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CERG 2006

"Flood Disaster Risk Reduction and Management Methods in Kumamoto City – Japan."

by

H. Volkan ORAL

In association with:

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
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The United Nations University

International Strategy for Disaster Reduction

Flood Disaster Risk Reduction and Management Methods in Kumamoto City - Japan

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15.July.2007

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CERG Thesis Study

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Acknowledgements

Thesis studies are considered as important corner stones in all researchers` life. I have the same feeling for this study. I spent unforgettable moments and gained different aspects on Risk & Disaster Management issue in Geneva during the CERG 2006 Course.

First of all, I would like to thank to my doctorate supervisor at Bogazici University, Prof.Dr. Orhan Yenigun. He always supported and encouraged me to attend these kinds of post-graduate events. Then many thanks to Prof.Dr. Katsuaki Koike who has helped me to prepare this study at his laboratory of Kumamoto University, Japan. Domo arigato gozaimaşhita Koike Sensei. I may also thank to Andou Shouhei , from River Network and Transportation Office of Kumamoto City. I have inserted many figures related with Shirakawa River improvements in this study with his help.

This work has been done under the supervisory of Dr. David Consuegra. For his profound knowledge on Hydrology and Flood Disaster Management was a good sign for me to choose him as a supervisor. Of course I would like to thank Dr. Corine Frischknecht. Her positive opinions were one of the main reasons that helped me to learn risk management perspective during the course.

I would like to thank to the head of CERG in 2006, Prof.Dr. Jean Jacques Wagner and the administrator of CERG Ms. Françoise Grondahl. I would not have selected for CERG 2006 Course without their paying attention on my application to CERG 2006. I also would like to thank Oussemi Foundation of Geneva for their generous financial support which covered all my expenses at CERG course.

Finally, many many thanks go to the family : My wife, Mrs. Özlem Oral, PhD Student at the field of developmental biology in Japan, and my parents Prof.Dr. Ugur Oral, M.D & Nalan Oral, Lawyer , and of course my brother Sarp Oral, PhD in National Laboratory of Oak Ridge in Tennessee, U.S.A.

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List of Acronyms

USA …………………….. United States of America

ICHARM ……………….. The International Center for Water Hazard and Risk Management

GIS……………………….. Geographic Information Systems

KDDI …………………….. Japanese Mobile Communication Company

DoCoMo …………………. Japanese Mobile Communication Company

UNESCO………………… United Nations Educational, Scientific and Cultural Organization

ISDR …………………….. International Strategy for Disaster Reduction

LPG ……………………… Liquifed Petroleum Gas

PVC ………………………. Polyvnyl Chloride

GIAJ……………………… The General Insurance Association of Japan

ARC INFO ………………. An ESRI software

ASTER…………………. Advanced Spaceborne Thermal Emission and Reflection Radiometer

VNIR……………………. Very Near Infrared Radiometer

SWIR…………………….. Short wave infrared

TIR ………………………. Thermal Infrared

CEOS …………………….. Committee on Earth Observation Satellites

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Summary

The main objective of the study is to demonstrate the advances of disaster management and risk reduction applications of possible flooding disaster in Kumamoto-Japan and to propose launching those outcomes in other countries such as in Turkey (in Silifke Town and Goksu Delta) and which are suffering from flood disasters. It was also aimed to show the latest river improvement facilities to reduce the possible effects of flooding in the center of Kumamoto City.

There is a common religious belief in Turkey, which is based on the philosophy of "Everything comes from God" among people. Any causality occurred after the disaster is acknowledged with this philosophy among the people. This study has been showed that launching monitoring systems along the Goksu River may reduce the flooding risks and changed the philosophy of "Everything comes from God".

Flood Disaster Risk Reduction and Management Methods in Kumamoto City, Japan

1. Introduction

Due to the geographical location of Japan , storm surged Typhoons and heavy rains are always seen in this country and according to Torii and Kato (2001) they are the major causes of flooding disasters in Japan. The history of storm surged flooding disasters in Japan is shown at Table 1.

Table 1 : Storm surged disasters in Japan (Torii and Kato, 2001)

Date	Major Damaged Area	Human Causalities			Damage to houses			Typhoon
		Dead	Injured	Missing	Completely Destroyed	Partially Destroyed	Gone Away	
1.Oct.1917	Tokyo Bay	1,127	2,022	197	34,459	21,274	2,442	
13.Sep.1934	Ariake Bay*	373	181	66	1,420		751	
21.Sep.1934	Osaka Bay	2,702	14,994	334	38,771	49,275	4,277	Muroto
27.Aug.1942	Suo Sea	891	1,438	267	33,283	66,2486	2,605	
17.Sep.1945	Southern Kys.	2,076	2,329	1,046	58,432	55,006	2,546	Makurazaki
3.Sep.1950	Osaka Bay	393	26,062	141	17,062	101,72	2069	Jane
14.Oct.1951	Southern Kys.	572	2,644	371	21,527	47,948	1,178	Ruth
7.Sep.1959	Ise Bay	4,692	38,921	401	38,921	113,052	4,703	Ise Bay
16.Sep.1961	Osaka Bay	185	3,897	15	13,292	40,954	536	Second Muroto
21.Aug.1970	Tosa Bay	12	352	1	811	3,628	40	No: 10
30.Aug.1985	Ariake Bay	3	16	0	0	589	0	No: 13

*: Located within prefecture limits of Kumamoto

1.1. Flood Disasters in Japan (in 2005 and 2006)

There were many flood disasters taken place in 2005 and 2006 and they are still taking place in the world. According to a report published by Dartmouth University (2006) in USA, more than half of the flooding disasters in the world taken place at Far East Asia and Pacific Rim Countries. As for Japan between 4 September and 5 September, 2005 - heavy rains triggered by Typhoon Nagy caused flooding in Tokyo area and destroyed more than 2,900 houses. On 6 September 2005 , Typhoon Nagy hit in Kyushu causing flooding and mudslides along the island. In total 21 dead, 6 missing and 300,000 people are evacuated. For mudslides and flooding 2,000 houses destroyed, 17,000 houses flooded and more than 130 cm of rain over 3 days observed in some parts of Kyushu. US$36.9 million agricultural damages are reported only in Kyushu Island.

In 2006 two flooding disasters are recorded in Darthmouth report. Between 22 July and 24 July 2006 Kagoshima and Kumamoto Prefectures are suffered from flooding of Minamata River. The rainfall caused floods and mudslides in the prefecture. 4 dead, 4 missing people are reported. The amount of the precipitation is measured as 540mm in 24 hours. 4,300 people are evacuated into shelters and 100,000 people are urged to evacuate. The next flooding disaster has seen in Nagano Prefecture. As a result of several days of heavy rains, mudslides killed 24 people and 10 missing people are reported by local authorities. 607 houses in 11 prefectures are destroyed and 14,767 people advised to evacuate from the disaster area. It was also reported that the dyke has broken in two places along the Tenryu River in Nagano Prefecture.

In Figure 1 presents , published by http://www.icharm.pwri.go.jp/, between 2000 and 2004 the flooding disasters are tend to increase in the world. As linked with other types of disasters, wind storms are also increased, respectively. In Figure 2, the same phenomena can be linked with Figure 1 described in terms of trend of water-related disaster by continent.

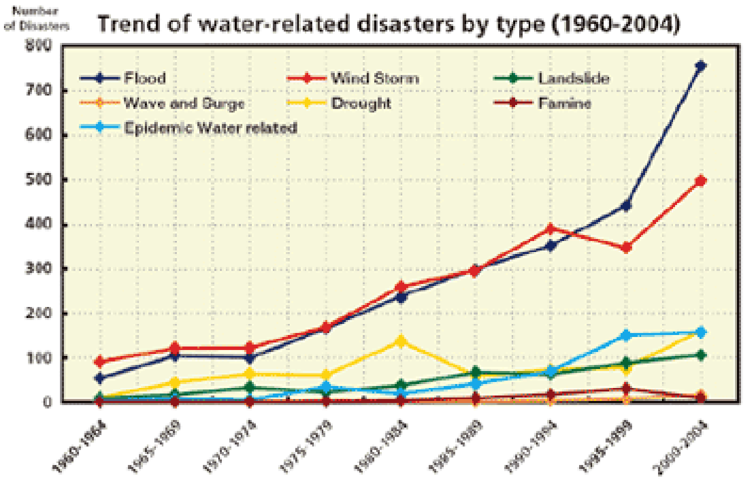


Figure 1 ：Trend of water-related disasters by type (1960-2004) (ICHARM, 2005)

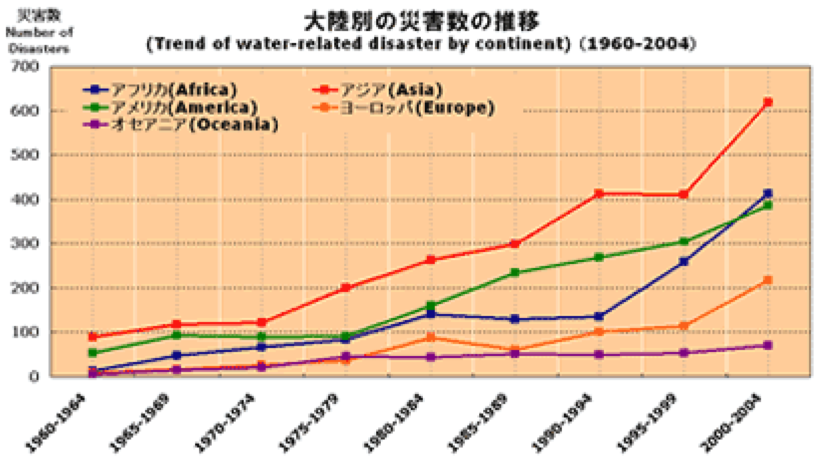


Figure 2 ：Trend of water-related disaster by continent (1960-2004) (ICHARM, 2005)

1.2 The geographical location of Japan

Japan is located in Eastern Asia. It is an island chain formed by Honshu, Hokkaido, Kyushu and Shikoku between the North Pasific Ocean and Sea of Japan. It lies next to east of Korean Peninsula. The coordinates are 6^0 North 138^0 East. Japan's closest neighbors are Korea, Russia and China. The Sea of Japan separates the Asian continent from the Japanese archipelago.

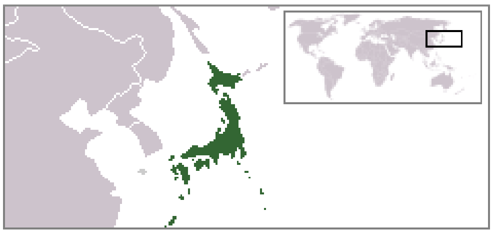


Figure 3 : **Location of Japan (http://en.wikipedia.org/wiki/Japan)**

1.3 The geographical location of Kumamoto-Prefecture

City Hall of Kumamoto brochure (2005) explains that Kumamoto Prefecture is one of the oldest human settlements on Kyushu Island. The coordinates of the prefecture as follows: 32^0 43` N $130^0$ 40` E.

The surface area is 7,404.14 km^2 and has the ranking of 16th among other prefectures in Japan. The number of the habitants at the prefecture as on October 2005 is 1,842,140. Hence the city has 23rd ranking among other cities` population in Japan. The population density is 249 people at 1 km^2.

Kumamoto Prefecture is well known for Mount Aso an extensive active Volcano. The Caldera of the Volcano is so popular for tourists tours in all Japan. The prefecture is surrounded by Ariake Sea and the Amakusa Archipelago to the West, Fukuoka and Oita Prefecture to the north and Kagoshima Prefecture to the south (Figure 4). There are 14 cities in the Prefecture known as : Amakusa, Aso, Arao, Hitoyoshi, Kami-Amakusa, Kikuchi,Koshi, Kumamoto City , Minamata, Tamana,Uki, Uto,Yamaga and Yatsushiro (Figure 5) .

