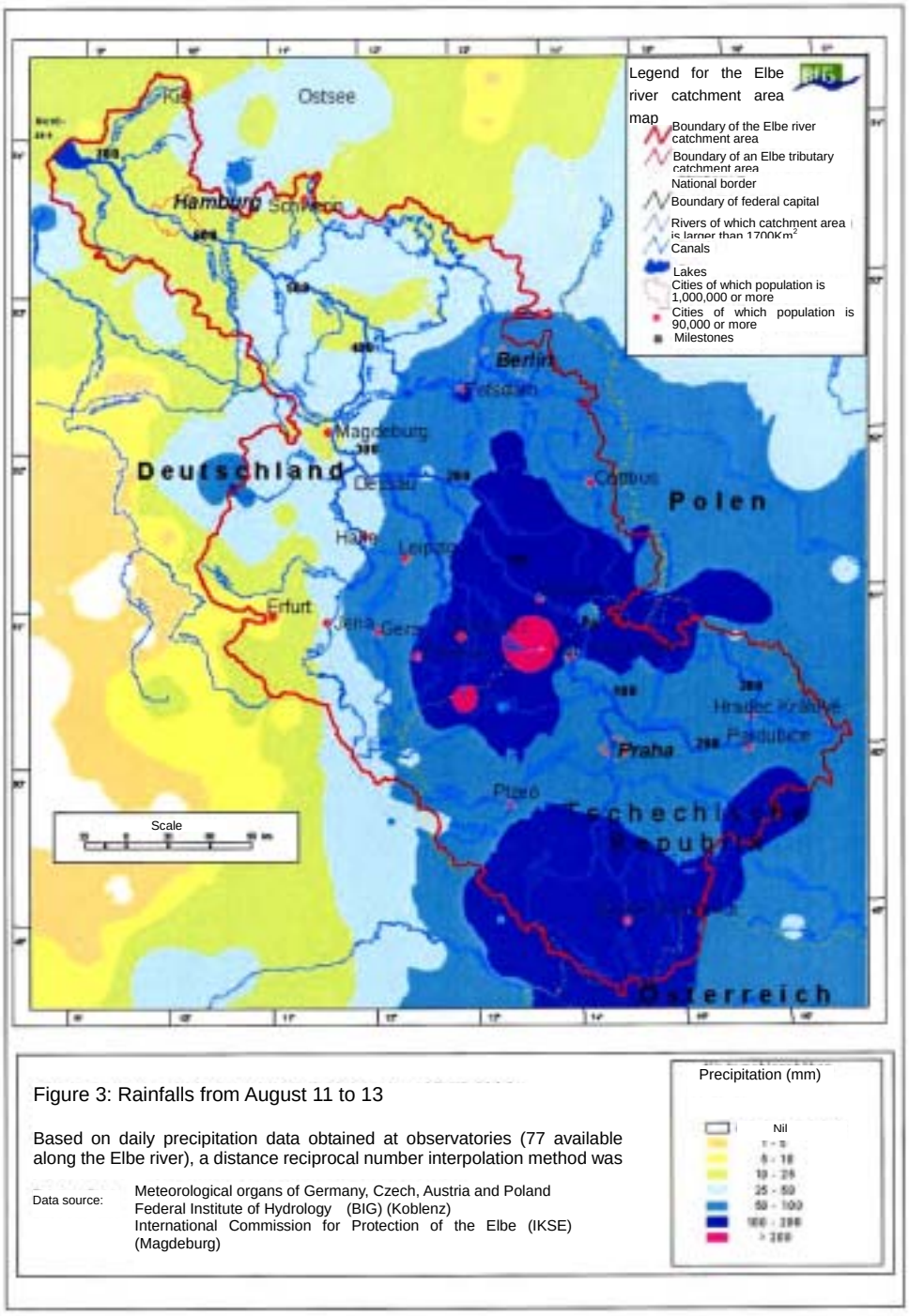
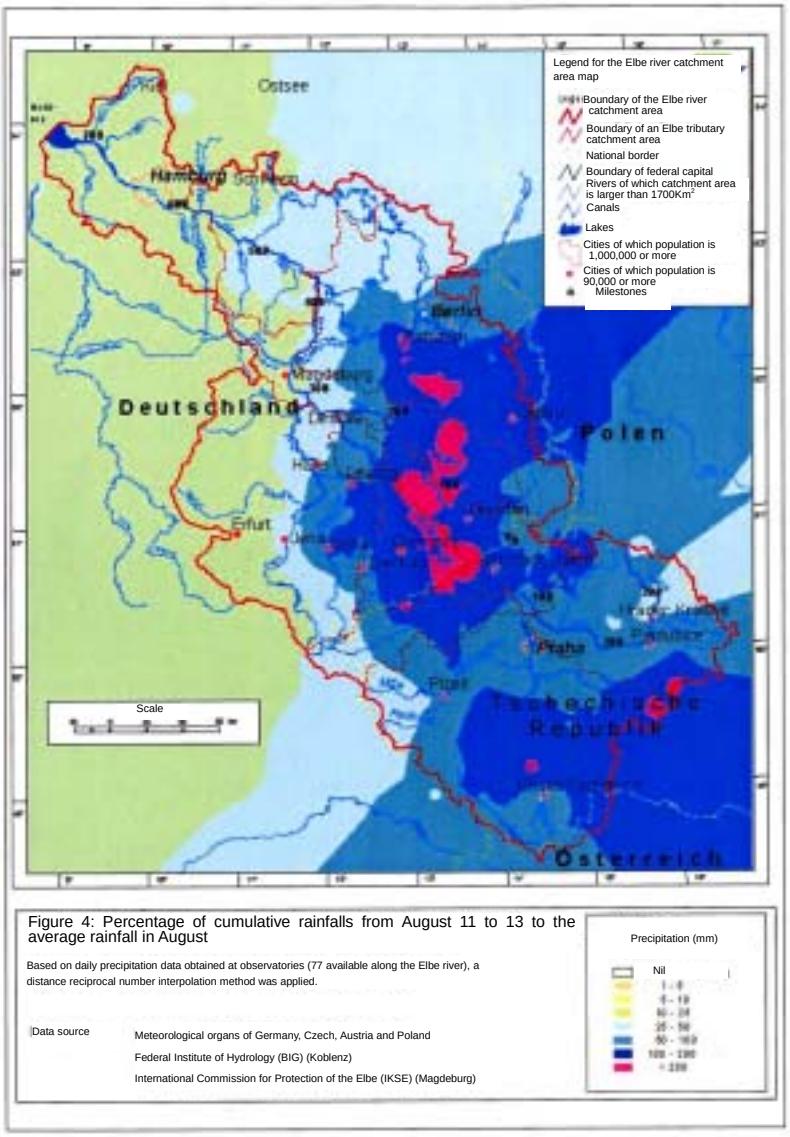


