1.3 River litter monitoring survey using stationary cameras

Section 1.3 of this Annex assumes that a variety of groups will conduct monitoring or surveys (hereinafter in this Annex referred to as "surveys") using stationary cameras for a variety of survey purposes to target litter in the environment, especially litter on the river, based on the common items listed in the main body of the guidelines.
The results of the demonstration test conducted using a survey methodology based on this Annex are presented in Appendix 3 Result of demonstration test for river litter survey using stationary cameras.

1.3.1 Survey planning and preparation

(1) Survey purpose

- It is important to clearly identify the survey purpose at the beginning since the survey plan depends on the survey purpose.
- See the main guidelines "Chapter II Purpose of monitoring and how to select the survey methods" for examples of survey objectives, methods for selecting survey (monitoring) methods, and monitoring methods to address various policy issues.

(2) Survey procedures

- A rough flow from the planning of the investigation to the image analysis is shown below. Stages 1 and 2 correspond to Section I of these guidelines Annex, and Stages 3 and 4 correspond to Section II.

Stage 1. Survey planning and preparation

- Determination of survey targets
- Selection of survey locations
- Determination of survey timing
- Preparation and setting of equipment
- Confirmation of legal requirements and implementation of necessary procedures
- Ensuring an adequate number of personnel to be involved in the survey

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Stage 2. Survey implementation

- Installation of survey equipment
- Shooting of scales
- Measurement of data necessary for flow estimation
- Measurement of data necessary for extrapolation of measurements
- Safety management
- Verifying Data
- Maintenance

↓

Stage 3. Image processing and analysis

- Selection of images for analysis from captured video
- Detection of litter from images (manual or automatic)

↓

Stage 4. Quantification of river litter

- Characterization of litter flowing in the river (counting objects, types, materials, analysis of the size of items)
- Estimation of the annual amount of litter discharged from the specified area

(3) Survey target

(A) Target size

- Determine the target size of litter in consideration of the survey purpose.
- In several existing guidelines for beach litter surveys, such as EU (European commission 2013), GESAMP (GESAMP 2019), NOAA(Burgess et al. 2021), and Japan (Ministry of the Environment, Government of Japan, 2023), the survey targets are litter of 2.5 cm or larger, which generally corresponds to macro litter. Therefore, it is recommended that litter of 2.5 cm or larger be targeted for comparability with existing surveys.
- It is necessary to note in advance, however, that the lower limit of the survey target size is related to the distance from camera to litter, and the measurable size isn't fixed because the distance from camera to litter varies depending on the river level. Examples of distances from camera to litter and target size ranges of litter, which can be inferred from general camera performance, are shown in Table 1.3.1. Note that even when the lower limit of the target size is set at 2.5 cm, the lower limit may be larger than 2.5 cm in image detection by the AI. Since this depends on the size of the litter in the AI training data, it is necessary to separately check the lower limit of AI detection beforehand or after detection. The recommended GSD for AI detection varies depending on the specific AI model and approach, but generally, using approximately 1.0 mm/pix for image segmentation (IS) is considered ideal for achieving optimal detection accuracy (Kataoka et al. 2024).

Table 1.3.1. Example of target size range of litter for each distance from camera to litter and image resolution

Distance from Camera to Litter (m)	Measured Litter Size in Full HD*2 (cm)	Measured Litter Size in 4K*3 (cm)
5	2.5 -	1.5 -
10	5.0 -	2.5 -
15	7.5 -	4.0 -
20	10.0 -	5.0 -

*1 The actual range of the camera and the size of the measurable litter may be depend on the environment in which the camera is installed and the surrounding conditions.
*2 Pixel count: 1,920×1,080
*3 Pixel count: 3,840×2,160

■Point
For comparability with existing surveys, it is recommended that the target litter be 2.5 cm or larger.

(B) Type of litter

River litter contains man-made and natural objects. The decision as to whether to target man-made litter or natural objects, or both, is based on the litter issues in the survey area and comparability with existing survey.

(C) Classification

- If identification of the type of man-made litter is included in the survey purpose, it is recommended to plan the type of litter that you would like to classify.
- The decision to classify litter is based on the litter that is an issue in the survey area and comparability with existing surveys.
- Table 1.1.3 shows the basic categories of litter used in Annex 1.1 Beach litter survey methods using UAV. The items in Table 1.1.3 are classified as litter in the above-mentioned guidelines for beach litter surveys, and since they are frequently found in the world, it is recommended to conduct surveys from the viewpoint of comparison with other surveys.

- Some of the litter (caps/lids, lighters, cigarettes, etc.) may be small in size or submerged in water, making them difficult to identify. Of these litter types, caps/lids and cigarettes are the major types of marine litter, and they should be identifiable wherever possible. Also, if there are other items that cannot be classified due to image resolution, only classifiable items should be classified.