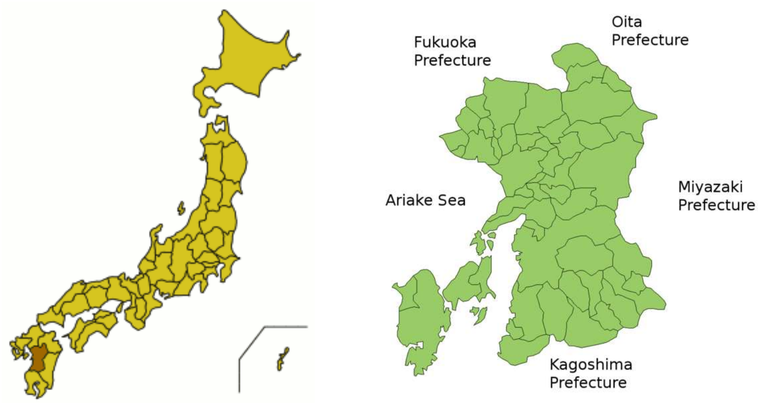


Figure4:The geographical location of Kumamoto Prefecture (http://en.wikipedia.org/wiki/Japan)

Figure 5: Kumamoto Prefecture (http://cyber.pref.kumamoto.jp/asp/kanko/map_kumamoto_kankou.asp?LangCod)

1.4. Climate

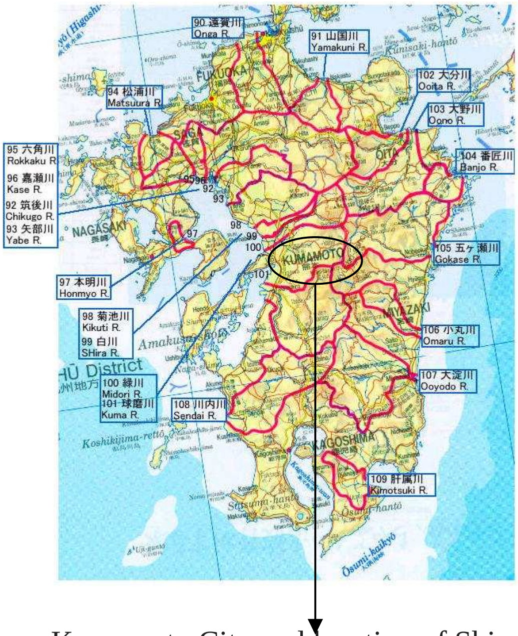
Ministry of Land and Infrastructure of Japan (2005) explains on the official web site the weather is in Japan generally mild and humid with considerable variation from north to south, and between the Pacific Ocean side, to the east of the central mountain lies and the Japan Sea side to the west. Two primary factors influence Japan's climate: a location near the Asian continent and the existence of major oceanic currents.

There are three periods of heavy precipitation in the country : Heavy winter snowfalls blanket the Japan Sea side in deep layers of snow, Particularly in the north *tsuyu* (the rainy season) brings continuous heavy rains to most of the archipelago during the second annual wet period in June and July; and typhoons that originate in the southern Pacific, assault the country - especially the southern portions - during the third wet period in September and October. These three wet periods shove the nation's average annual precipitation which is almost double of the world average. As a result of this, Kumamoto Prefecture has an inland-basin climate and temperature changes can be drastic. The average annual temperature is 17.4℃ and the average annual precipitation is 1,543mm. Winters are mild and snow is rare (Kumamaoto City Hall Brochure , 2005)

1.5 . Rivers

The narrow and mountainous topography of Japan is one of the main reasons that shape the rivers in the country. According to Ministry of Land and Infrastructure of Japan the rivers of Japan have short lengths and considerably steep.
The rivers in Japan are prone to flooding because they flow rapidly, due to the steepness of slopes along their basins and the relative shortness (http://www.mlit.go.jp/river/english/land.html) . The ratio of peak flow discharge to basin area is relatively large, ranging from 10 times to as much as 100 times that of major rivers of other countries. The water level rises and falls very quickly. The river regime coefficient - the ratio of the maximum discharge to minimum discharge - is between 200 and 400,10 times larger than that of continental rivers. The volume of sediment runoff is large. Meanwhile Torii and Kato, (2001) postulated that typhoons are also the main reasons that triggers to occur flooding on Japanese rivers.

Land and Real Property with Report (2001) sketched the following map for locating the rivers in Kyushu Island (Figure 6) On the figure the location of City of Kumamoto and River Shirakawa is highlighted with the arrow.



Kumamoto City and location of Shirakawa river

Figure 6: Rivers in Kyushu Island (Land and Real Property with Report (2001)

2. Objectives

The main objective of the study is to demonstrate the advances of disaster management and risk reduction applications of possible flooding disaster in Kumamoto-Japan and to propose launching those outcomes in other countries such as in Turkey which are suffering from flood disasters. It was also aimed to show the latest river improvement facilities to reduce the possible effects of flooding in the center of Kumamoto City.

Kumamoto City , the center of the Province of Kumamoto is chosen to due to the city's high sources of financial input at the whole agricultural production of Japan. According to Kyushu Regional Agricultural Administration Office 2004 , the city has the industry of electrical equipment, transportation equipment, food and beverage products, general equipment and metal products, semiconductor related industries and life science related industries. The output of the city of Kumamoto in Japan economy is shown at the Figure 7 and 8.

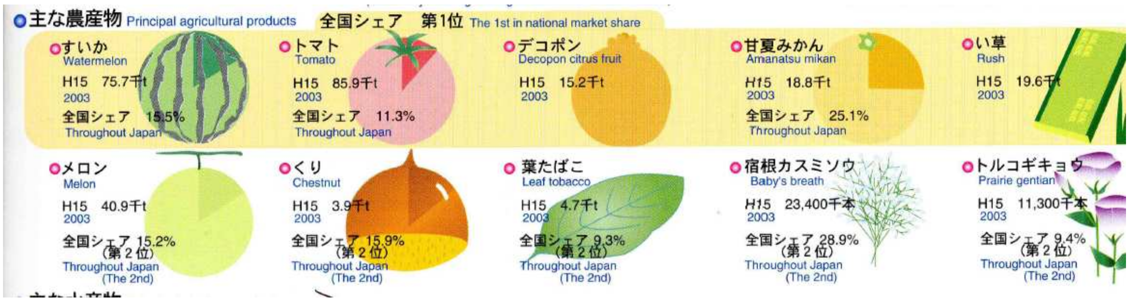


Figure 7 : The Percentage of the Agricultural Productions` of City of Kumamoto in Japan (Kyushu Regional Agricultural Administration Office, 2004)

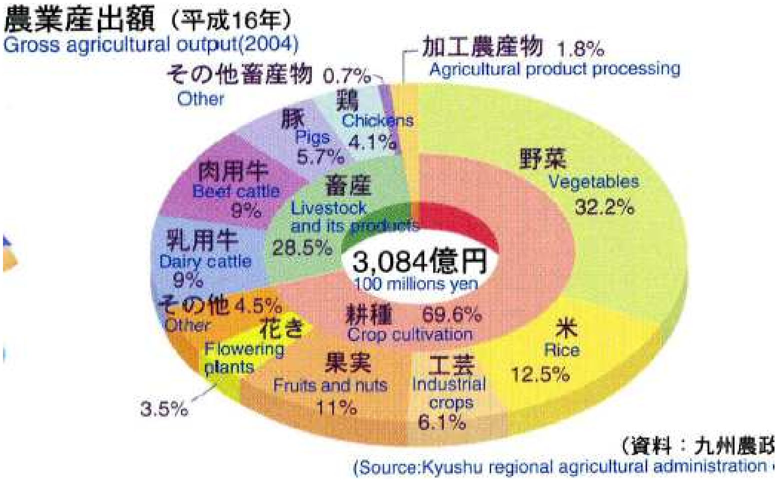


Figure 8 : Total Agricultural Output of the city (Kyushu Regional Agricultural Administration Office, 2004)

2.1 Special Case for Kumamoto City

Kumamoto City has such rich groundwater resources that 100% of its drinking and residential water supply is provided by groundwater sources . Koike (2005) explained that there is a high trend of using groundwater in all Kumamoto Plain for the purpose of Agricultural and Domestical uses. The main source of this groundwater is supplied by permeating the water into the soil from rice fields through the Shirakawa river. Mainly, 200 million tons of groundwater is pumped every year (Kyushu Sony Semiconducture Factory, 2006) . Ichikawa (2002) observed the amount of flowing water at nearly 300 monitoring points in the middle-stream basin of the Shirakawa river in Kumamoto prefecture in Japan. Hence it can be said that the reduction of the capacity of the region to recharge the groundwater balance is being corrupted by flashing floods in the prefecture area.

During the peak time of rain falls there is extent rising observed during several hours in Shirakawa due to the typical geography of the area. Also short length but has a high depth of water- belong to rivers in Japan is other reason of the rising (Ministry of Land and Infrastructure of Japan, 2005) . As can be seen on figures at below, daily groundwater levels are monitoring and announcing to the public in Kumamoto (Figure 9). The Figure on the left shows the 4 sampling points on the main groundwater flow from Aso Caldera to Ariake Sea. The figure on the right shows the daily amount of alkalinity and other levels of minerals in groundwater. The parameters are obtaining from 4 sampling points on the flow way of river.

Figure 9 : Electronic Groundwater Announcement Board in City Hall of Kumamoto (Archive of Volkan ORAL on 16 November 2006)

Koike (1996) pointed out that Kumamoto Plain is mainly formed by upper Quaternary unconsolidated deposits. Then the groundwater is contained in the uppermost of the unconfined aquifer on those deposits. In the middle part of the Kumamoto Plain the demand for the ground water is especially high because of the urban and industrial activities. The water-table that is so close to the surface area may have the high potential of danger during the flooding disaster. Flooded and underground water could be joined and threaten the center of Kumamoto.

Moreover, Koike et. Al 2005 described another potential danger of entering the Ariake Sea to Kumamoto Plain through the southern- mouth of Shirakawa river. It was also taken into consideration about the possible flooding danger of Kumamoto.

City Hall of Kumamoto (2005) postulated that the flowing way of the Tsuboi river in the city had been changed during the Meiji Period (1868-1912) to save a place to build human settlements next to the castle. As a result, flooding disasters were recorded after this changing

Figure 10 : Constructed road on the flow way of the Tsuboi River (Archive of Volkan ORAL on March 11th, 2006)

The drainage system of the city has been improved in last 50 years because of the urbanization. However this improvement is not adequate to enhance the possible flooding in the near future. Therefore, strengthening the dykes , launching the crisis management facilities and establishing the crisis management system all around the city have been performed since 1953 to decrease the affects of the flooding damage before hand.

3. Study Area

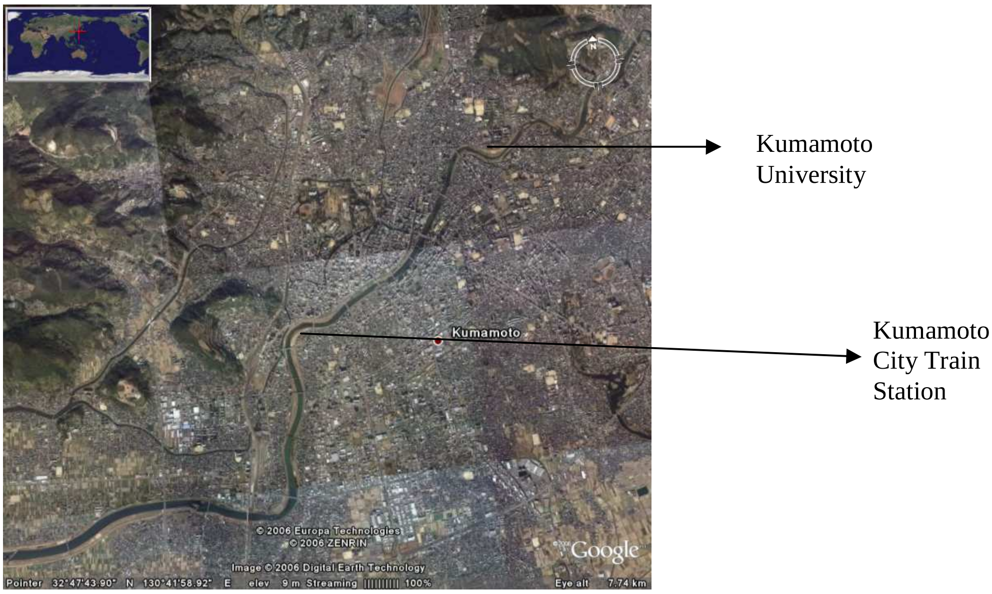


Figure 11 : Study Area (Points on Shirakawa River – Google Earth View 2006)

The study area starts from Kumamoto University and ends in Kumamoto City Train Station in downtown. The Center of the Kumamoto locates between these two locations. Majority of the city population live in this region and in the past 1953 great flooding of Kumamoto was harmful in the study area. After flooding main river improvements and bridges renovations such as Kokai Bridge and Yotsugi Bridge also taken place between those two locations.