Figure 3: Rainfalls from August 11 to 13

Based on daily precipitation data obtained at observatories (77 available along the Elbe river), a distance reciprocal number interpolation method was

Data source: Meteorological organs of Germany, Czech, Austria and Poland
Federal Institute of Hydrology (BIG) (Koblenz)
International Commission for Protection of the Elbe (IKSE) (Magdeburg)

Explanation of Figure 3:
Rainfalls from August 11 to 13
Light blue: 25-50 mm
Blue: 50-100 mm
Dark blue: 100-200 mm
Red: over 200 mm



Explanation of Figure 4
Percentage of rainfalls from August 11 to 13 to the average rainfall in August

Light blue:	25-50% (1.25-1.5 times)
Blue:	50-100% (1.5-2.0 times)
Dark blue:	100-200% (2-3 times)
Red:	over 200% (over 3 times)

In some places, the percentage was over 400%.

(b) Case of the flood

(i) Within Czech Territory

The heavy rains started on the 11th and the water levels of three dams (from the upstream, Lipno, Orik and Slapy dams) constructed by the former Soviet Union along the Vltava River, which flows through Southern Czech Republic, rose to dangerous levels on the 12th, so they began discharging water, (probably meaning so-called proviso discharge in Japan) (See Table 1)

In the dawn of the 12th, the mayor of Praha issued an evacuation order to the citizens residing along the river based on the information of the dams' discharge.

The water level of the Vltava River rose only slightly in Praha to a level washing terraces along the river until the 13th, but it rose quickly on the 14th, causing a historic

flood above the normal level by 7 to 8 m. A Czech paper reported it as a flood of once in 700 years, (according to Mr. Tatsuki, Secretary of the Japanese Embassy).

There is a building that shows water levels recorded in the past floods, and a TV program broadcasted a picture of a chair carried by the flood and caught on a tree 3 m above the previously recorded highest flood level (According to Mr. Vackar).

The flood began to ebb on the 15th.