Table 1.3.2. Average sizes for small items

Items	Average Size (cm)	Note
Caps/lids	2-3	
Lighters	5-8	Near neutral buoyancy, flows vertically due to heavy ignition part, difficult to see from the bridge
Cigarettes	6-10	

*The size of each piece of litter represents the average length of its longest side, based on the standard product sizes in Japan

Table 1.1.3. Classification item proposal and correspondence with other guidelines

Classification Item		Correspondence with Other Guidelines				
Level1	Level2	EU (Item Code and Name)	OSPAR (Item Code and Name)	UNEP (Item Code and Name)	NOAA (Item Name)	Japan (Item Name)
Plastic	Caps/lids	G21-G24 (Plastic caps/lids drinks, Plastic caps/lids chemicals, detergents (non-food) , Plastic caps/lids unidentified, Plastic rings from bottle caps/lids)	15 (Caps/lids)	PL01 (Bottle caps & lids)	Bottle or container caps	Bottle cap, lid
	Beverage bottles	G7-G8 (Drink bottles <=0.5L, Drink bottles >0.5L)	4 (Drinks (bottles, containers and drums))	PL02 (Bottles < 2 L)	Beverage bottles	Plastic bottles for beverage (pet bottle) <1L, Plastic bottles for beverage (pet bottle)≧1L
	Plastic bags	G3 (Shopping Bags incl. pieces)	2 (Bags (e.g. shopping))	PL07 (Plastic bags (opaque & clear))	Bags	Plastic shopping bag
	Floats, buoys	G62, G63 (Floats for fishing nets, Buoys)	37 (Floats/Buoys)	PL14 (Plastic buoys)	Buoys and floats	Buoy (fishing implements) (plastics), Float/buoy made of foamed polystyrene
	Fishing nets, ropes, and twine (including ropes and twine other than fishing tools)	G49, G50, G52-G54, G56 (Rope (diameter more than 1cm), String and cord (diameter less than 1cm) , Nets and pieces of net, Nets and pieces of net < 50 cm, Nets and pieces of net > 50 cm, Tangled nets/cord)	31, 32, 33, 115, 116 (Rope (diameter more than 1 cm), String and cord (diameter less than 1 cm), Tangled nets/cord/rope and string, Nets and pieces of net < 50 cm, Nets and pieces of net > 50 cm)	PL19, PL20 (Rope, Fishing net)	Rope and nets	Rope/string (fishing implements), Fishing nets (fishing implements)
	Food packaging*	G3 (Crisps packets/sweets wrappers)	—	—	Food wrappers	Container and package for food
	Lighters*	G26 (Cigarette lighters)	16 (Cigarette lighters)	PL10 (Cigarette lighters)	Disposable lighters	Lighter
	Cigarettes*	G27 (Cigarette butts and filters)	64 (Cigarette butts)	PL11 (Cigarettes, butts & filters)	Cigarettes	Cigarette butt (filter)
Rubber	—	—	—	—	—	—
Cloth/textile	—	—	—	—	—	—
Paper/cardboard	—	—	—	—	—	—
Processed/worked wood	—	—	—	—	—	—
Metal	—	—	—	—	—	—
Glass/ceramics	—	—	—	—	—	—

*Caps/lids, Food packaging, lighters, and cigarettes are not items that must be classified because their small size makes them difficult to distinguish at this time. However, future technological development may make it possible to identify them.

(4) Survey location

(A) Survey region

- In selecting the study area, the following points should be confirmed.
  - Whether the equipment can be brought to the site or procured.
  - Whether there is a suitable environment for a network. (In locations where a network is available, webcams can be used where captured images are automatically shared to the cloud. However, it is possible to survey cameras that store images on the camera's hard disk even in the absence of a network.)

(B) Survey categories

- According to previous surveys, there is a positive correlation between the amount of man-made litter and the rate of urbanization (Figure 1.3.1). Therefore, if you want to know the amount of river litter from a wide area district, it would be difficult to accurately assess the amount of man-made litter from the entire district by estimating it through a survey on a single river with an extremely high (or extremely low) urbanization rate.
- To minimize such errors, the concentration of population in a watershed should be sorted out and then divided into three categories by population density (population density: high, medium, and low). If it is difficult to classify by population density, geographical balance (administrative divisions, watershed divisions) should be considered in addition to population density.
- If only one river is to be surveyed, it is preferable to conduct the survey in a river with a high urbanization rate as much as possible to avoid loss of estimation accuracy due to extremely low river litter.

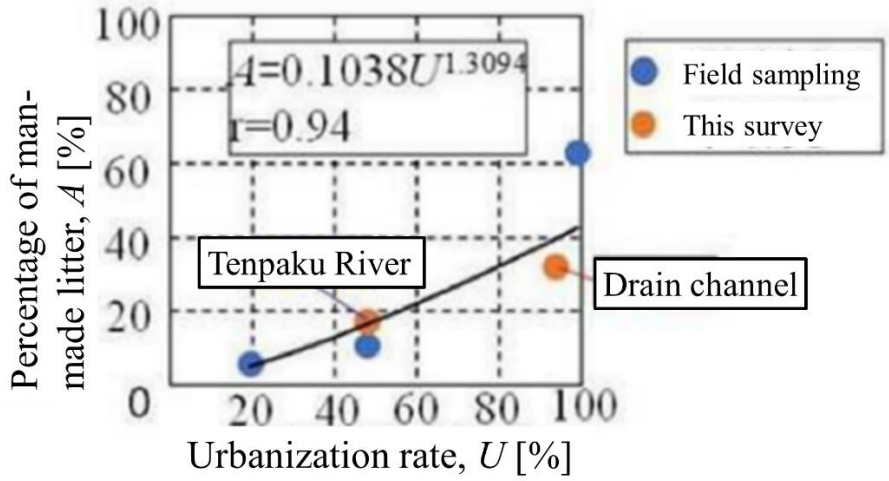


Figure 1.3.1. Relationship between urbanization rate and percentage of man-made litter
(Translated and processed from Japan Environmental Sanitation Center, 2020)
*Figure 1.3.1 was made based on the research conducted in Japan. The relationship between the percentage of manmade litter and urbanization rate varies in other countries.