4. Methodology

ASTER Level 1B Satellite image date to 2003 belong to Kumamoto Prefecture is used to produce risk maps and to run Geographical Information (GIS) analysis such as drawing thematically layers rivers and settlements and to propose short term shelter locations in the study area . The digital topological map of Kumamoto Province, prepared by Japan Geological Survey Institute, scale in 1:25.000 is used to support GIS analysis (Nirupama & Simonovic, 2002) .

4.1 Field Study

The GPS vehicle GARMIN MAP 76CS is used to collect ground control points to produce the contour map of the study area (Chadwick, et. Al , 2005). It was aimed to show the slope of Shirakawa River flow downs from Aso Caldera to the downtown of Kumamoto City. A digital camera has a focus range of 7.3 Megapixel is used to take pictures of river improvements and other structural & non-structural measures to enhance the flooding along the shirakawa river.

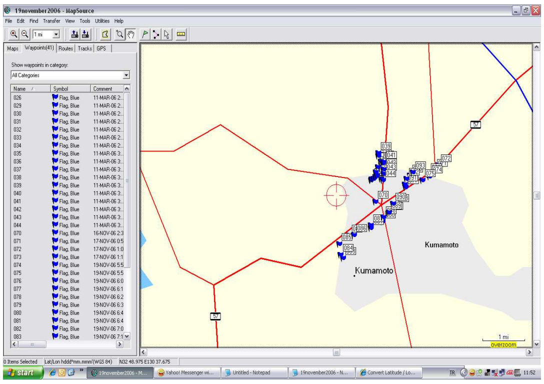


Figure 12 : Ground Control Points shown in the interface of MAPSOURCE Garmin Software

4.1.1 Shirakawa river

Shirakawa River has springs in the Caldera of Mount Aso. One of the branch is known as Kurokawa . The water catchment area of Shirakawa River is 480 km^2 (Figures 13- 14). Mainly the river is shaped by the Volcanic Ashes and residues formed by the Mount Aso Volcano (City Hall of Kumamoto, 2005)
According to Matsuno et. al (2002) , the annual precipitation in river valley is measured approximately 3,250 mm and in Kumamoto City it is 1,458 mm in a year.

Due to the formation of the river in the Volcanic Caldera, Kumamoto Plain is always prone to have flooding and mudflows regularly in a year.

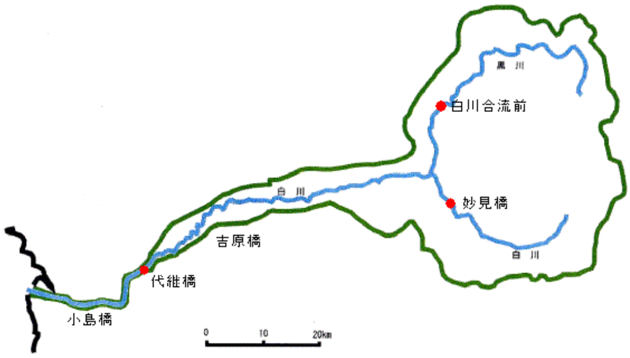


Figure 13 : Shirakawa River (City Hall of Kumamoto, 2005)

Figure 14 : Actual Facts of Shirakawa river (Kumamoto River Road Network Office, 2005)

4.1.2 Annual Flow Rates of Shirakawa River from 2000 to 2002

According to `River Discharges Year Book of Japan`, 2002 the highest flow rate measured in Yotsugibashi Bridge on Shirakawa River was 1.197 m^3 on May. The average flow rate of the river is 38.64 m^3/sec. The lowest flow rate measured on the river was 200.34 m^3/sec on September. This amount followed as an increasing trend on October and November. The measurements were 451.06 m^3/sec and 549.27 m^3 respectively. The total flow rate of the river in 2002 was 7015.63 m^3/sec.

River Discharges Year Book of Japan, 2000 also postulated that on June 2000 the total flow rate on Shirakawa river was measured 1573.26 m^3/sec. The total flow rate of the river in 2000 was 7928.92 m^3/sec. In 2001 the flow rate of the river was 1.660,38 m^3/sec and the average rate was 55.35 m^3/sec.

4.1.3 The actual water level on Shirakawa river on 11 November 2006

In Figure 15 the water level on Shirakawa River can be seen on 20 October 2006 at 15:00 P.M . Figure 16 shows the current situation on 11 November 2006 after the heavy rain in Kumamoto at 15:15 P.M.

Figure 15 & 16 : The water level on 20 October 2006 and on 11 November 2006

To illustrate the same phenomena with the measurement units, it is easy compare the Figures 17- Figure 18 & 19 together. In Figure 17 the water level on branch of the Shirakawa river in City of Kumamoto downtown can be seen at measured scale on 20 October 2006 at 15:40 P.M . Figures 18 and 19 also are showing the rise of the water level.

Figure 17 : The measured water level on branch of Shirakawa River on 20 October 2006.

Figure 18 & 19 : The measured water level- 3.7 cm- on branch of Shirakawa River on 11 November 2006

4.1.4 Flooding Disaster on June 26th ,1953 in Kumamoto City

City hall of Kumamoto 2005, published the dates of big disasters and floods taken place in Kumamoto City such as the Shirakawa River Flood in 1953 (Figure 20) and other floods in 1988, 1990, 1995 and 1997. To prevent from such disasters, the city hall promotes river improvement and drainage systems along the rivers.
These systems can be counted as follows : Rainwater disposal measures, rainwater infiltration systems, residential development adjustment ponds, water infiltration pavements and other efforts which prevent the outflow of rainwater.

Figure 20 : Shirakawa River Flooding Disaster on 1953 Info Monumentary on Kokai-bashi bridge (Archive of Volkan ORAL on October 19th,2006)

Heavy rain mixed with volcanic ash and sand from the Aso volcano to be swept into the river and carried to the city where it took out 85 bridges (Figure 22) and inundated 31,145 homes. The flooding occurred on June 26, and is sometimes called the "Great Flood of June 26th" (6 - 26 dai suigai). Figure 21 shows the Schematic Representation of the 1953 Flooding Disaster .

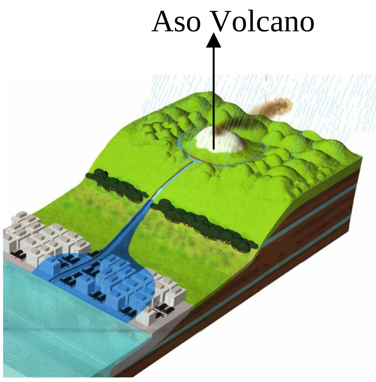


Figure 21 : Schematic Representation of the 1953 Flooding Disaster (Personal Communication from River and Road Network office of Kumamoto City,2006)

Figure 22 : Kokai Bridge (50th Anniversary of the flooding brochure, 2003)

Figure 23 shows the inundation time at 11:40 a.m , the flooding starts then at 14: 20 p.m , the water level rises at Yatsuki Bridge followed at 15:05 p.m , the railway lines halted. At 16:25 p.m the lower plain areas in Kumamoto city flooded. At 18: 50 p.m the Rendaji bridge covered with flooded river waters. At 21:50 p.m the picture at Figure 24 shows the situation at Kokai Bashi Bridge.

11時40分頃より	市内低地で浸水はじまる。
14時20分	代継橋 警戒水位に達する。
15時05分	国鉄運行停止。
16時25分頃	市内低地各所で大浸水、がけくずれ。
17時15分	安巳橋流失。
17時30分	坪井川左岸、清水町堤防決壊。
17時40分	小碩橋流失。
18時30分	白川蓮台寺橋上流右岸堤防決壊。
18時50分頃	白川蓮台寺橋上流左岸堤防、蓮台寺橋下流右岸堤防、薄場橋上流両岸堤防が、つぎつぎ決壊。
19時20分	白川薄場橋下流右岸堤防決壊。
21時40分	代継橋流失(鉄筋コンクリート)。
21時45分	大江町の弘済寮流失(死者52名)、白川、子飼橋上流右岸堤防(一夜塘)決壊。
21時50分	子飼橋に流木がかかったため水位が上昇し、左岸を溢れて大江町の家屋130戸(200余人)が流失。

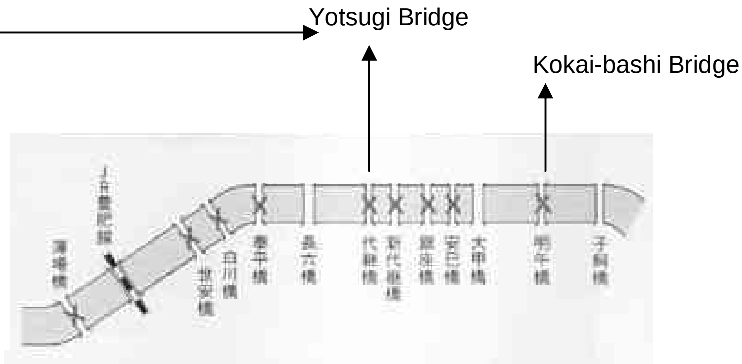


Figure 23 & 24 : Time Log of Shirakawa Flooding and the schema of the demolished bridges on the Shirakawa River (50th Anniversary of the flooding brochure, 2003)

422 people lost or death during the flooding. 1,077 are injured and 388,848 houses are destroyed. Beside that one of the most important incomes, rice paddies are injured at scale of 1,372 acres. 85 bridges are all destroyed at Kumamoto City. The total causalities calculated more than 241 million Japanese Yen (Figures 25-26)

【被害状況】

■死者行方不明	422人
■負傷者	1,077人
■罹災者数	388,848人
■流失全壊家屋	2,585戸
■半壊家屋	6,517戸
■浸水家屋	31,145戸
■田畑流失埋没	1,372ha
■田畑冠水	2,980ha
■橋梁流失	水系85橋 (うち熊本市内の白川本川にかかる橋14橋)
■被害総額	約241億円 (昭和28年単価)

Figure 25 & 26 :   List of causalities and the debris occurred after flooding (50th Anniversary of the flooding brochure, 2003)

5. Flooding Disaster Management Measures Against Flooding in Kumamoto City

According to the report of `Disaster Management in Japan` (2001) the amount of damage was led to loss of many human lives due to natural disasters every year in Japan. Up until the 1950s, there were numerous large typhoons or large-scale earthquakes which claimed the lives of more than 1,000 people. However, due to the progress of countermeasures such as promotion of national land conservation projects, improvement in weather forecasting technologies, completion of disaster information communications systems and preparation of disaster management systems, the number of deaths and missing due to natural disasters shows a declining tendency (Figure 27).

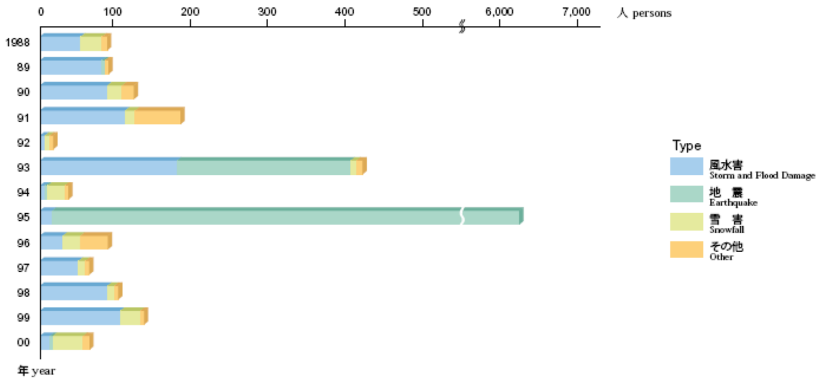


Figure 27 : The number of death people from disasters in Japan (Disaster Management in Japan, 2002)

The rest of this study is prepared by joining with the `Risk Assessment` chart published by International Strategy For Disaster Reduction (ISDR) (2005) and `Disaster Management Cycle` published by United Nations Development Programme (2004) . Disaster Management facilities that are currently running in Kumamoto City against flooding are analyzed and reported under the title of ` Flooding Disaster Prevention Techniques Applying in Kumamoto` by following the steps sketched in the Figure 28.