In Praha, the soldiers were deployed to control access to dangerous and ristricted areas, while an evacuation order was issued to the residents of the lowest lying land. (Even at the time of a study conducted on September 3, access to the inundated area and driving through the old town was restricted) They also constructed steel parapets in the low-lying land along the river in the old town to protect this area. With these measures, the loss of life was limited to 17 people.

Figure 5: Map of the Vltava river inundation

Explanation of Figure 5 Inundated area within Praha City (Source: Japanese Embassy in The Czech Republic)

However, low-lying land other than the old town including the heart of the city such as the government office area on the opposite side of the river, where the Japanese Embassy is located, and shopping areas, electric appliance shop areas and hotels in the Karlin district downstream were submerged

under 3m of water in some places and damaged severely. In addition, reverse flows from the drainage system inundated basements in an extensive area stretching beyond the old town.

Although the subway system had flood barriers, they were only about 1 m high, so water flowed over them and submerged the subway completely. It will take three months to restore the subway to operation (according to Tatsuki Secretary).

Similarly, damage was also reported at both the upper and lower reaches of the Vltava River; soldiers boarded a cargo boat from a hovering helicopter and blew it up to prevent it drifting and destroying bridges downstream. The cargo boat was found in the midst of fields along the Elbe River downstream of Praha after the flood (according to Mr. Vackar).
(See Figure-5)

(ii) Implications among the flood and up-river dams in the Czech Republic

In the Czech Republic, some people believe that water discharged from the three up-river dams caused damage and disaster downstream in Dresden.

The two dams nearer Praha, Slapy and Orik, are located about 40 km and 80 km upstream of Praha respectively, so discharge impact should have occurred within half a day. As mentioned earlier, the water level in Praha peaked two days later on the 14th, which challenges this view. The Lipno dam located the furthest upstream is about 150 km in a direct line or 300 km along the river away from Praha and there are two reservoirs, the Orik and Slapy dams, in-between, which combined add around 80 km to the distance, so water discharged would take 40 hours to reach Praha, which coincides with the peak observed on the 14th. The Lipno dam doesn't seem to increase the flood damage of Praha because of the following reasons.

-Table 1-

Specifications of dams in Czech

Name	Completion year	River	Nearest city/town	Province/region	Type	Position and material of water sealing	Insitu ground	Dam height (m)	Crest length (m)	Volume of dam body (103m^3)	Total reservoir capacity (103m^3) /Total reservoir area (103m^2)	Purpose	Spillway's discharging capacity (m^3/s)	Spillway type	Owner	Engineering	Construction
LIPNO1	1960	Vitava	Cesky Krumlov Czech Rep.	South Bohemia EUROPE	Gravity/Earth	Inner core	Rock/Sand	42	282	58	306,000/48,700	Power generation	312/948	Gate	Povodi Vlavy.a.s	Hydroprojekt Praha	Vodni stavby
LIPNO2	1960	Vitava	Cesky Krumlov Czech Rep.	South Bohemia EUROPE	Earth	Inner core	Rock/Sand	16	224	25	1,690/450	Power generation	353/996	Gate	Povodi Vlavy.a.s	Hydroprojekt Praha	Vodni stavby
ORLIK	1963	Vitava	Pribam Czech Rep.	Central Bohemia EUROPE	Gravity		Rock	91	450	1,030	716,500/27,320	Power generation	2,555/12,106	Gate	Povodi Vlavy.a.s	Hydroprojekt Praha	Vodni stavby
SLAPY	1957	Vitava	Praha Czech Rep.	Central Bohemia EUROPE	Gravity		Rock	70	260	347	269,300/13,920	Power generation/recreational	3,362/12,952	Gate	Povodi Vlavy.a.s	Hydroprojekt Praha	Vodni stavby

Figure 5-2 : Location of Lipno dam and Chesky Krumlov City

Figure 5-3 is the flow-rating curve, which shows inflow and outflow of Lipno dam, and stream-flow volume of Chesky Krumlov City located downstream of the river. The figure shows the following three points:

a. 320m^3/s was discharged at the Lipno Dam, which was reduced by150m^3/s from the maximum inflow (470 m^3/s)
b. Then the stream-flow volume of Chesky Krumlov City was hold at 410m^3/s, not at 560m^3/s
c. It is estimated that the stream-flow volume was more than 5,000m^3/s during the

flood in Praha. Since there was only 320m^3/s discharge volume (maximum capacity) at the Lipno dam, the influence was extremely small.