【Reference: Example of establishment of survey categories (Osaka, Japan)】

- Since the amount of river litter is considered to be dependent on the concentration of population in the watershed, municipalities in Osaka were divided into three categories by population density in urbanized areas, and rivers with watersheds in each category were selected as model rivers.
- The number of pieces of litter flowing downstream was counted from images taken by the disaster prevention river cameras installed in the model rivers on rainfall days* and non-rainfall days for each model river, and multiplied by the number of rainfall days and non-

rainfall days per year to calculate the annual number of pieces of litter flowing downstream.

- The annual number of river litter per area of each model river was estimated by dividing the annual number of river litter per area of each model river proportionally by the watershed population of “urbanized areas” and “other areas” and by the watershed area.
- This estimate was averaged by the population density category and multiplied by the total area for each category to arrive at the total amount of litter entering Osaka Bay from Osaka.

* Rainfall days: A daily rainfall of over 10 mm or a maximum hourly rainfall of over 5 mm.

Table 1.3.3. List of model rivers in Osaka

Categories	Model Rivers	River Camera Locations
Category 1 (High)	Hirano River	Osaka (Ken Bridge)
	Heya River	Daito (Neyagawa Retarding Basin)
	Furu River	Kadoma (Kuwazai)
	Onchi River	Higashioosaka (Onchi River Flood Control Green Space)
Category 2 (Middle)	Nishiyoke River	Osakasayama (Kusazawa Footbridge)
	Tsuda River	Kaizuka (Nankai Main Line)
	Sumiyoshi River	Kumatori (Okubonaka)
Category 3 (Low)	Ume River	Kanan (Terada Bridge)
	Okawa River	Misaki (Nankai Bridge)
	Hitokura Oroji River	Nose (Fukada Bridge)

(Translated and processed from Osaka website)
https://www.pref.osaka.lg.jp/o120070/kankyohozen/osaka-wan/gomisuikei.html

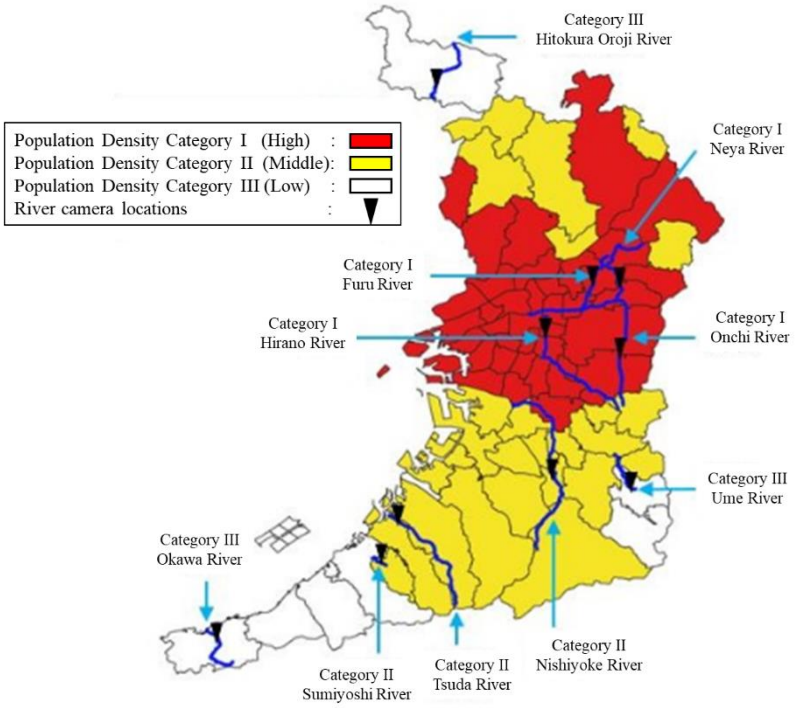


Figure 1.3.2. Model rivers and camera locations in Osaka
(Translated and processed from the Osaka website)
https://www.pref.osaka.lg.jp/o120070/kankyohozen/osaka-wan/gomisuikei.html