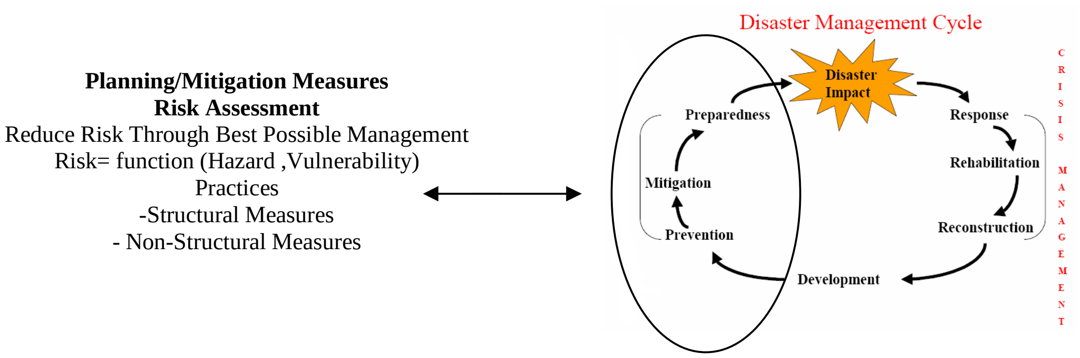


Figure 28 : ISDR Planning-Mitigation Measures and The Disaster Management Cycle (ISDR Flood Guidelines (2005) & http://www.undp.org.in/VRSE/BestPract/Article-DRM%20Assam.pdf (modified)

5. 1. Public Awareness

The internet technology plugged with cellular phones are using to inform the public about the disasters. For instance, very well known Japanese information and communication companies KDDI and DoCoMo broadcast the ` Disaster Message Board` via cellular phone interface. This service is free of charge and during the disaster all necessary information that are crucial to save the lives of the sufferers . The health condition of the disaster victim also will be notified via the sms service. Figure 29 shows the English edition of `Disaster Message Board` on Cellular Phones.

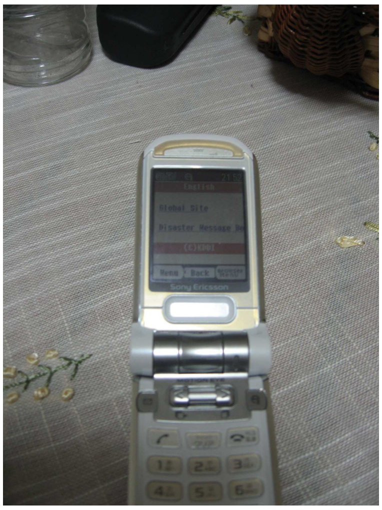


Figure 29 : `Disaster Message Board` Service broadcasting via Cellular Phones

The Figure 30 at below shows the internet broadcasting of the schema of `Disaster Message Board` system on cellular phones via KDDI and DoCoMo. The red circle highlights also the `health condition` of the disaster victim.

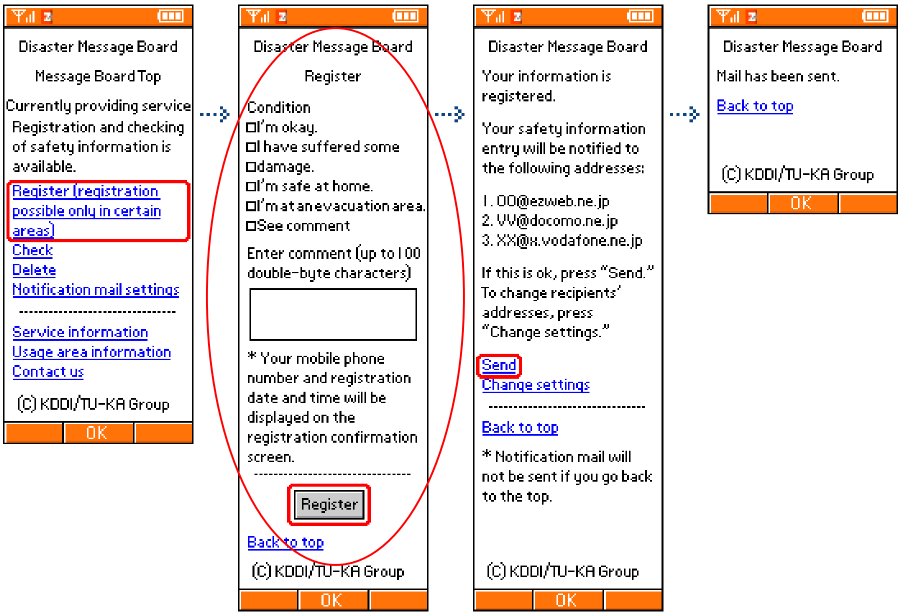


Figure 30 : Flow Chart of `Disaster Message Board` Systems on KDDI and DoCoMo cellular phones (http://www.au.kddi.com/english/message_board/index.html)

5.2 Education Campaigns in Kumamoto

Kumamoto City suffered from many disasters occurred in the city such as follows: Kumamoto Earthquake in 1889, the Shirakawa River flood in 1953, No10 Typhoon in 1991. To overcome the damage from disasters, the city hall promotes community disaster prevention projects, carries out disaster prevention demonstrations, and strengthens cooperation with school children by launching education campaigns on Shirakawa River (Figures 31-33). The city hall run regularly open classes on disaster prevention and exhibitions to show the ways of protection against disasters. In classes citizens are also given courses about means of disaster prevention. There are also information boards located along the Shirakawa River that gives spot information about flooding (Figure32).

Figures (31) & (32) (33) : From left to right: Disaster Prevention Exhibition (City Hall, 2005) – Flooding Information Board (Archive of Volkan ORAL on 16.November.2006) – School Children tell the reasons of flooding in a campaign (Personal Communication from River and Road Network office of Kumamoto City,2006)

5.3 Early Warning System in Japan

In Japan , all means of communications are utilizing to alert people before the disaster will take place. The early warning systems feature multiple lines of communications (such as e-mail , fax , radio and telex, often using hardened dedicated systems) enabling emergency messages to be sent to the emergency services and armed forces, as well to population alerting systems such as sirens.

For instance on 15 November 2006 after following a powerful earthquake with a preliminary magnitude of 8.1 near the Etorofu Island off Hokkaido, the Meteorological Agency broadcasted Tsunami alerts via the national TV channels in Japan (Figures 34 – 35)

Figure 34 & 35 : Japanese TV warnings of Tsunamis on 15 November 2006

Early warning of disasters can save lives by giving people time to seek shelter or take appropriate action. Radio and television broadcasts often provide such warnings. As mentioned at top under the title of ` Public Awareness` it was showed how mobiles can be used to warn people of impending disasters.

6. Flooding Disaster Prevention Techniques Applying in Kumamoto

Kumamoto City has the highest vulnerability to flood disasters. Vulnerability is a potential loss of people and goods as a consequence of a damaging phenomenon, social and economic conditions and perceptions, institutions and policies of the society (UNESCO, 1995).
The city infrastructure, such as roads and railway systems, bridges, water and electricity supply systems, sewerage systems are the main vulnerable areas in the city. These types of infrastructures were investigated and reported under the titles of `Structural Measures` and `Non-structural Measures` briefly.

According to International Strategy For Disaster Reduction – Guidelines for Reducing Flood Losses (http://www.unisdr.org/) Flood Plain Management can be grouped as follows :

1. **Structural Measures**
2. **Non-structural Measures**

Those measures can be grouped with risk assessment elements as sketched on ISDR report (Figure 36).

Planning/Mitigation Measures		**Risk Assessment**
Reduce Risk Through Best Possible Management Practices -Structural Measures -Non-Structural Measures	➔	Risk= function (Hazard ,Vulnerability)

Figure 36 : Linkage between Flood Planning/Mitigation Measures and Risk Assessment (Modified from ISDR- Guidelines for Reducing Flood Losses)

Structural Measures can be classified as follows :

1. Construction of dams/diversions/storm channels/leeves
2. Inspection, rehabilitation and maintenance
3. Flood proofing of new and existing structures
4. Bridges and roads
5. Enforcement of standard and codes

Non-structural Measures can also be grouped as follows:

1. Land-use planning
2. Zoning of flood-prone lands
3. Redevelopment of flood-prone lands
4. Insurance

6.1 Structural Measures

6.1.1 Construction of dams/diversions/storm channels/ leeves

According to ISDR Flood Guidelines (2005) and UNESCO (1995) , some improvement actions stems from various level of protection are based on as follows :

a. Minimum standards for flood protection
b. The optimum level of costs and benefits based on an economic analysis
c. To meet established levels of acceptable risk

The period after 1953 flooding in Kumamoto City can be said as the beginning time of the river improvement facilities along the Shirakawa River. Until today those improvement facilities have been going on along the river.

Figure 37 & 38 : Scheme of the dyke construction along the river side (Personal Communication from River and Road Network office of Kumamoto City,2006)

In the Figure 37 at top meandering position of the river is paid attention and considered as the right location of construction the dykes. The Figure 38 on right side and the figure 40 show the first phase of constructing the dykes along the river side and on coast line . The Figure 39 at below shows the today`s appearance of river dykes .

Figure 39 & 40 : Shirakawa River and Ariake Sea dykes on Yatsushiro City Coast line (Archive of Volkan ORAL 20 October 2006 & 10 November 2006)

Jurajda, et. Al (2004) and Wolsink (2006) pointed out the method ` Room for River Management` for river basin improvements. This method is known as widening the cross sections of the river by situating the dikes further away from the river or by lowering the river forelands. This practical example can be seen in Figure 41 at below ` Rooms` constructed by gravels are located along the river side but much further away from the dyke.

Figure 41 : Oe Area-Gravel Supported Dykes (Personal Communication from River and Road Network office of Kumamoto City,2006)

Another type of river improvement can be seen in branches of Shirakawa River in Kumamoto downtown. The concrete type of river bed materials are used to control the river flow (Figure 42). After the improvements rivers are also turned up the living places of Japanese Gold Fishes

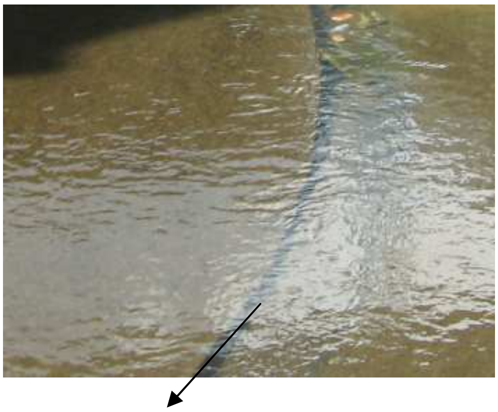


Figure 42 : Concrete type of river bed in branch of Shirakawa river at Kumamoto City Downtown (Archive of Volkan ORAL on October 20th, 2006)

6.1.2. Inspection , rehabilitation and maintenance

ISDR (2005) defined the structural works that require a periodic and systematic inspection, rehabilitation and maintenance program to ensure that the design capabilities are maintained for decreasing the causalities of the flooding disaster. The periodic and systematic inspection along the Shirakawa River and also to control the fluctuations of water level on Shirakawa River are running by the latest technological advances (Figure 45)

Figure 43 & 44 : The interior view of River Network office of City of Kumamoto-main control unit (Archive of Volkan ORAL on 15 November 2006)

The river and highway network office of Kumamoto City is the main authorization place where is responsible for screening the vehicle traffic on the national highways and Shirakawa River flow in Kumamoto City. (Figures 43 – 44)

The surveillance and data transmitting facilities are listed in Table 2. The hourly data transforming and scenes from live camera surveillances from Shirakawa River is being transmitted from observation points to river network office via the optical fibers technology.

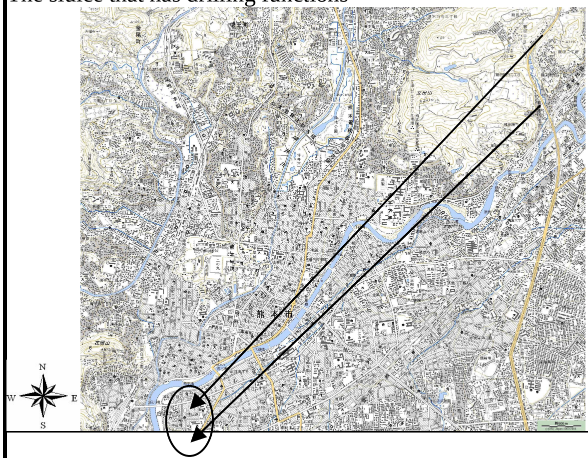
The river flow control facilities to protect the Kumamoto City against flooding and high tides from Ariake Sea can be seen at Table 3. The control points that are located in the study are also shown on 1:25.000 Scales minimized Topological Map of the city.