Therefore, the Lipno dam contributes for the retaining water with the amount of 150m^3/s to mitigate the downstream flooding in Praha.

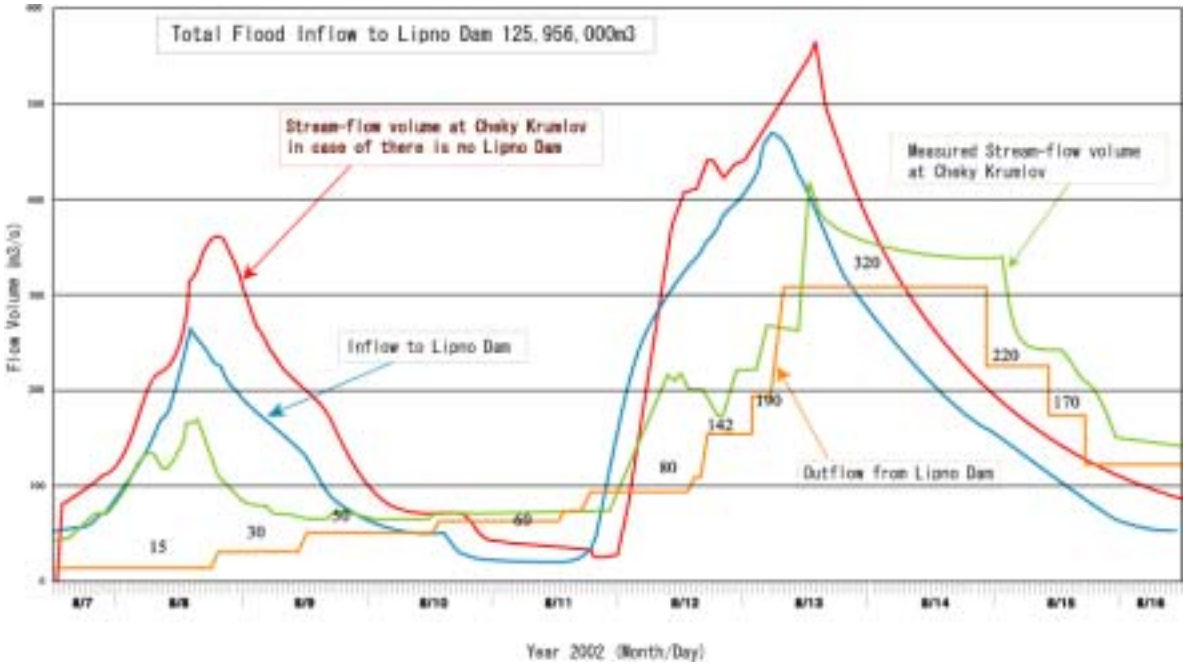


Figure 5-3 : Outflow from Linpo dam and Stream-flow Volume of Chesky Krumlov City

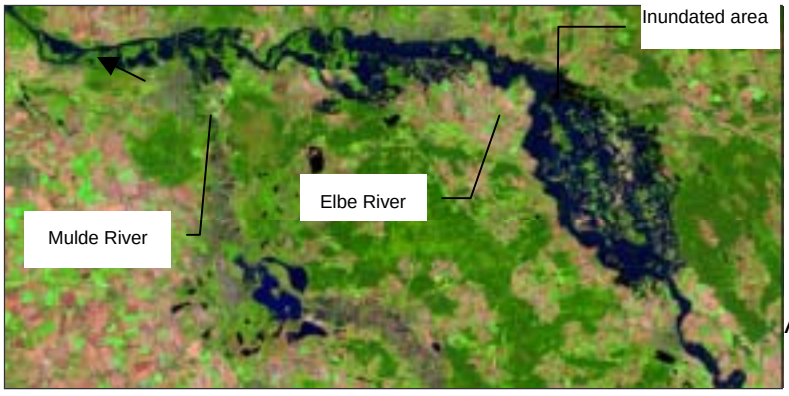
(iii) Within German Territory (according to the Federal Institute of Hydrology)

The flood started in Germany as flash floods from the Mulde River and other tributaries flowing from the left bank of the Elbe River in the middle reaches. Damage caused by such flash floods and water overflowing from underground rivers, which are artificially channeled underground, running through Dresden was much severer than that caused by water flowing over the banks of the Elbe's mainstream.