(C) Survey river

- The survey river is selected based on the purpose of the survey and status of the rivers in the watershed, land use patterns, and water use conditions.
- Measurement of the river litter survey should be conducted in a river that is representative of the survey area in terms of surrounding land use patterns and water use conditions. (For example, if most of the survey area is occupied by agricultural lands, it is considered possible to more accurately determine the status of river litter by conducting the survey in a river where the surrounding area is agricultural land.)
- In selecting the survey area, the following points should be confirmed.
  - Whether the site is suitable for the survey described below (1.3.1(4) (D)Survey site).
  - If a survey area is defined in the previous section (1.3.1(4)(B) Survey categories), whether the watershed is within the survey area (although it is possible to survey the watershed even if it is not contained, it is possible to estimate more accurately if it is contained).
  - Whether the survey site is affected by tidal changes. It is recommended to select locations unaffected by tides. If the site is affected by tides, measures should be taken to prevent the same litter from being counted multiple times.
- If the purpose is to estimate the annual amount of litter, the following points should be confirmed in the selection of rivers.
  - Whether the river is able to determine its flow on an annual watershed.
  - Whether the river is watered throughout the year.
- It is desirable to consider rivers by taking into account the occurrence of illegal dumping based on past surveys. By conducting the survey downstream from where the illegal dumping of litter is occurring, it would be possible to more accurately determine the amount of litter in the river.
- The scale of rivers surveyed using stationary cameras in previous research cases is shown in Table 1.3.4

Table 1.3.4. Overview of representative river litter surveys using stationary cameras

Research Title	River Name (Country)	Observation Method	River Width
Study on total floating-litter and drift-woods transport in Mogami River and countermeasures for floating-litter (Minami et al., 2016)	Mogami River (Japan)	Two stationary cameras installed on the bridge	Approx. 60 m *1
	Mogami River (Japan)	Three stationary cameras installed on the bridge	Approx. 100 m *1
Comparison of anthropogenic debris flux in various floods with continuous monitoring of IP camera and image analysis (Yoshida et al., 2021)	Tempaku River (Japan)	One stationary camera installed on the bridge	8.6 m
	Tempaku River Drainage Channel in the Same Basin (Japan)	One stationary camera installed above the open channel	4.5 m
Automated River Plastic Monitoring Using Deep Learning and Cameras (Van Lieshout et al., 2020)	Ciliwung River (Indonesia)	One stationary camera installed on a bridge	Approx. 50 m *1
Automated River Plastic Monitoring Using Deep Learning and Cameras (Van Lieshout et al., 2020)	5 riverways in Jakarta (Indonesia)	One stationary camera installed on a bridge	N/A
Water Hyacinths as Riverine Plastic Pollution Carriers (van Emmerik et al., 2024)	Saigon River (Vietnam)	Multiple stationary cameras installed on the bridge	185 m, 225 m, 305 m *2

*1 For rivers where the width was not explicitly stated in the research papers, the river width was measured using Google Maps.

*2 Conducted at multiple locations along the same river.

(D) Survey site

- For estimating net flow rate of litter, sites downstream of urban areas or where there is a confluence of rivers are preferred. As close to the estuary as possible is desirable, provided that there is no accumulation of litter (as this may lead to overestimation).
- In selecting the location for the stationary camera, the following points should be confirmed.
  - Where safe installation and removal operations can be conducted.
  - Close to the flow observation point or water level observation point (to use the flow rate for estimating the amount of litter outside of the survey period when using observations for each point）.
  - It is recommended that the flow is as uniform as possible in the cross-sectional direction when estimating the entire cross-sectional flow by shooting only a portion of the river cross-sectional direction.
  - Not a place that is accessible to passersby, such as a bridge on a public road, but a place that is locked or otherwise inaccessible to passersby.
- When estimating the area of litter in a river, it is necessary to take images so that the optical axis of the camera is pointing vertically downward toward the surface of the water. In this case, the following points should be confirmed when determining the survey site.
  - There is a bridge or other structure suitable for shooting directly above the river surface.
  - Locations with little vibration due to vehicle travel (to acquire images with less blurring).
- Existing stationary cameras (for example disaster prevention cameras) can be used for survey if the installation position, angle of view, image quality, and frequency of shooting meet the survey objectives.

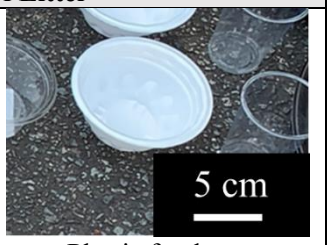
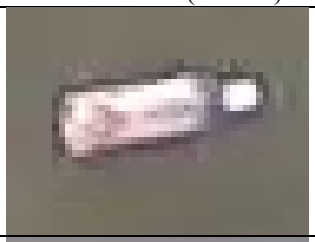
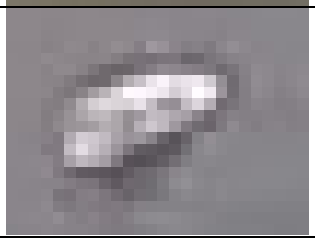
(E) Shooting area

- The range of shooting depends on the river width and distance from the camera to the litter, the resolution of the image, and the performance of the camera (focal length and angle of view).
- In general, the greater the distance from the camera to the litter stream, the wider the area that can be shot, but the resolution of the distant view is reduced, making it difficult to distinguish fine litter.
- The amount of litter in the river may vary at the same location depending on the flow rate at each location (right, center, and left bank side), whether there is vegetation, and whether it is rocky. Therefore, it is recommended to photograph the entire river crossing direction.
- If it is difficult to shoot the entire cross-sectional direction of a river due to its wide width, a specific area is shot, and the measured values are extended to the entire river width to estimate the amount of litter flowing in the entire river (See 1.3.2(2)). In this case, it is necessary to determine the cross-sectional distribution of litter in the flow direction by measuring flow velocity or conducting a visual survey.
- Since the distribution of litter may vary depending on the river conditions, it is desirable to have a system that can acquire data for the entire river (data obtained by stationary camera or visual survey) depending on the situation. For example, one stationary camera is installed, and for the area not covered by it, a visual survey is conducted or supplementary cameras are installed to survey the entire river.