Figure 45 : Shirakawa river electronic announcement board and camera surveillance located on dyke (Archive of Volkan ORAL on 20 October 2006)

Table 2: Technical Improvements on Shirakawa River (Personal Communication from River and Road Network office of Kumamoto City,2006)

Facilites on the river	**Function**	**Purpose**
Optical Fibers	Sending and Receiving information	
Supervisor Camera	Remote manipulation of rivers management facility	For gaining data about disaster management
Indication Monitors	Supervision of the water level and river managament facility	

Table 3 : The river flow control facilities to protect the Kumamoto City against flooding and high tides from Ariake Sea –control points in the study area shown on 1:25.000 Scale minimized topological map (Personal Communication from River and Road Network office of Kumamoto City,2006)

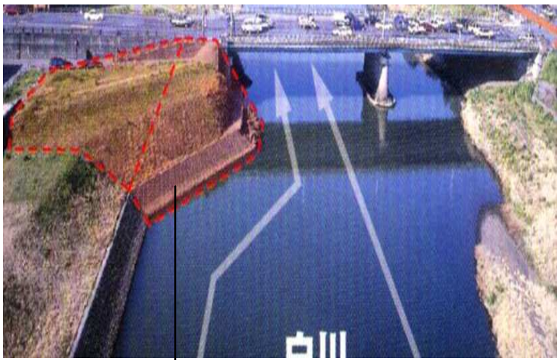
Main Rivers Management Facility		Enforcement Location	
Dyke Bulkhead	River Flow Control Unit	白川：河口～小磧橋	17.300 km
	Kumamoto Prefecture Department of Management	白川：小磧橋～谷桐砂防堰堤	42.770 km
		黒川：立野～一の宮	38.800 km
Sluice The sluice that has drilling functions 		大江第１樋管	左岸 14.190 km
		大江第２樋管	左岸 14.310 km
		桜山排水樋管（新設）	右岸 16.050 km
		宇留毛排水樋管（新設）	右岸 16.200 km
		渡鹿排水樋管（新設）	左岸 16.950 km
Reservoir Water Area		黒川（熊本県管理区間）	—
Stand Field Dam		立野：白川と黒川の合流点	—
Observation	Water level observatory	妙見橋	
		栃木	河口より 49.0 km
		立野	河口より 45.2 km
		陣内	河口より 36.05km
		子飼橋	河口より 14.5 km
		代継橋	河口より 12.15km
		小島	河口より 3.1 km
	Rain-Gauge Station	色　見	支配面積 39.4km^2
		新　町	〃 55.4km^2
		久木野	〃 44.5km^2

		坊　中	〃　71.3km^2
		内　牧	〃　69.9km^2

6.1.3. Flood proofing of new and existing structures

The Yotsugi bridge located on the Shirakawa river is one of the important pathways that links the two sides of the city each other. In the figures (46-47) at top the new flood proofing facilities are shown.

Before



After

Removed Part

Figure 46 & 47 : The River Improvements on Yotsugi Bridge (Personal Communication from River and Road Network office of Kumamoto City, 2006)

In Figure 48 and 49 we can also see the Shirakawa River side before the river improvements work. Those two pictures were taken in 2005 to show the before and after situation of the river side improvements.

Before

After

Figure 48 & 49 : Flood proofing river improvement pictures on Shirakawa River in 2005 (Personal Communication from River and Road Network office of Kumamoto City,2006)

Figure 50 & 51 : Shokebori River Improvements (http://www.city.kumamoto.kumamoto.jp)

In Figure 50 and 51 other river improvements are shown along the Shokebori River in Kumamoto City. The river bed is difficult to notice in Figure 50 . In Figure 51 the river bed is re-shaped and improved. Beside that the road located next to river is also renovated and expanded. According to ISDR (2005) this re-development has a meaning as follows: Roads can act as leeves when they are parallel to river. However this changing has a drawback that while flood protection is being provided the water level upstream can increase, and result the additional flood damages. Hydraulic studies should be run before applying those re-developments.

6.1.4 Bridges and roads

According to Konrad (2004) structures that locate on the floodplain, such as bridges, and roads can increase upstream flooding by narrowing the width of the channel and increasing the channel's resistance to flow. ISDR (2005) also added that bridges can act as artifical dams if debris jams on the structure. It was highlighted that during the flooding, bridges are the main access for evacuation and delivery of medical and other emergency services. Then roads have the potential to increase the effect of flooding. They should act as leeves when they are parallel to river. In Kumamoto City bridges and roads on the Shirakawa River were all improved after 1953 Great Flooding. Above the Figure 52 shows the details of those renovations on bridges.

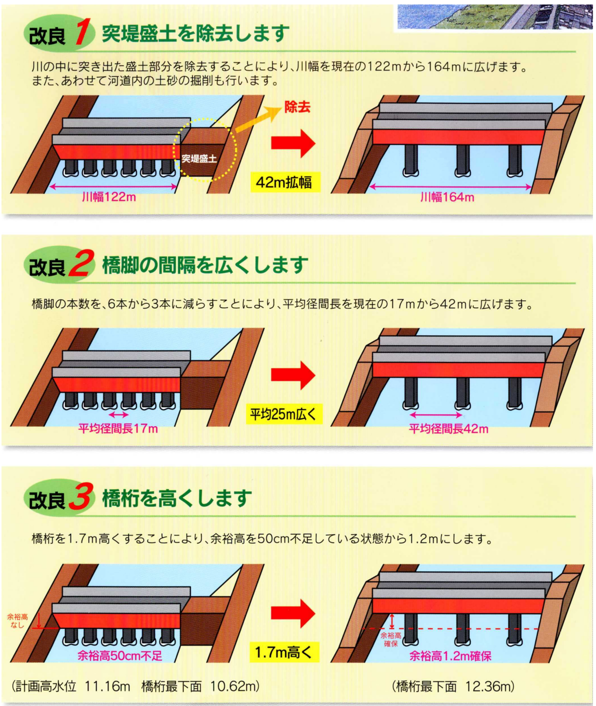


Figure 52 : Bridge and Road improvements on Shirakawa River in Kumamoto City (Personal Communication from River and Road Network office of Kumamoto City,2006)

The Figure 52 shows that there are 3 ways to improve the bridges including the sluices improvement. In the first part, it is telling that the part as yellow circled should be removed and the distance between two sides of the river will be increased. In the second part the same function will be followed to do but also the number of sluices will be decreased but the distance again here will be increased respectively.

In suburbs of Kumamoto the bridges and roads are not enough wide as can be seen in Figures 53 and 54. As a result those roads and bridges might have the potential dangers during the flooding which increase the effect of flooding as follows : accumulating the debris (Figure 26) and sedimentation along the river side.

Figures (53) & (54) The Kokai Bashi Bridge at Downtown and a regular bridge on the branch of Shirakawa river in the suburb of Kumamoto City (Archive of Volkan ORAL on 22 November 2006 & 20 October 2006)

6.1.5 Enforcement of standard and codes

In Japan many human settlements are located next to the sea sides. Some metropolitan cities such as Tokyo, Osaka and Fukuoka , the newly constructed human settlements located in territories that are far away from the sea side. However out of those city limits even in Kyushu, villages have been constructed so close to the sea sides. A village of Yatsushiro City which is located within the limits of Kumamoto Prefecture can be given as an example (Figure 55).

Figure 55 : A village on Yatsuhiro-Minamata Coast Line (Archive of Volkan ORAL 10 November 2006)

In the Figure 56 , a coastal house constructed behind a road and further away from a dyke. This figure at below shows the back side of the house. To protect from the effects of high waves, the main entrance of the house constructed at the opposite side of the road.

Figure 56 : A coastal house located on the Yatsushiro coast line (Archive of Volkan ORAL on 10.November.2006)

During the flooding there are some possible dangers which are based on building codes in Japan. For instance, in all Japanese cities` streets have the unique view in Figure 57 . The electric circuit transport cables or even local communication cables are not paved beneath the roads.

Figure 57 : The view from Toroku 3-8-10 in Kumamoto City (Archive of Volkan ORAL on 17.September.2006)

The Liquified Petroleum Gas (LPG) is using to heat or to sustain energy for Japanese houses. There is no central gas transporting network in the country. As can be seen in the Figure 58, all houses or apartments have their own LPG tanks. These tanks have the potential danger during the flooding disaster. They might be detached from the regulators by the immediate action of flood waters and tend to blow up.

Figure 58 : LPG Gas Tanks (Archive of Volkan ORAL on 22.November.2006)

Poly Vinyl Chloride (PVC) is commonly used to build water supply tanks in Japan. Most of these tanks located next to human settlements on the basement level (Figure 59). During the disaster there is low risk of the contamination of potable water. As an advantage PVC keeps the water safe and clear from flood waters.

Figure 59 : PVC Water supply tanks (Archive of Volkan ORAL on 23. November.2006)

According to ISDR Guidelines for Reducing Flood Losses (2005) water supply tanks and treatment plants are particularly vulnerable . They are often located on the flood plain yet are critical for the protection of human health during and after a flooding. Such structures need to be constructed cross-contamination from floodwaters or sewers.

6.2. Non-structural Measures

This section can be grouped into 4 sub-sections as follow:

- **6.2.1 Land-use planning**
- **6.2.2 Zoning of flood-prone lands**
- **6.2.3 Redevelopment of flood-prone lands**
- **6.2.4 Insurance**

6.2.1. Land use Planning

According to Land Information Division / Land and Water Bureau Ministry of Land, Infrastructure and Transport of Japan (2001) generally in every Japanese towns the land use planning was divided into six areas with land use standards for each area as follows:

a. Forest conservation area,
b. Forest production area,
c. Hills
d. Agricultural production area
e. Residential area
f. Rivers and lakes

To reduce the effect of flooding in Kumamoto buildings are not allowed to constructed at flooding prone areas. Actually the dykes located around the river sides shapes the boundaries of human settlements area in the city. It was followed the idea that integrating the land-use planning for flood-prone lands into the broader plans for the urban and surrounding area.

6.2.2 Zoning of Flood Prone Areas

Kumamoto located in Kyushu Island is an inherently prone city to flooding. Annual summer rains part of Monsoon season in all pacific region, drench the alluvial plains that stretch down to the sea. As a result it threatens the populated areas with serious flooding. One example can be given for that part is utilizing river side area for having sport purposes or any similar activities (Figure 60)

ISDR (2005) figured out that zoning of flood-prone lands as ecological reserves or protected wetlands can often help to meet broader environmental or biodiversity goals. Those lands often play an important role in temporary storage and infiltration areas.

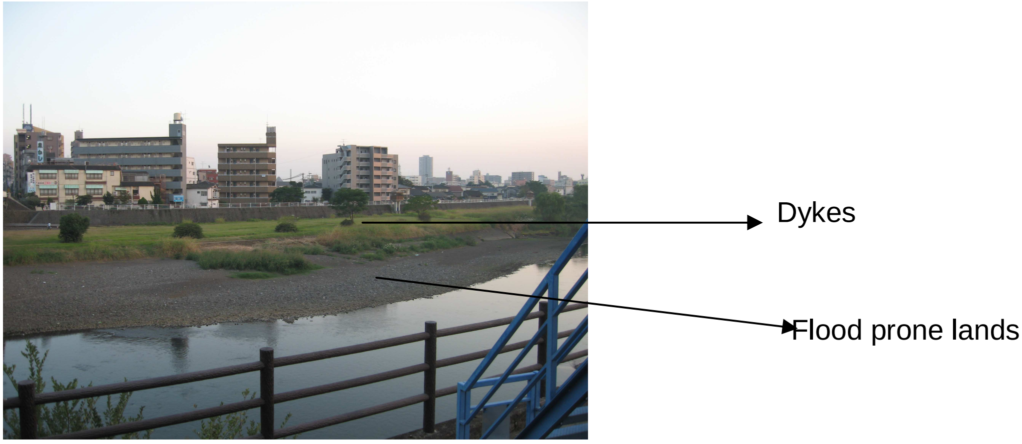


Figure 60 : Flood prone lands located in Shirakawa River side (Archive of Volkan ORAL on 20.0ctober.2006)

6.2.3 Redevelopment of Flood Prone Areas

It is shown in the figure 61 that `Flood Prone Areas` on the Shirakawa River side are re-designing after 1953 Flooding in the city. Mainly those areas are now open for public access. Mainly this approach is very common in all Japanese cities where have the potential danger of flooding.

