vi) Spill overtopping discharge

To estimate the spill overtopping discharge, an appropriate formula shall be selected, taking into consideration the relation between the river channel alignment and the shifting of the water route during a flood, for the respective flooding spots.

- In the case of frontal overflowing

Use Honma's formulae:

- Complete overflow $(h_2/h_1 < 2/3)$ $Q=0.35 \times h_1 \sqrt{2gh_1} \times B$
- Submerged overflow $(h_2/h_1 > 2/3)$ $Q=0.91 \times h_2 \sqrt{2g(h_1-h_2)} \times B$

where

h_1 = Inundation depth to the levee-break threshold, whichever is larger

h_2 = Do, whichever is smaller

- In the case of transversal overflowing

Use the formulae below:

where

Q_0 = Flooding discharge, obtained through Honma's formula

I = Riverbed slope

and the unit in parentheses of cosine is degree:

- Flooding discharge (Q) due to levee break

$I > 1/1,580$ $Q/Q_0 = (0.14+0.19 \times \log_{10}(1/I)*\cos(48-15 \times \log_{10}(1/I))$

$1/1,580 \geqq I > 1/33,600$ $Q/Q_0 = (0.14+0.19 \times \log_{10}(1/I))$

$1/33,600 \geqq I$ $Q/Q_0 = 1$

- Overflowing discharge due to spill overtopping:

$I > 1/12,000$ $Q/Q_0 = \cos(155-38 \times \log_{10}(1/I))$

$1/12,000 \geqq I$ $Q/Q_0 = 1$

vii) Roughness

Roughness shall be identified taking into consideration all factors, such as simulation model type, land-use patterns of the flood plain, past inundation records, etc.

The effects of existing buildings and others are approximately incorporated into the model constant. The effects of buildings and others are related in the form of roughness coefficients for the simplified one-dimensional unsteady flow model among one-dimensional models, as well as for two-dimensional models.

- Overflow pond model

With the progress of urbanization, the coefficient of discharge "c", which includes the roughness coefficient "n", increases due to the *vena contracta* effect of existing buildings. In the majority of simulation cases, the roughness coefficient is more or less defined as:

c = 0.05 to 0.1

- Open-channel pond model, flood pond model, and simplified one-dimensional unsteady flow model.

The roughness coefficient is defined in accordance with the land-use pattern, which is commonly classified into two types: "rice field and farmland" and "urbanized area." In majority of simulation cases, the roughness coefficients are more or less defined as:

- Rice field and farmland n = 0.1 to 0.25
- Urbanized area n = 0.1 to 0.3

In the flood pond model, however, the roughness coefficient often varies in accordance with the inundation depth.

- Two-dimensional unsteady flow model

The formula shown below is proposed to define the roughness coefficient of the flood plain "n", integrating the roughness coefficients, through the weighted average formula, on those facilities other than buildings, the tenement rate " **θ** " and the inundation depth "h". The areas of respective land-use patterns are to be identified for each divided mesh.

- Agricultural land:
  A_1 = Area of rice field, farmland, forest, orchard, bamboo thicket, etc.
  n_1 = Roughness coefficient for agricultural land
- Roads:
  A_2 = Area of national highways and major local roads, including sidewalks
  n_2 = Roughness coefficient for roads
- Other types of land-use:
  A_3 = Area of wasteland, grass lawn, marshland, salt field, etc.
  n_3 = Roughness coefficient for other types of land use

$$n^2 = n_0^2 + 0.020 * \frac{\theta}{100 - \theta} * h^{4/3}$$

$$n_0^2 = \frac{n_1^2 A_1 + n_2^2 A_2 + n_3^2 A_3}{A_1 + A_2 + A_3}$$

where
n_1 = 0.060, n_2 = 0.047, and n_3 = 0.050

3) Performance of Flood Simulation Analysis

The two-dimensional unsteady flow analysis is commonly applied, although other analysis methods may be used if appropriate in view of the topographic features of the flood plain. When dividing the flood plain into meshes, they should be consistent with the meshes for the averaged ground level data, coinciding with the "Numerical Map Information" or "National Land Numerical Information" data.

(5) Defining the Flood-prone Area

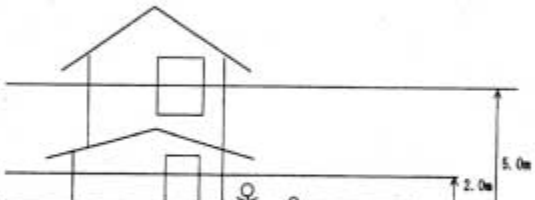
Identify the highest inundation level, through the flood simulation, of each divided mesh for overall cases of possible flooding spots and, in turn, define the maximum one for the respective divided meshes.