Table 1.3.5. Example of distance from camera to litter and possible shooting range

Distance from Camera to Litter [m]	Shooting Range (Cross-Section) [m]
5	4 - 10
10	7 - 20
15	11 - 30
20	14 - 40

Table 1.3.6. Example of the images of litter

Distance from Camera to Litter [m]	Measured GSD* in Full HD [cm/pix]	Images of Litter	
		 Plastic bottle (500 ml)	 Plastic food tray
13	1.3		
22	1.9		

* Ground Sampling Distance (GSD) is the size of each pixel (Kako et al. 2024)

■Point
It is recommended to shoot the entire river crossing direction since the distribution of litter may vary depending on the river conditions.
When photographing only a specific area, it is necessary to determine the cross-sectional distribution of litter in the flow direction.

(5) Survey timing

(A) Season

- Conduct the survey in the appropriate season according to the research purpose.
- When estimating the annual amount of litter, survey data from both the high water level period (the periods when there is a possibility of a rapid rise in water level due to typhoons, rainy season, and other heavy rains), and normal water level periods (the periods when the river is at its normal level and volume) are required. The division between high and normal water level periods is established based on the annual water level (level condition) of the survey river and the annual daily precipitation near the survey river. In cases where it is difficult to conduct surveys during both the high water level and normal periods, it is preferable to conduct surveys during the high water level period in areas where the amount of litter during the normal period is low. In areas where the volume of litter in the normal water flow is high, it is also possible to estimate the amount of litter in the normal flow period.
- If you want to survey during the high water level period, note that the camera should be set before the high water level period for safety.
- Note that the time when many petals and fallen leaves are flowing down the river requires more time and effort for analysis.

■Point
The timing of the survey (high/normal water level period, weather on the day of the survey) should be decided from the perspective of the survey data comparison.

(B) Survey period

- It is recommended that the shooting period be as long as possible. According to a previous survey, the number of high water level events required to estimate the annual amount of litter from one river is generally considered to be about 10 (Ministry of the Environment 2021); however, depending on the extent of the high water level, a larger number of data may be needed. It is also desirable to observe large-scale high level water events such as floods. The number of hours for which data can be obtained for one high water level event, from the rise of the water level to the peak and almost zero litter, should be confirmed in advance. In the previous case study conducted in Japan, the time required was approximately 6 hours.
- The presence or absence of a high water level event refers to the water level obtained from the water level sensor installed on the camera. Since the criteria for high water level events are expected to vary from river to river, appropriate criteria are selected from the water level records after the survey is conducted.
- For surveys conducted during normal water levels, it is recommended that a minimum count of about 100 pieces of litter be measured to determine the composition of the litter. When conducting a survey during normal water levels, the number of pieces of litter observed during the observation period should be investigated in advance before deciding on the survey period. In a previous case in Japan, a total of about 40 pieces of litter were observed for an observation period of 21 days (Osaka 2021).

■Point
It is recommended that the observation period be as long as possible. It is also desirable to observe large-scale high level water event such as floods.

(6) Survey equipment and installation image

- Table 1.3.7 shows examples of equipment used for shooting, and Table 1.3.8 shows examples of equipment used for shooting (installation fixtures). Table 1.3.9 shows the main specifications for an example of a camera.
- The camera must have an interval shooting function (a function that repeatedly takes images at regular intervals). In addition, the use of webcams with the ability to automatically upload captured images to the cloud enables automated, long-term observations and facilitate observation of time series variations.
- The number of pixels required varies depending on the distance from the water surface to the camera and other factors, but 3 million pixels or more is desirable, and it is recommended that the camera be used within the optical zoom range (if this is not readily available, use a camera with a higher pixel count).
- Equipment can be installed in the following ways.
  - Fixed to the railing of a bridge crossing a river
  - Install pipes to secure the camera
- When estimating the dimensions of river litter, water level sensors need to be installed because water level data is necessary for analysis. If you want to change the frequency of shooting by the interval camera according to the river water level, the sensor is required to monitor the river water level.
- Since the survey equipment (especially solar panels and stationary cameras) may be severely blown away by strong winds such as typhoons, it is advisable to take as thorough measures

as possible to secure and prevent the loss of the survey equipment. Specifically, it is effective to use ropes to secure the survey equipment to existing structures (such as the parapet of a bridge) that is different from the installation fixtures.