Figure 61 : Re-developed Flood Prone Areas (Archive of Volkan ORAL on 20.October.2006)

6.2.4. Insurance

Japan is prone to have many disasters along the country. The Disaster Insurance called in Japan Language as **Kasai hoken** (火災保険). According to **GIAJ (** The **General Insurance Association of Japan),** 2005 , most Japanese cities located lower than the water level of the rivers in times of flood . As a result these are prone to disaster flooding as a result of geographical conditions. To give an example related with landslide : in July 2003, a landslide occurred in Minamata - Kumamoto Prefecture, due to torrential local rains. The Cabinet Office held a liaison meeting with the agencies involved in disaster management, and ensured that every effort was made to implement emergency countermeasures and collected information for the disaster. The Cabinet Office dispatched 3 staff as members of the Advance Information Team and also dispatched the government inspection team, who played a coordinating role between Insurance Companies and landslide sufferers

7. Findings

The following map in figure at below is produced after running GIS Analysis using ARC INFO software. On the map the thematically layers shown in the legend of the study area are sketched due to collected data from field trip. Main roads are shown by brown colour and rivers by dark blue. There are also called `open spaces`(hills) in the study are shown by `grey`.

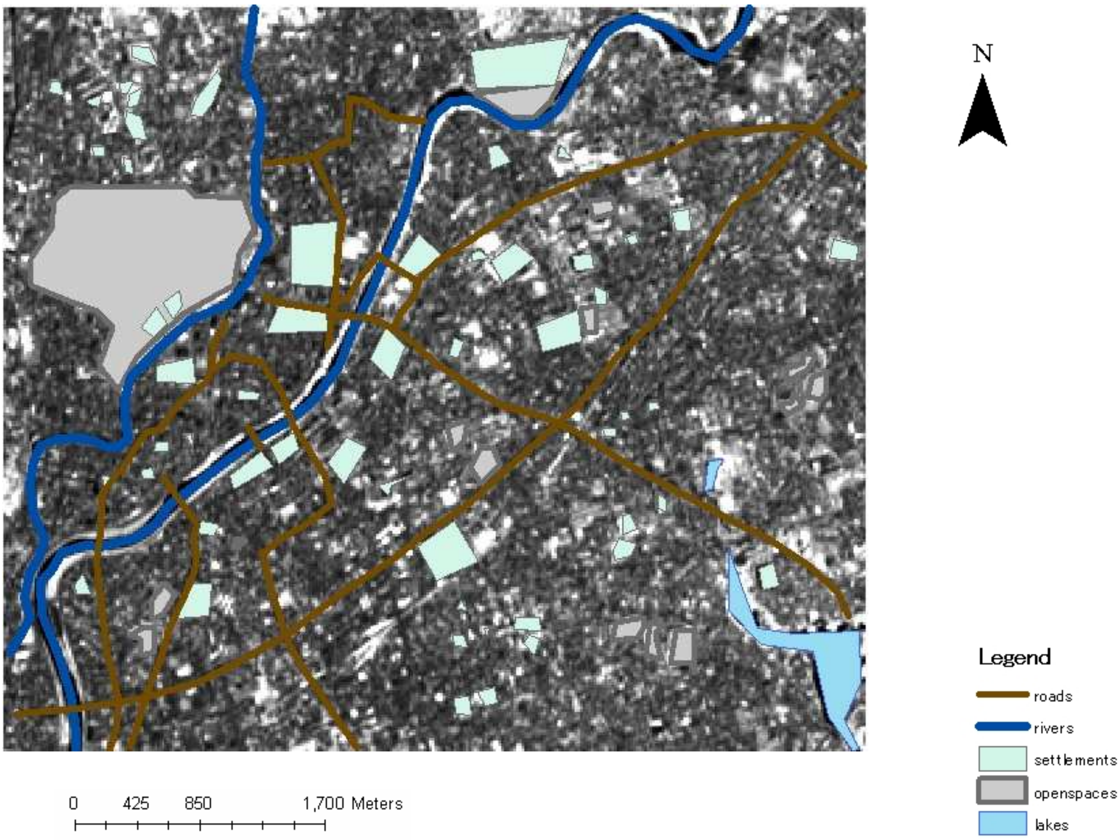


Figure 62: GIS thematically layers of the Study Area

7.1 Contour map of the study area

The collected ground control points are plot with SURFER Software (Suarez, 2004 & Garcia et. Al, 2005) (Surfer, 2004) to obtain the elevation map of the study area along the shirakawa river. We can understand from the map that the Shirakawa River flowing towards the north-south. At the elevation of 46.00 m there is gently sloping land and on 65 m of elevation a steep-sided flat-topped hill covers the area. The center of the map has the elevation of 20 m. This point locates in the downtown of the Kumamoto City.

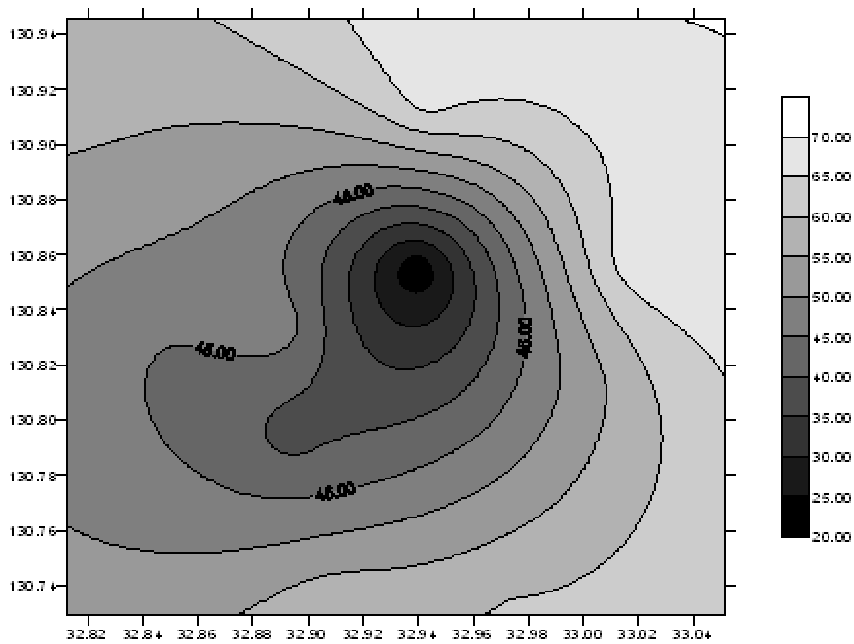


Figure 63 : Contour Map of Study Area

In the Figure above the 3D view of the study area is produced from ASTER (Advanced Spaceborne Thermal Emission) LEVEL 1B Satellite Images dated to 2003. ERDAS IMAGINE 8.5 from Leica Geosystems Geospatial Imaging is used to handle the 3D view image of the study area (Oral, 2002)

ASTER satellite image is used since it has a high spatial resolution imaging sensor, consists of visible and near infrared (VNIR), short-wave infrared (SWIR) and thermal infrared (TIR) regions subsystems and capable of simultaneously operating in wide spectral ranges.(Aster User`s Guide, 2003) .

According to Committee on Earth Observation Satellites (CEOS), 2003 floods are among the most devastating natural hazards in the world, claiming the largest amount of lives and property damage and needed to analyze the floods where available using satellite images.

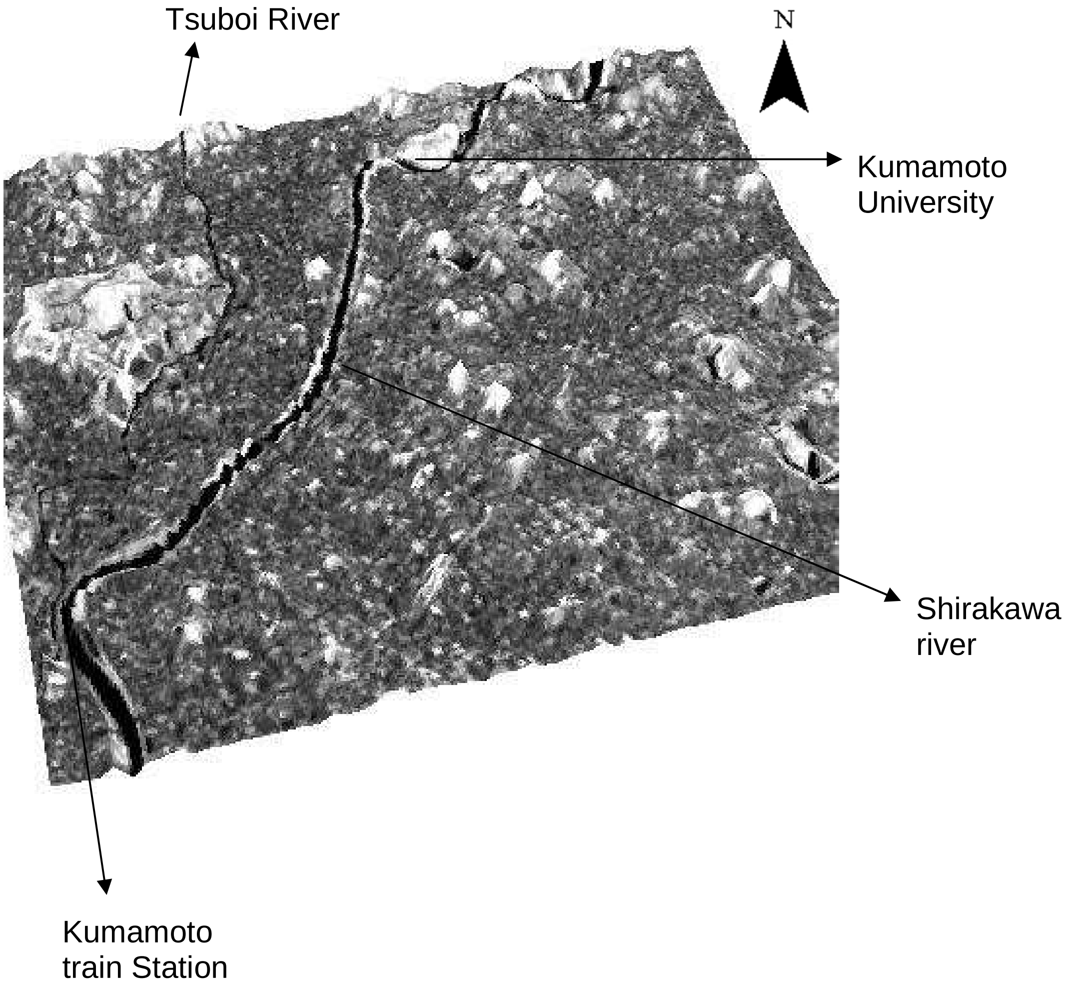


Figure 64: 3D view of Study area-produced from ASTER Level1B

7.2 Flooding Risk Map of Kumamoto City

The flooding risk map is produced by ARC INFO Software. `Red`, `Blue` and ` Yellow` colors symbolize the thematically layers inserted into the map. To plot of `Red` coloured layer , the coverage of 1953 Flooding of Kumamoto City is taken as the boundary limits. It is shown on the map that no buildings are not allowed to construct in `High` risk zone (Red Layer) . `Blue Lines` symbolize the boundary limit of `Medium` Zone and between `Red ` colured zone and `Blue` coloured zone, buildings can be constructed. `Green Lines` symbolize the `low` risk zone where has no immediate flooding danger of Shirakawa and Tsuboi Rivers.