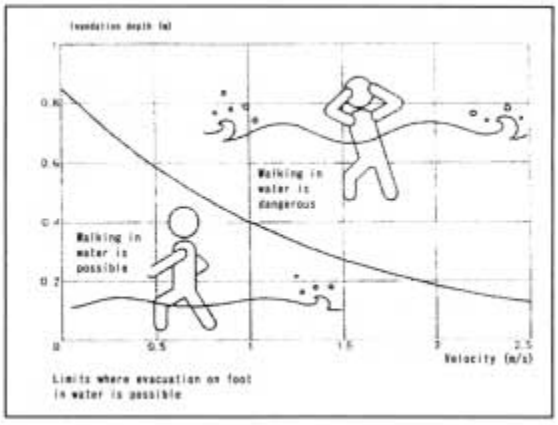
Estimate the inundation depth of each mesh by subtracting the averaged ground level (commonly, 50-m mesh in Japan) from the maximum inundation level as defined above, and finally, define the boundary of the flood-prone area, taking into consideration the relevant factors such as existing continuous structures and micro-topographic features.

(6) Designation of Inundation Depth

Designation, by using colors, the inundation depth so that the local residents are able to easily understand accurate inundation information.
Inundation depth is normally classified into five ranks, as shown below. Whenever necessary, other ranks such as 2.0 to less than 3.0 m, 3.0 to less than 4.0 m and 4.0 to less than 5.0 m are acceptable.

Category of inundation depth	Reference description
0.0 m	no inundation
0.5 m	around the level of the knee of an adult
1.0 m	around the level of the waist of an adult
2.0 m	around the level of the eaves of the first floor
5.0 m	around the level of the eaves of the second floor





Evacuation on foot in flowing water would be substantially difficult and dangerous. Accordingly, evacuation well in advance of the start of flooding, is strongly recommended.

8.5 Establishment of Evacuation Plans

1) Identification of Evacuation Refuges
Identify existing buildings and facilities suitable for use as refuges. It may be possible to set up the temporary refuges in the flood-prone area, which flood-resistance and number of stories have been affirmed in relation to the potential inundation depth.

2) Determination of Evacuation Means
It is not advisable to use cars to escape from flooding, except under special circumstances. Traffic jams and unexpected accidents may result from many residents evacuating by car at the same time. Evacuation on foot is a primary rule.

3) Identification of Evacuation Distance and Timing
It is desirable that the distance of evacuation on foot shall be less than 2 km in all cases. Identify proper refuges for the respective areas to be evacuated, taking into consideration the distance and the accommodating capacity of the respective refuges.

4) Identification of Evacuation Routes
Identify the evacuation routes that are safe from flooding and other disasters, such as mudflows and debris torrents. If recommended routes exist, clearly specify them on the map.

5) Identification of Dangerous Spots on Evacuation Routes
Identify flood-prone roads, bridges and other potential dangerous spots, and clearly show them on the map.

6) Zoning of Areas to be Evacuated and Appropriate Evacuation Refuges
Establish zonings for proper refuges, in correspondence with the location and population of the relevant areas to be evacuated, and the location and accommodating capacity of the respective refuges.

7) Establishment of Positive Assistance Plans to Vulnerable Residents
Establish evacuation means for those who are vulnerable, such as the elderly and handicapped (preparation for evacuation, issuance of advisory evacuation warning, specifically-prepared refuges, etc.).

8) Establishment of Communication Channels
Establish reliable communication channels for urgent, essential information, ensuring safe evacuation (TVs, radios, walkie-talkies, cable broadcast telephones, CATV, ordinary telephones, Internet homepages, messengers, loudspeaker vans, sirens, electric-light notice boards, etc.).

8.6 Establishment of Issuance Criteria for Evacuation Warnings

Evacuation warnings are issued in the following order and steps:

-Preparation warning for evacuation	Warning to residents to make preparations for possible evacuation (earlier preparation warning is particularly effective).
-Advisory evacuation warning	Warning to residents advising start of evacuation.
-Imperative evacuation warning	Warning to residents ordering immediate evacuation.