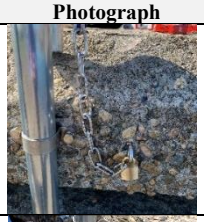
- Since the cloud service has capacity limitations and the data backup system may not function in the event of a typhoon or other large-scale flooding, it is recommended that priority be given to saving backup photographs/videos taken and water level information.
- For reference, Figure 1.3.3 and Figure 1.3.4 show details of the equipment used in the Ministry of the Environment's demonstration project, Figure 1.3.5 shows an image of the equipment installed, and Figure 1.3.6 shows an example of the equipment installed.

Table 1.3.7. Examples of equipment used for survey

Equipment	Uses	Consideration	Photograph
Interval camera	Used to remotely view and store image data	It is recommended that the camera be equipped with a lens (varifocal lens or optical zoom lens) that can change the shooting range (magnification) by changing the focal length. In general, a 12 VDC power supply that can be connected to a DC battery is used; if 100 VAC is used, an AC converter is required, which is not suitable for long-term operation due to the high power consumption of the converter. A device that can be connected to an Internet device is recommended.	
SD card	Installed on camera and used to store images	The larger the storage capacity, the more images can be stored. Therefore, the storage capacity should be selected according to the number of pixels in the video and the shooting time. In addition, make sure in advance that the SD card is compatible with the camera to be used. Generally, a 64GB SD card can record approximately 10 hours of Full HD video and 1 hour and 50 minutes of 4K video. Even cameras that can automatically store images in the cloud can be disconnected from the network due to problems, so it is recommended that an SD card be used in conjunction with the camera.	
SIM card	Used to connect the camera to the network	Use a SIM card that can connect to an Internet connection in the survey area. Prepare the camera that is compatible with the SIM card in advance.	
Solar panel	Used to shoot without power source	Select panels according to the required battery capacity, such as 80W_17.5V, 100W_22.5V, etc. Select a charge controller that is compatible with the panel's release voltage (V).	
Battery	Used to store power obtained from solar panels	Select a battery suitable for solar power generation, such as a lead-acid shielded battery for marine use. Common automotive batteries are not suitable for on-site use because they are prone to performance degradation due to voltage drops. Connect the above charge controller to prevent overcharging and over-discharging of the battery. Take safety measures such as housing the battery in a waterproof case to prevent electric shock or fire due to short circuit.	

Water level sensor	Used to measure water level	Accuracy: 0.25% or 6 mm, whichever is greater. Resolution: 0.01% or 2 mm, whichever is greater.	
Controls	Controllers with built-in Internet equipment and contain the system that coordinates each facility	This is not necessary if the interval camera has a built-in network function. If not, install an external control device to control it.	 (Ministry of the Environment, 2020)
Installation fixtures	Rubber sheet to protect mounting hardware and mounting pipes	To prevent the paint from peeling off the pole on which the interval camera is fixed, take extra precautions such as wrapping a rubber sheet around the pole to protect it when installing the camera.	

Table 1.3.8. Examples of equipment used for survey (installation fixtures)

Equipment	Uses	Consideration	Photograph
Anti-theft chain and padlock	Used to prevent theft of cameras and solar panels	-	
Single pipe	Used as equipment to install cameras in high locations	Adjust the length and number of pieces according to the installation location.	
Bracket for camera and solar panel installation	Used to fix camera and solar panel to single pipe and adjust angle	Use a case appropriate for the size of the camera case and solar panel.	
Saddle band	Used to fix a single pipe	Use one that fits the thickness of the single pipe.	
Clamp, cover for clamp	Used to connect single pipes and to install cameras and solar panels	It is recommended that the clamp is protected by a plastic or other cover.	

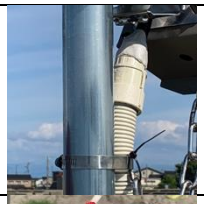
Zip tie	Used to bind single pipes	-	
Clincher	Used to secure clamps and fittings	The size and length should be appropriate for each application.	
Ropes	Used to secure and prevent the loss of the survey equipment (especially solar panels and stationary cameras).	Protective material should be placed between areas where wear is expected.	
Hose and seal putty for pipe protection	Used to install hoses for pipe protection and fill the joints with waterproof seal putty	-	
Rust inhibitor, lubricant	Used to prevent metal corrosion and rusting	-	

Table 1.3.9. Example of interval camera specifications

Function	Specifications
Resolution	2560×1440
Zoom	Optical 4x, Digital 16x
Focal length	2.8 ～12 mm
Compression	H.265+/H.265/H.264+/H.264/MJPEG
Power output	DC12V、Max 60 mA
Operating environment	Temperature: -20℃～60℃ Humidity: over 90% (Non-condensing)
Protection class	Waterproof, dustproof IP66 (IEC 60529-2013) / shockproof IK10 TVS 4000V lightning protection, surge protection, voltage transient protection