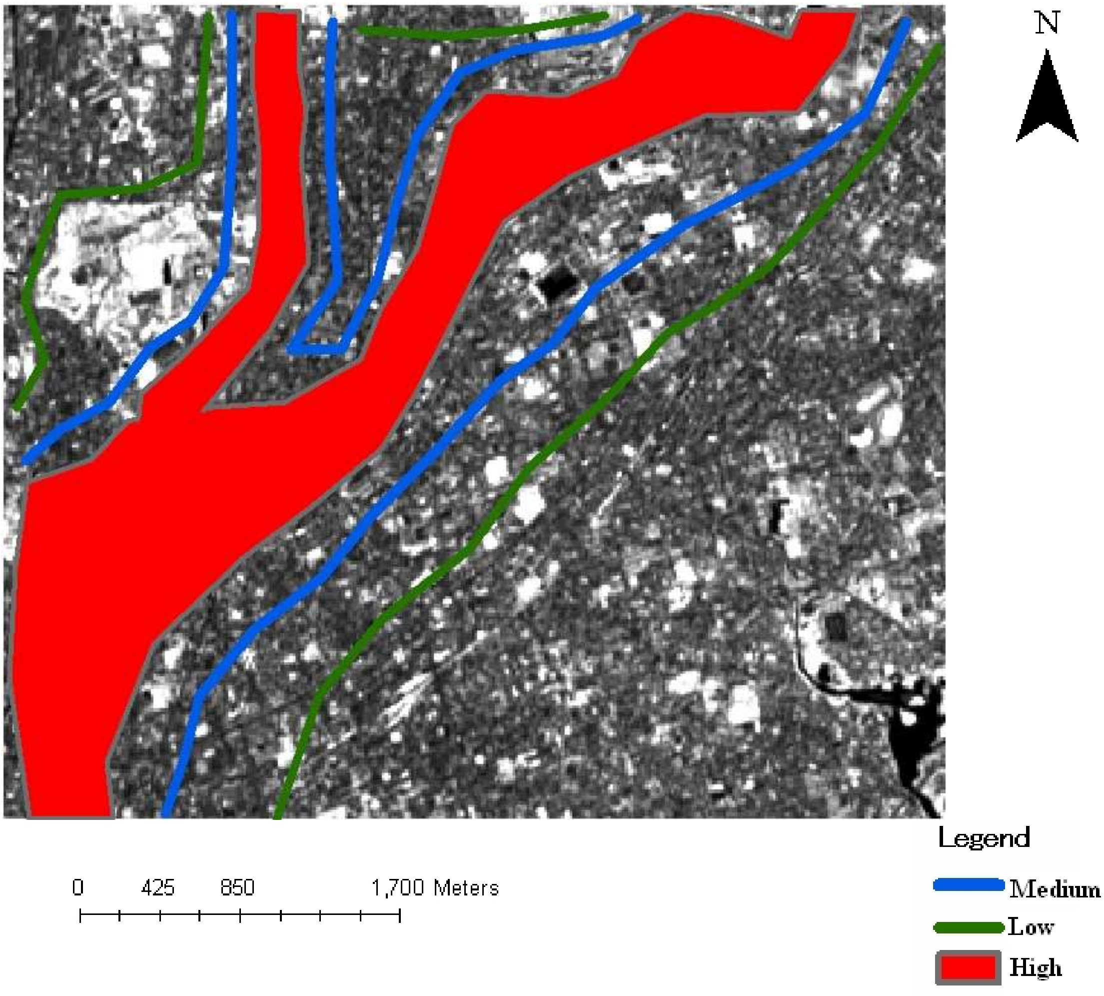


Figure 65 : Flooding Risk Map Kumamoto City (Shirakawa and Tsuboi Rivers)

7.3 The proposed shelter locations in Study Area

According to www.mothernature-hawaii.com (1997) shelter locations should be selected due to some specifications as follows :

A. An independent emergency electrical power source
B. Rest rooms and potable water available for shelter occupants
C. A communications system available for shelter management
D. Topographical features that makes shelter locations away from disaster area

To be linked with the above specifications 3 shelter locations are proposed in the study area for short term sheltering (Figure 66) . The Shelter Location 1 is located in an `open space` area where has the highest elevation and in the area of `Low` flooding risk zone. Actually this area proposed to meet the requirements at part `D` at top. Undoubtedly, there is no alternative place to propose for possible shelter locations in that region of the study area during the possible flooding disaster.

The Shelter Location 2 and 3 also are located in far away from flooding area. Beside, the main transportation roads are so close to them for easy accessing. These locations have also potable water sources for shelter occupants.

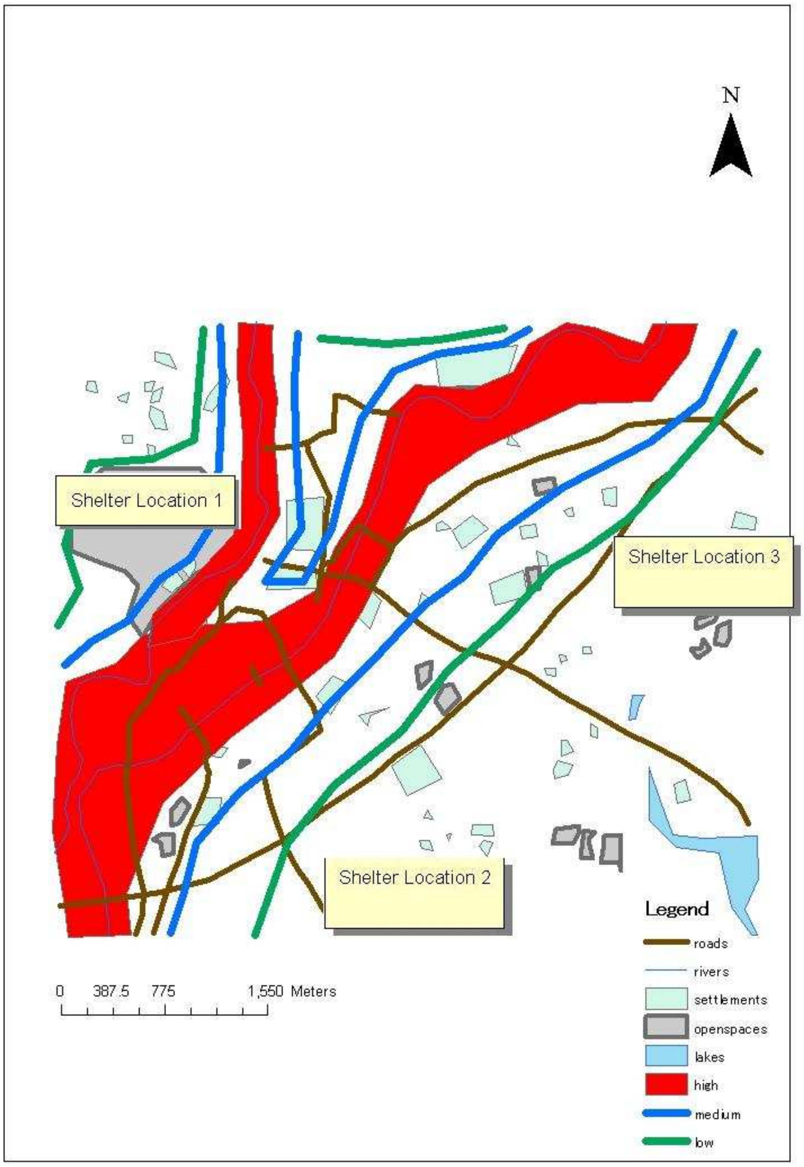


Figure 66 : Proposed shelter Locations Map in Study Area

7.4 Hydrological Facts of Flooding in Japan and Turkey

In Japan, increased urbanization on watershed areas has negative effects on river flowing regimes in cities. Uncontrollable population expansion at human settlements triggers the way of searching alternative human settlement places. According to the website of www.nsf.gov/nsb/committees/hurricane/2/**vieux**.pdf , there are also some other factors which accelerate the speed of flash floods related with watersheds in terms of hydrology as follows :

1. Drainage area
2. Drainage network
3. Slope
4. Channel geometry and roughness
5. Overland flow and roughness
6. Vegetative cover
7. Soil infiltration capacity
8. Storage capacity

"Vegetative cover" can be linked with the flooding disaster in Silifke, Turkey. Removing the natural vegetation cover is one of the main reasons of flooding in Silifke Town, Turkey in 2004. The higher slope at the skirts of Taurus Mountain located in Silifke accelerated the flood waters. There was no vegetation cover to enhance the acceleration of flowing.

According to White and Greer, (2004) urbanization has shown to increase peak discharges and flood magnitudes, particularly floods with lower return intervals. On the other hand flood magnitudes in Turkey can be related with uncontrolled urbanization along the banks of rivers and the meteorological and hydrological reasons.

World Meteorological Organization , The Associated Programme on Flood Management Report (2004) stated that magnitude of the effect of the flooding can be described using two parameters .

1. Number of people lost in the flood

2. Number of injured lost in the flood

These two parameters can be helped us to group the magnitude of flood damage and losses as follow (www.survas.mdx.ac.uk/ppts/Edmund/tsld009.htm) :

Direct damages on Settlements :

Shops, offices
Houses
Factories
Infrastructure
Livestock
Crops

Road traffic disruption

Indirect losses
Loss of medium term agricultural production

7. 5 Integrating The Flood Disaster Prevention Practices of Kumamoto City in Turkey (Town of Silifke)

Oral, et, Al, (2006) postulated that Turkey faces flood disasters more than twice in a year due to its geographical location. The country is located in the northern hemisphere between the 36º - 42º northern parallel and the 26º - 45º eastern meridian. Flash floods have become unfailing events in Turkey leaving behind great loss of casualties and properties. Extreme climate conditions, removing the natural vegetation and mis-landuse for the flood plains are among the main factors that increase the flood vulnerability in Turkey . Town of Silifke, located in South Side of Turkey, within the limits of Province of Mersin, Mediterranean Region of Turkey – at coordinates $36,22^0$ North and 33.58^0 East (Figure 67) (Oral, et, Al, 2006) can be given as a model area to propose integrating the flood disaster prevention practices of Kumamoto City. River of Goksu is one of the important water sources within the city limits. The water surface area is 200 hectare and the actual water consumption of the river is 3, 900 hectometercube/year (Oral, et, Al, 2006). Holis, 1993 figured out that the water catchment area of the river is 10,069 square kilometers . According to Holis, 1994 the highest flows in April come from snowmelt and floods occur with velocities of over 2,000 m^3/s during this period. As can be seen same phenomena in Kumamoto Prefecture, the groundwater is in Silifke plain replenished by infiltration of the river water. The underground flow in Goksu River is feeding from the coastal mountains (83 m^3/day in the uppermost 4 meters) (Holis, 1994).
In March 2004 there was a drastic flooding in Silifke by extremely rising up temperatures after snowing period in Taurus Mountains in Eastern Mediterranean Region of Turkey.
304,698 m^2 area is flooded by Goksu River (Oral, et, Al, 2006)

Table 4: Flood Disaster Prevention Practices that will be applied in Town of Silifke

Flood Disaster Prevention Practices applied in Kumamoto City – Japan	Silifke – Turkey
Visual surveillance of the River	have a chance of applicability
River Dykes Construction	have a chance of applicability
Re-developments of Flood Zone Areas	have a chance of applicability
Early Warning System by Mobile Network	A negotiable issue to talk with Turkish Mobile Telephone Companies
Flood proofing of new and existing structures	depends on Goksu River flow regime

8. Recommendations

There are many approaches for reducing flood hazards in Kumamoto City . Some territories identified as flood-prone have been used for parks and playgrounds that can tolerate possible flooding. It was observed that those flood prone areas are not settled around the whole river sides of Shirakawa River. It was preferred to settle them some locations in downtown area. Those areas should be settled as much as possible along the both river sides.

As for standard building codes LPG Gas Tanks should be located at the interior of residences to prevent possible dangers during the flooding. Meanwhile the electrical circuit of the city should be renovated again and if possible they should be paved beneath the road.

Kumamoto City is one of the oldest human settlements located in Kyushu Island. As typical in other Japanese cities, traditional Japanese styled houses and narrow roads can be seen in the city. For the present day purposes those roads are inadequate to allow vehicle and human transport in the same time. During the disaster they should be allowed for all means of transportation. As a result they urgently needed to be expanded to meet the necessary requirements.

It was also seen that traditional Japanese styled houses are not strong enough to resist against flooding. Those houses should be surrounded with floodwalls. If possible new styled modern houses that are designed to resist against flooding should be constructed to replace them.

The camera surveillance system of the Shirakawa River is adequate to take precautions against flooding. However, those scenes received via camera should be broadcasted on local TV channels to inform the local people of Kumamoto City. During these broadcasting, explanations about the water levels also might be given using charts, graphics or other necessary audio-visual elements to inform the local people.

Heliport areas should be located in Kumamoto City to evacuate the people easy and fast way through the shelter locations or safer places away from the flooding area.

More international events such as symposia, panels or workshops should be prepared to share the experiences that are gained after flooding or to teach the new ways of disaster management practices. As being an outcome of this study the river improvements observed along the Shirakawa River can be applied in Turkey where suffers from flooding more than twice in a year.