(1) Issuance Criteria for Imperative Evacuation Warning

1) Define flooding-start levels
   Define possible water levels (such as HWL) for levee-break or spillover water levels for the reaches without levees.
2) Define necessary time for evacuation
   It is desirable, in principle, that evacuation would be completed by the time the floodwater reaches the above-mentioned reference levels. The necessary time for complete evacuation after the issuance of the imperative evacuation warning is to be specified.
3) Define reference water levels for issuance of respective warnings
   Assuming that the necessary time for evacuation is n hours, find the water level from which the river water reaches the specified flooding-start level n hours later. Define this level as the reference water level for issuance of the imperative evacuation warning. To predict specific water levels, it is conceivable to use the predicted flood-forecast results in cases of jurisdictionally-designated rivers. However, such flood-forecasts are not yet sufficiently accurate, and, in some areas, more accurately predicted water levels may simply be derived by correlating the observed water levels at nearby stations with the predicted water levels.

(2) Issuance Criteria for Advisory Evacuation Warning

The issuance of the advisory evacuation warning shall be done well in advance of the imperative evacuation warning, and the timing of issuance of the advisory evacuation warning shall be one or two hours earlier, depending on the specific conditions of the respective areas.

(3) Issuance Criteria for Preparation Warning for Evacuation

When urging evacuation prior to inner-basin inundation, the advisory evacuation warning shall be issued before the occurrence of inner-basin flooding and accordingly, the timing of the issuance of the advisory evacuation warning shall be one or two hours ahead, estimating the starting time of the inner-basin flooding.

8.7 Production of Flood Hazard Map

Flood hazard maps shall be produced in easy-to-understand format, integrating various types of information on inundation and evacuation, as well as evacuation intent.

Table 4 Principal Items and Information to be Incorporated in Flood Hazard Maps

Category			Description
Evacuation-use Information	Information on inundation	Past inundation	Historical records of inundation (maximum or latest)
		Predicted inundation	Inundation-prone areas, other possible inundation areas Inundation depths, inner-basin water, time of flood concentration, flood flow velocity Degree of hazard when inundated
	Information on evacuation	Areas to be evacuated	Endangered areas
		Evacuation refuges	Names, locations and phones number of refuges Family's notes on disaster prevention activities
		Dangerous spots on evacuation routes	Dangerous spots on evacuation routes with potential mudflows, debris torrents, steep-slope collapse and underpasses
		Rules to follow in the event of evacuation	Hints for evacuation
		Communication channels for flood forecasts	Communication channels for flood forecasts (usually the same as those for information on evacuation)
		Communication channels for information on evacuation	Channels for information on evacuation (Evacuation Preparation Warning, Advisory Evacuation Warning and Imperative Evacuation Warning)
		Underground spaces	Information on evacuation for underground spaces (recognition of danger in underground spaces, locations of spaces, communication system to users)
		Evacuation criteria	Criteria on evacuation warnings and guidelines for successive action
		Facilities for the vulnerable	Names, locations and phone numbers of facilities, such as specific hospitals, welfare facilities and schools, ready to accommodate the vulnerable
	Base maps		Base maps to identify location and extent of inundation areas to be evacuated
	Other information		Title, explanation, scale, azimuth, local municipalities, authors, phone numbers, date of production, and local organizations concerned for disaster prevention activities
Educational-use Information	Past inundation		Data on hydrological and meteorological conditions (rainfall, water level, flood discharge), inundation records (extent, depth and duration of inundation), damage suffered and evacuation records at inundations
	Rainfall		Correlation of hourly rainfall, flood status and successive evacuation, to be represented in easy-to-understand format with illustrations
	Communication channels for information on disaster prevention efforts		Information in easy-to-understand format on meteorological warnings, flood forecasts, evacuation warnings, etc.
	Mechanism of flooding		Flooding mechanism with local characteristics
	Rules to follow in everyday life and in the event of flood		Hints in brief to follow in everyday life and in the event of flood
	Staying in refuges		Rules to follow when staying in refuges
	Directions for familiarizing oneself with Flood Hazard Maps		How to familiarize oneself with Flood Hazard Maps
	Directions for using the Flood Hazard Map		How to determine the route between one's house and a proper refuge on the Flood Hazard Map, and how to specify family's actions in the event of emergency
	Other information		Other valuable information to encourage effective use of the Flood Hazard Map in everyday life, such as: Emergency evacuation from a flooded house Rope knotting Rescue procedures when one falls in a river First-aid to the injured