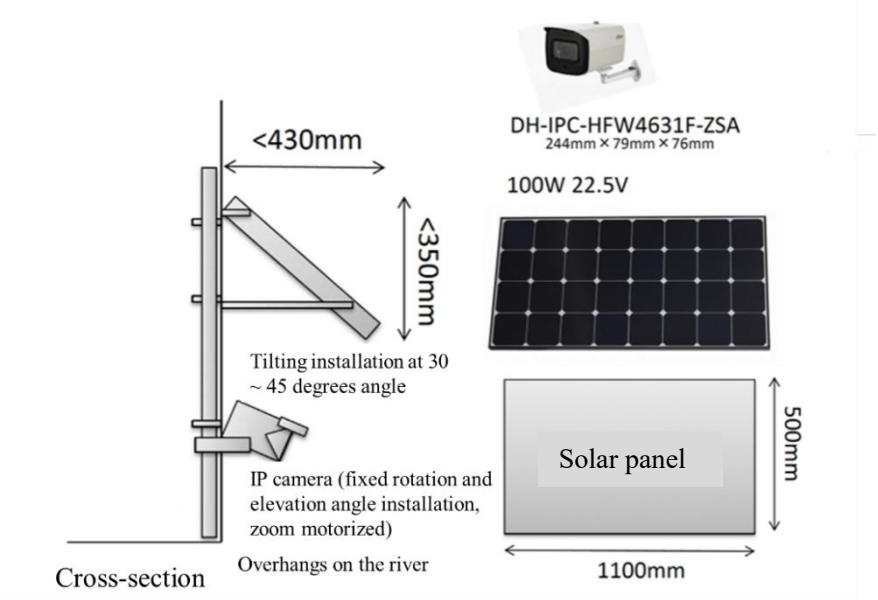


Figure 1.3.3. Details of interval camera and solar panel
(Translated and processed from Ministry of the Environment, 2020)

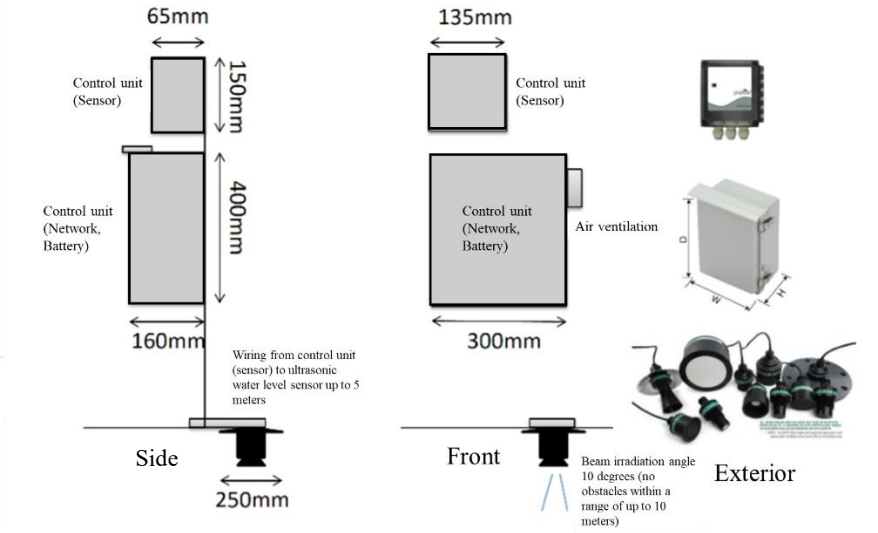


Figure 1.3.4. Details of water level sensor and control devices
(Translated and processed from Ministry of the Environment, 2020)

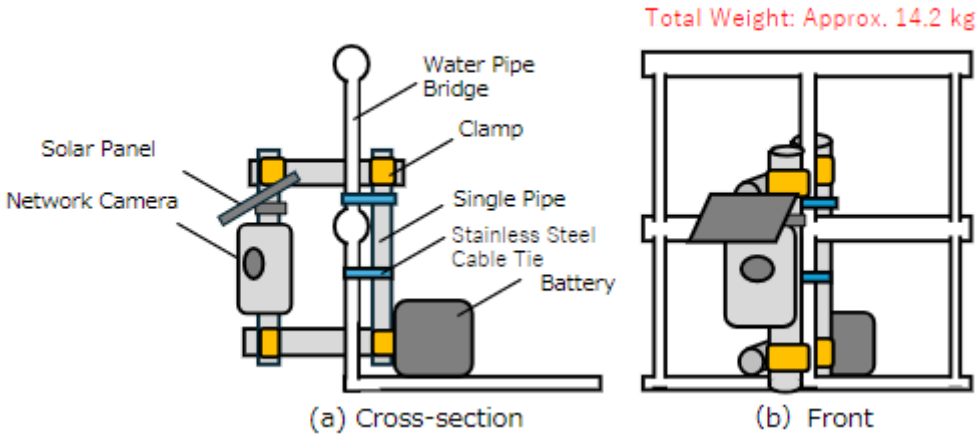


Figure 1.3.5. Installation image of equipment

Figure 1.3.6. Example of equipment installation

- Shooting scales are necessary to estimate the area of river litter, and the following equipment is used.
  - Scale (square frame (1 m x 1 m), etc.): Any material, thickness is acceptable, as long as the length is accurately ascertained and can be hung down while remaining horizontal.
  - Rope for hanging down.
- Consideration of other equipment is recommended according to the survey plan.

(7) Legal considerations and requirements
- Apply for permits for stationary cameras and use of the river. Information such as location and method of installation, duration of installation, frequency of data collection, need for constant monitoring/patrol network, date and time of installation/removal work, should be organized in advance. Since there are different laws and regulations by national and local governments, etc., and the applications required differ depending on the installation location, the necessary applications should be made after confirming in advance what type of application is required, and surveys should be conducted in accordance with the laws and regulations.
- Since it may take several months to obtain a permit, it is recommended that applications be submitted well in advance.