In Dresden, which is located furthest upstream of the Elbe River in Germany, the peak water level was recorded on the 17th, following a small peak observed on the 13th. The highest level recorded in Dresden surpassed the previous record established in 1845 by 65 cm, indicating that the flood was of a magnitude that would be observed once in 300 years in terms of the flow rate and once in 200 years in terms of the water level.

The river forms a gorge upstream of Dresden, but its valley widens downstream of Dresden, where it flows in the confines of an embankment. Since the embankment in this section was constructed to a probability of overflow of once in 100 to 200 years, the banks on both sides of the river were broken in the section from about 60 km downstream of Dresden to the Elster River junction (about 120 km downstream of Dresden), inundating an area of 300 km^2. The right bank of the Mulde River was also broken just before its junction with the Elbe River.

August 14, 2002

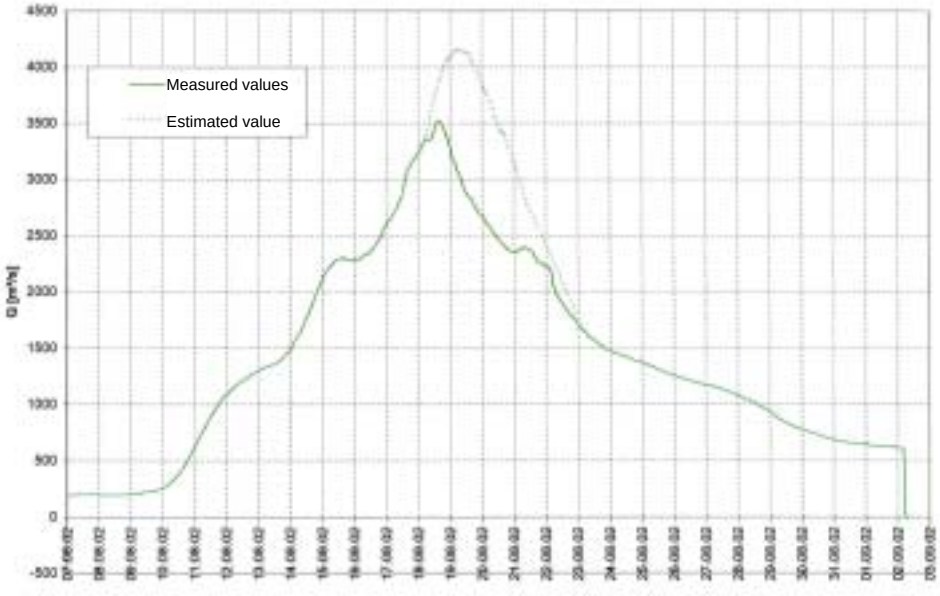


August 20, 2002

Figure 6: Satellite photo of the Elbe river: an inundated area downstream of Dresden

No embankment washouts occurred downstream of the Mulde River junction in spite of an increase in the flow rate of water due to inflows from the Mulde River, because the flood spread over an extensive area due to breaches of the embankment upstream, which helped lower the peak water level. In the recent flood, incoming water from the tributaries flowing from the right hand side such as the Elster and Havel Rivers had little impact on the overall situation, because their flow rates were measured at only 190 m^3/s and 110 m^3/s respectively.

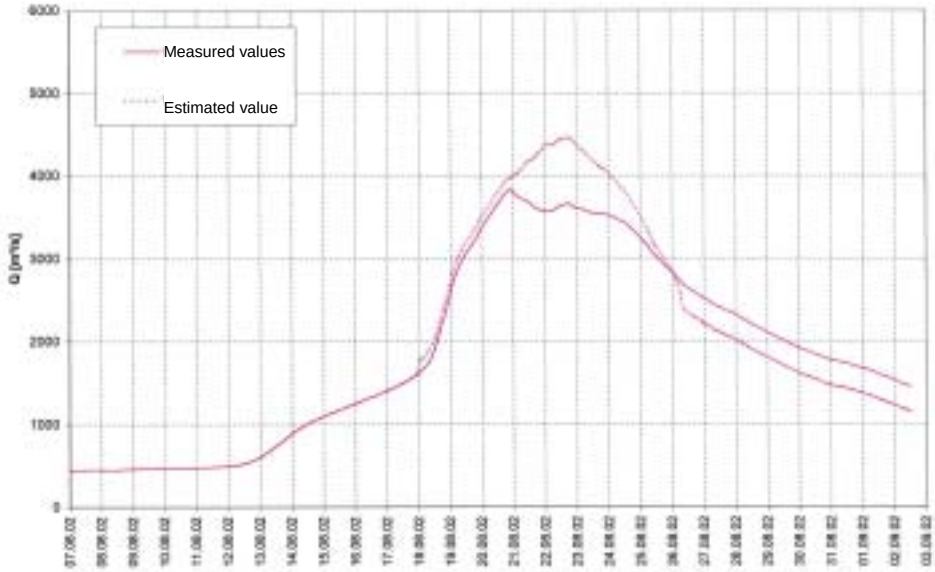
Figure 7: Flow rate observation data (Wittenberg)[2]