9. Conclusions

A. The city infrastructure roads, bridges, water and electricity supply systems, sewerage systems are the main vulnerable areas in the city.
B. Bridges have been already elevated, and reinforced with levees.
C. Bridges are also re-designed to withstand temporary inundation and prevent to accumulate the debris and sedimentation along the river side
D. Drainage systems have been expanded to increase their capacity for detaining and conveying high streamflows ;
E. LPG tanks located outside of the residences. They have the potential danger of flaming during the flooding. PVC made water storage tanks can store the potable waters safe and clean.
F. Electrical circuits on the streets should be paved beneath the roads to reduce the vulnerability to flooding.
G. The improvement systems known as rainwater disposal measures, rainwater infiltration systems, residential development adjustment ponds, water infiltration pavements are already at service on Shirakawa River.
H. Flood-prone zones on Shirakawa River sides are using to tolerate the flood.
I. The advanced means of technology is using to control the water level of Shirakawa River for taking precautions before flooding. What is impressed that enabling ` Disaster Message Board Service` via cellular phones in all over Japan.
J. Education campaigns are currently running with school children to teach the ways of reducing flood hazards.
K. Kumamoto University and main Train Station in downtown are located at `High Risk Zone` of possible flooding.

References

Arc Info User’s Guide., (2005) ESRI I Inc. Publications, U.S.A

Aster User`s Guide, (2003) ERSDAC Publications, Tokyo, Japan

CEOS, (2003) . The Use of Earth Observing Satellites for Hazard Support: Assessments and Scenarios. Final Report of the CEOS Disaster Management Support Group (DMSG), November.

Chadwick, et. Al , (2005), ` Application of multi-temporal high-resolution imagery and GPS in a study of the motion of a canyon rim landslide`, ISPRS Journal of Photogrammetry and Remote Sensing , Vol. 59, Issue 4 , June 2005, p.p, 212-221

City Hall of Kumamoto Brochure (2005), City Hall Publications, Kumamoto, Japan (Japanese Version)

Disaster Management in Japan (2002), DIRECTOR GENERAL FOR DISASTER MANAGEMENT Publications, Tokyo Japan

Erdas Imagine 8.5 Remote Sensing Software., (2001), Leica Geosystems Geospatial Imaging Publications, U.S.A

`50th Anniversary of 1953 Shirakawa Flooding Brochure` (Japanese Version)., (2003), Kumamoto Prefectural Publications, Kumamoto, Japan

Garcia, A., et. Al, (2005) ` Quaternary evolution of the Ría de Vigo, Spain`, Marine Geology , Elsevier Ltd. Publications,Vol. 220, Issues 1-4 , p.p 153-179

GIAJ, (2005) General Insurance Association of Japan Report, Tokyo, Japan

`Groundwater Recharge for a Sustainable Society`.,(2006), Kyushu Sony Semiconductor Factory Publications, Fukuoka

Google Earth View (2006) Software

`Guidelines for Reducing Flood Losses `(2005) *International Strategy for Disaster Reduction (ISDR) Publications,* p.p 16-24-31-47

Hollis, G. E. (1993) ` The effect of water use on the hyrology of Göksu Delta`, Wild Life Protection Fund International Goksu Delta Environmental Development Seminar, DHKD publications. ,p.p 97-108, Istanbul, Turkey.

Hollis, G. E. 1994. Mediterranean wetland management and the Göksu and Kizilirmak Deltas: Priorities for Turkish wetlands. Turkish Journal of Zoology 18:95-105.
UNESCO (1995) "Fighting Floods in Cities"; *Project: Training Material for Disaster Reduction;* Delft, Holland

Ichikawa, T., (2002). `Kumamoto Shirakawa Chuuryuuiki ni okeru Chikasui Kanyou no Hyouka `Proceedingsof the 6th Symposium on Water Resources in Japan, pp.87-92

Jurajda,.P, Ondrackova., M, and Reichard (2004), `Managed flooding as a tool for supporting natural fish reproduction in man-made lentic water bodies`, Journal of Fisheries Management & Ecology, Blackwell Publications, Vol. 11 Issue 3-4, p. 237,

Koike,K., et. Al (1996)., `Hydrogeological and Ground-Water Resource Anaylsis Using a Geotechnical Database` , Journal of Nonrenewable Resources, Vol.5. No:1 , p.p 23-32

Koike, K., (2005) ,` Spatial Modeling of discontinuous geologic attributes with geotechnical applications`, Journal of Engineering Geology, vol. 78, p.p 143-161

Konrad,C. P., (2006), ` Effects of Urban Development on Floods`, U.S Geological Survey Publications, Fact Sheet 076-03, U.S.A

Kumamoto City Agricultural Output Report (Japanese Version), (2004) Kyushu Regional Agricultural Administration Office.

Kumamoto River Road Network Office., (2005), ` `Shirakawa River Facts`, Kumamoto, Japan

` Land and Real Property with Report`, (2001) Land Information Division / Land and Water Bureau Ministry of Land, Infrastructure and Transport of Japan Publications, Tokyo

Makoto Y., et. Al (2005), ` Ecological dynamics of urban and rural landscapes in East Asia`, Journal of Landscape and Urban Planning, Vol.70, Issues 3-4, p.p 193-194

Nirupama,N., and Simonovic, S., (2002), ` Role of Remote Sensing in Disaster Management`, Institute for Catastrophic Loss Reduction (ICLR) Research Paper Series-No.21, Ontario, Canada

Oral, H.V., (2002) ` Land use change analysis of Erdemli-Kız Kalesi region by using GIS methodology, Master of Science Thesis, Bogazici University Publications,Istanbul, p.p 35-36

Oral, H.V., et. Al , (2006) ` Geographical Information Systems Based Flood Disaster Assessment of Turkey`, State Water Agency of Turkey 1st National Flooding Symposium, April 2006,Ankara

Personal Photo Archive of Volkan Oral, (2006)

Personal Photo Archive of Ozlem Oral, (2007)

River Discharges Year Book of Japan, River Bureau Ministry of Land, Infrastructure and Transport, 2000, Japan

River Discharges Year Book of Japan, River Bureau Ministry of Land, Infrastructure and Transport, 2001, Japan

River Discharges Year Book of Japan, River Bureau Ministry of Land, Infrastructure and Transport, 2002, Vol.55, Japan

Shouhei Andou, (2006). Personal Communication, Chief Officer, River and National Highway Ministry of Land , Infrastructure and Transport

Suarez,B., (2004) `The Sinú river delta on the northwestern Caribbean coast of Colombia: Bay infilling associated with delta development `, Journal of South American Earth Sciences, Elsevier Ltd. Publications, Vol.16, Issue 7 , p.p 623-631

Surfer 6.00 Version User’s Guide., (2004) Golden Software Inc. Publications. U.S.A

Torii, K. and F. Kato., (2001), `Study on Storm Surge Disaster`, Technical Memorandum of Public Works Research Institute, No.3803, Japan.

The Associated Programme on Flood Management , (2004) " Integrated Flood Management : A Case Study on Turkey" World Meteorological Organization Publications Switzerland

White,D. M. and Greer, A.K 2004, " The effects of watershed urbanization on the stream hydrology and riparian vegetation of Los Peñasquitos Creek, California", Journal of Landscape and Urban Planning, Elsevier Publications, Vol. 74, Issue 2, p.p 125 – 138

Wolsink,.M (2005), ` River basin approach and integrated water management: Governance pitfalls for the Dutch Space-Water-Adjustment Management Principle`, Geoforum, Elsevier Ltd. Publications, Vol. 37, Issue 4 , Pages 473-487

Y. Matsuno , et, Al, (2002) , `Accounting of agriculture and nonagricultural impacts of irrigation and drainage systems, Working paper 43,IWMI , Colombo, Sri Lanka

Internet References

International Center for Water Hazard and Risk Managemen (2006) :, http:// www.icharm.pwri.go.jp/

Kumamoto Prefecture Information (2006) : cyber.pref.kumamoto.jp/asp/kanko/map_kumamoto_kankou.

Ministry of Land and Infrastructure of Japan (2005) http://www.mlit.go.jp/river/english/land.html

Japan Geological Survey Institute, http://www.gsi.go.jp/

Japanese Geological Location**,** http://en.wikipedia.org/wiki/Japan

Shokebori River Improvements., (2001) : http://www.city.kumamoto.kumamoto.jp

Disaster Management Cycle (2004) :http://www.undp.org.in/VRSE/BestPract/Article-DRM%20Assam.pdf

KDDI Company Disaster Message Board System via Cellular Phones (2006) http://www.au.kddi.com/english/message_board/index.html -

City Hall of Kumamoto Brochure (2005) :http://www.city.kumamoto.kumamoto.jp

Hawai State Hazard Mitigation Forum (1997) : http:// www.mothernature-hawaii.com

Baxter E. Vieux , ` Hydrology of Fast Response` www.nsf.gov/nsb/committees/hurricane/2/**vieux**.pdf

The Magnitude of Flood Damages and Losses www.survas.mdx.ac.uk/ppts/Edmund/tsld009.htm

Appendices

Appendix 1

Disaster Prevention Information in the Province of Kumamoto for Flooding on 06/07/08 July 2007

Due to heavy rains taking place in the Province, the disaster prevention information has been published by the City Hall website of Kumamoto on 06.July.2007 as follows :

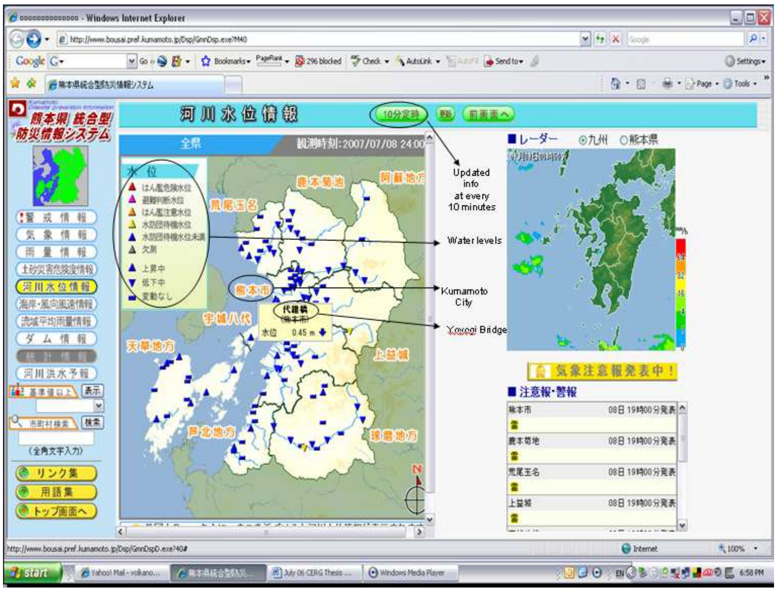


Figure I: Disaster Prevention Information on Web Site

The information on the map seems to be current as of 10:00 AM. Areas on the Shirakawa River are marked with orange triangles, which seem to correspond to Level 4. Fortunately, levels in these areas seem to be going down so it looks like we may be OK. However, there are a couple of areas in Amakusa (located on south direction of Kumamoto City) that have purple marks, indicating Level 3. Water levels are increasing in these areas.

According to City Hall Disaster Prevention unit there are 5 danger levels related with flooding. These levels are grouped as follows :

Level 1: Flood reaction squad prepares for actions
レベル１　水防団待機水位超過

Level 2: Flood warning water level has been exceeded
レベル２　はん濫注意水位（警戒水位）超過

Level 3: Water level requiring an evacuation decision has been exceeded
レベル３　避難判断水位超過

Level 4: Flood danger level exceeded
レベル４　はん濫危険水位超過

Level 5: Flood has occurred
レベル５　はん濫の発生

Figure II : The Water Level on Shirakawa River on 07.July.2007 (Personal Archive of Özlem ORAL)

Appendix II

Evacuation Orders

On 7.July.2007 the following evacuation orders has been announced by City Hall :

`避難勧告発令
2007年7月7日(8:13:45) 更新

7月7日07時40分、河内全校区、松尾東・西・北地域
の方に避難勧告を発令しました。
家族・隣近所・要援護者の方へ声掛け合って避難してください。
避難場所は、河内小学校、自浜分校、河内中学校、河内公民館、みかん

の里、松尾東・西・北小学校、に開設しました`

`July 7th 07:40, the Kawachi all school district, evacuation advice was announced officially to Matsuo east & west & north area. To the family neighboring main point backing person voice negotiating, please evacuate. Kawachi elementary school, the Shirahama branch school, Kawachi junior high school, the Kawachi public citizen's hall, the village of the tangerine, Matsuo east & west & north elementary school, it established the evacuation place.

The areas to be evacuated are Kawachi, Matsuo-higashi, Matsuo-nishi, Matsuo-kita. Call 096-328-2490 for more information.

Persons in Suidocho (sections 7 through 14) should prepare to evacuate. For more information you can call 328-2222.