Explanation of Figure 7: Flow rate chart at Wittenberg

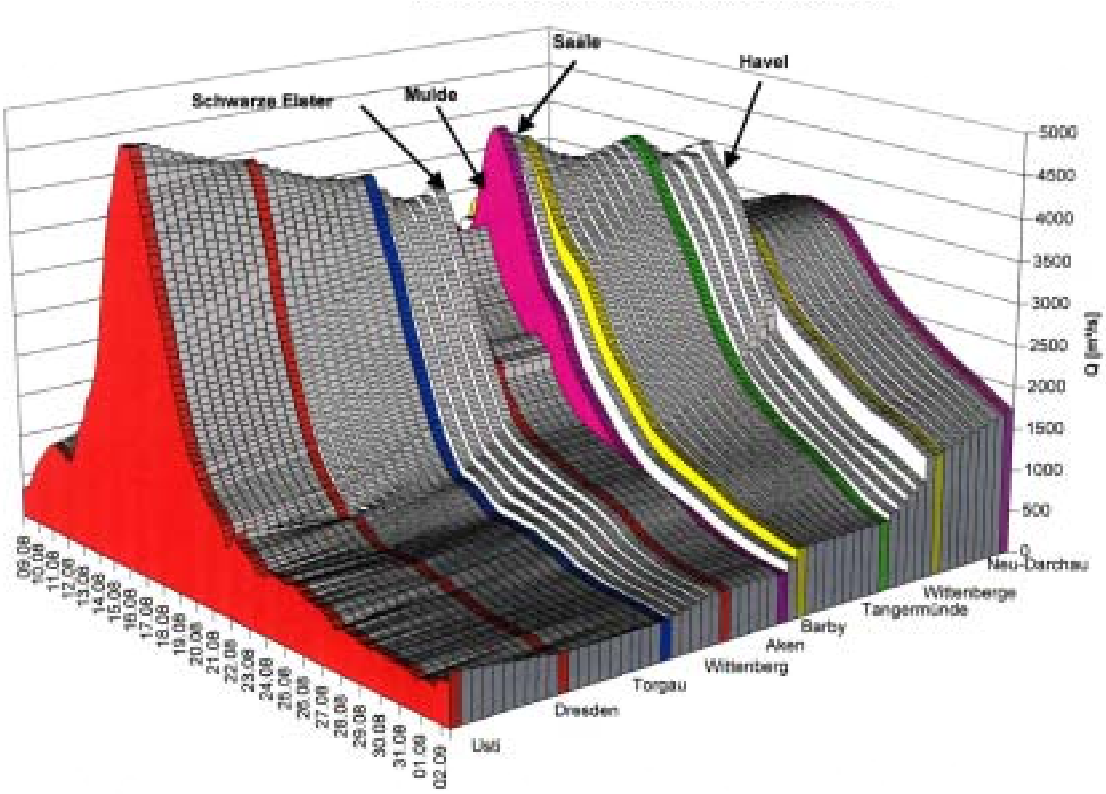
As a result of the washouts of the Elbe River's embankments, the flow rate lowered from 4,100 m^3/s to 3,500 m^3.

Figure 8: Flow rate observation data (Wittenberge)2002



Explanation of Figure 8: At Wittenberg, the flow rate lowered by 650 m^3/s as a result of the dam's flow regulation.

Figure 9: Flow rate observation data overview (measured values)



Explanation of Figure 9: Hydro Graph by region and time, the Elbe River Flood in August 2002

A lowering water level due to the breached embankment at Torgau located downstream of Dresden and Wittenberg. As a result, curves are discontinuous. An increase in the flow rate at the Mulde River junction and effect of regulation at the Havel dam are evidenced by these waves.

As a consequence of the dam at the Havel River junction that regulated flood water (660 m^3/s, 75 million m^3), 50% of the total precipitation that fell on the catchment area above Dresden, or 5 billion tons, flowed into the Elbe River and 500 million tons were regulated as a result of the embankment washouts and the dam.

The water level was lowered by 50 cm in Wittenberg as a result of the embankment washouts and by 40 cm in Wittenberg by artificial flow regulation. (See Figure-6, 7, 8, 9)

(iv) Diminishing vegetation and the flood

In Germany, land covered by vegetation has decreased from 6,200 km^2 800 years ago to 1,000 km^2, which is a suggested cause of the disaster. The Greens have proposed specific areas to be covered by vegetation.

(v) Dam washouts in Germany

It has not been established whether there were dam washouts in Germany that worsened damage from the Elbe River flood because embankments are also referred to as dams in Germany, so breached embankments may have been reported incorrectly as breached dams. A small agricultural-purpose dam constructed in a tributary was reported to have collapsed, but it had not been maintained properly, and although it caused a flash flood inflicting damage downstream, it certainly did not affect the flood of the Elbe River. (According to the Federal Institute of Hydrology)

(3) Damage from the August 2002 flood

(a) Personal damage

(i) Dead and missing persons

The Czech Republic: 17 dead (source: Japanese Embassy in the Czech Republic)

Germany: 20 dead, 20 missing (source: Federal Institute of Hydrology)

(ii) Cause of death

- Death caused by flash flood from tributaries of the Elbe River (from pressure of collapsed house, etc.)
- Those who went back into inundated houses to collect personal belongings
- Those who did not obey the evacuation order and remained in their houses (some elderly people, etc.)
- Those who tried to rescue a drowning person
- Those who went to see the flood out of curiosity

(b) Damages

(i) Within the Czech Republic 3 billion euros (about ¥360 billion)

(ii) Within Germany 25 billion euros (about ¥3 trillion)

(4) Proposed restorative action

(i) Within the Czech Republic

Presently, primary evaluation of the disaster is being conducted. (Czech National Committee for Hydrology)

Construction of a large number of additional parapets, which successfully protected Praha's old town during the flood, is being considered. (According to Mr. Vackar)

(ii) Within Germany

- The German Chancellor declared that his government would pay indemnities in order to compensate the flood victims.
- The EU offered a loan of 10 billion euros (¥1,200 billion)
- A conference involving 30 organizations including the federal and provincial authorities for river training, the relevant countries (the Rhein, Donau and Elbe Rivers), and NGO's will be organized by the German Federal Ministry for Transport, Building and Housing on September 15, 2002, while preparing a report to elucidate the causes of the recent flood. (Federal Institute of Hydrology)

According to the Federal Institute of Hydrology, appointing the Federal Ministry for Transport, Building and Housing, whose original role is to control and manage canals, as the ministry responsible for matters relating to the recent flood is questionable, but it has decided to organize the above-mentioned conference, because critics have blamed canal construction for worsening the flood damage. An investigation revealed that the damage was caused by flash floods from tributaries, not by flooding of the Elbe River itself as expected, so it hopes to make this understood in the conference.

(5) Field Study

(a) Within Praha

(i) Praha stretches over seven hills and the Vltava River runs through them with a span of about 250-500 m. Therefore, the area affected by the flood was limited to a small area along the river, when compared with the whole of Praha. The small area along the river, however, encompassed the old town, an emerging commercial district, a university and a museum, which made the damage quite serious.

(ii) The old town located on the right hand side of the Vltava River escaped the flood at ground level thanks to the installation of emergency parapets (anchors and fittings for installation were in place before the flood), but basements, which most of the buildings in the district had, were submerged due to reverse flows through pipes from the drainage system. In the commercial district, many of the basements were used as restaurants, which made the economic damage a serious, while tremendous volumes of books kept in the basements of the museum and the university were soaked, causing great cultural loss. Since this area has many underpasses and basements built in medieval times, many of the roads near the river are still blocked due to the danger of collapse, which is quite unpredictable. Only two bridges were available to the traffic among those connecting the old town with the rest of the

city, not only causing terrible traffic jams in the morning and evening but also making a fied study of the area by car almost impossible except for those who were familiar with local conditions.

As of September 3rd, people were engaged in restorative work on the street collecting household articles and goods that became unusable due to the inundation of basements.

(iii) The opposite (left bank) side of the river in the old town is an important area encompassing the Japanese Embassy, Japan Cultural Center and other governmental buildings. This area was subjected to over 2 m of water and was seriously damaged. To the inundated area, only those who had a residence or a working place were allowed to enter by car, so we headed for the Japanese Embassy on foot. On the street, people were engaged in restorative work using a high-pressure water jets to wash mud from household articles damaged in the flood or drying basements with large gas burners of 30 cm diameter. In some houses, construction work was also underway to remove damaged walls and apply new grout.

(iv) The Cultural Center was subjected to about 1 to 1.5 m of water and damaged, while the Embassy was subjected to about 80 cm of water. In the Cultural Center, many PCs were damaged and became unusable. The Embassy had already resumed its operation.

(v) The Karlin District, which is located on the right hand side of an underground channel running through the old town, is a bustling new commercial center with many establishments including the Hilton Hotel, electric appliance shops, office buildings and restaurants. The district was subjected to over 3 m of water and incurred the worst damage from the flood due to spoiled goods, etc. We were allowed to enter this district on foot and perform the study, because we were a delegation dispatched by the Japanese government for a preliminary study. (It is essential to obtain prior approval, if a study team is sent to this district for more detailed investigation) Mr. Vackar, who helped us as a guide, said that it was also the first time for him to be allowed to enter this district after the flood.

(vi) In the Karlin District, several hundred soldiers were deployed to clear debris. There were many pumps still draining water from basements and the subway system and the smell of dirty water inundated the town.

(vii) We saw a five-storied wood/brick construction building (brick walls are piled within a wooden exterior framework) that collapsed completely. The entire building collapsed when

its foundations gave way to the pressure of water in the adjoining house's basement, when water in its own basement was suddenly emptied. We saw two such cases.

(viii) Immediately downstream of the Hilton Hotel, we found the point where the Vltava River breached its banks. There we found a lock gate and a spillway installed along the Vltava River and a bank of 4 m high and 5 m wide at the top was built outside the spillway's 3-m high sidewall. The water had flowed over the bank at a height of 1.5 m. An embankment using parapets will probably be constructed here in the future.

(b) Upstream of Praha up to the Slapy dam (about 40 km)

(i) In Praha's urban area, the river flows with a span of 250 m, forming a shallow U-shaped valley rising immediately from the shores on both sides. The river also flows with a span of 250 m in the vicinity of the junction with the Berounka River, a tributary of the Vltava, located about 10 km upstream of Praha, but the valley is much wider there at about 2 km.

(ii) The Berounka River runs through a valley about 2 km wide for a considerable length. There, water filled the full width of the valley in the August flood, causing a great deal of damage to towns located along the banks.

(iii) Further upstream, the Vltava River runs around 250 m wide. At around 20 km from Praha, the Vrané dam (measuring about 15 m tall) is located. The dam has a power plant on the right bank, four main gates on the center and two lock gates on the left bank. According to a dam official, the gates were fully opened during the flood, but water flowed as if there had been no dam at all. The water level rose to 20 cm above the foundation of the dam's control tower. Downstream, water rose to 3 m above the top of an embankment, which was built to a probability of overflow of once in 100 years.

(iv) When we went another several kilometers upstream, we found that the road was blocked due to damage (nobody except residents were allowed to enter), so we made a detour to the Slapy dam. We crossed the Sázava River on the way, but found no evidence of water having risen to a high level.

(v) The Slapy dam located 40 km upstream of Praha is a gravity type concrete dam of 70 m high (according to a brochure obtained from the site office, the dam height was 65 m probably due to difference in the definition of dam height) and 269.3 million m^3 water holding capacity. The water discharging capacity of the gates is 3,362 m^3/s for those for

regular-use and 12,952 m^3/s for those for emergency-use.

(vi) If we assume that the regular-use spillways of the Slapy dam were built to withstand a flood of once-in-100-year occurrence probability, since the water level rose to 3 m above the top of the embankment just below the Vrané dam located downstream, the flow rate at the Vrané dam then is estimated at approximately 4,000-5,000 m^3/s.

We tried to obtain information on discharge rates, etc. during the flood at the dam site office, but we were told to send inquiries through the Dam Bureau of the Ministry of Agriculture. Contact for the Dam Bureau of the Ministry of Agriculture is as follows:
Povodi Vltava Holecknova 8/106, 150 24 Praha-5
+420-02/2 2740 1151

6. Acknowledgment

During the preliminary study, we received invaluable support from Mr. Tomio Tatsuki, first secretary of the Japanese Embassy in Czech, Mr. Tadayuki Akamatsu, first secretary of the Japanese Embassy in Germany, Mr. Katsuhito Miyake of WMO and various other people. We would like to express our sincere appreciation to these people.