(8) Researcher
- When installing equipment, it is recommended that at least two researchers work together for safety (at least one person to monitor the safety of the surrounding area and one person to install the equipment).
- Depending on how the equipment is installed, partial fabrication (cutting, drilling, bending) of sheet metal parts for the stationary camera and solar panel installation may be required. In such cases, design and installation can be outsourced to a construction company.

(9) Setting of equipment

(A) Shooting time and frequency
- Cameras should be set to shoot at times when sunlight is available, and shooting is possible (e.g. 9:00 AM -4:00 PM). Note that the time of daylight availability varies with the season.
- Recording settings depends on the time of the survey (during high or normal water level period for small rivers in Japan) (Table 1.3.10).
- For each high water level event, it is necessary to collect a series of data from the time the water level rises to peaks until the amount of litter is the same as during the normal water level period. Since the observation time required for this is expected to vary depending on the amount of precipitation of the high water level event, it is recommended to vary the number of days of data acquisition according to the amount of precipitation.
- In small rivers, even large-scale high level water events may be completed in a short period of time (approximately half a day). Therefore, it is desirable to use a standard shooting interval such as once every 10 minutes for 1 minute recording.
- For surveys during normal water level periods, it is desirable to shoot once every 60 minutes for 5 minutes. However, if it is difficult to shoot for more than 1 minute in a survey using a stationary camera, it is recommended that the frequency be increased to every 10 minutes or every 30 minutes. Additionally, it is recommended to set appropriate shooting intervals based on the conditions and characteristics of the river.

Table 1.3.10. Example of stationary camera observation settings for small rivers in Japan

Survey season	Shooting Frequency	Number of Observation Days
High water level period (small)	Recorded once every 10 minutes for 1 minute	1 day observation per event
High water level period (large)	Recorded once every 10 minutes for 1 minute	2 - 3 days observation per event
Normal water level period	Recorded once every 60 minutes for 5 minutes	About 25 days

■Point
For comparability, the recommended shooting frequency are once every 10 minutes for 1-minute during high water level period and once every 60 minutes for 1-minute during normal water level period.

(B) Other

- Depending on the camera specifications, setting changes and shooting instructions can be sent remotely via SMS on a smartphone application by registering the phone number of a smartphone or other device.

(10) Preparation of survey equipment

- To ensure smooth installation of equipment at the survey site, preparations for equipment installation should be made in advance.
- When installing the camera in a high position, it is recommended to insert the SIM card and SD card and setting the camera beforehand.
- By installing solar panels, it is possible to eliminate the need to periodically replace the camera batteries.
- When installing a solar panel on a stationary camera, specialized skills, such as fabrication and processing of parts, may be required to adjust the angle of the solar panel and connect the wiring to the camera.

1.3.2 Survey implementation

(1) Setting up survey equipment

- Install survey equipment, including a stationary camera, at the survey site.
- The survey equipment can be fixed to the railing of a bridge crossing a river, or to pipes to hold the camera.
- Since it is expected to take half a day to one day to set up the survey equipment, it is recommended to schedule the survey well in advance.

(2) Acquisition of data that may be needed for quantification of river litter

- The data items required for quantification of river litter are listed below. Table 1.3.11 shows the types of data and measurement methods required for quantification of that.

(A) Shooting scales and test litter

- When estimating the area of river litter, the basic unit of image analysis is the pixel (the smallest unit that makes up an image), so it is necessary to know in advance the river water level and the length of one pixel at the river surface.
- Figure 1.3.7 shows an example of an image taken using a 1 m x 1 m square frame. A formula relating the water level to the number of pixels per meter is created from the captured image (Figure 1.3.8).

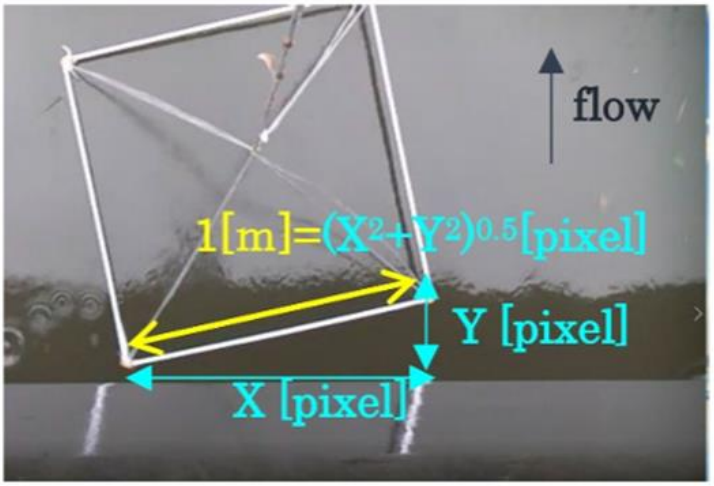


Figure 1.3.7. Pixel length calculation image
(Translated and processed from Ministry of the Environment, 2020)

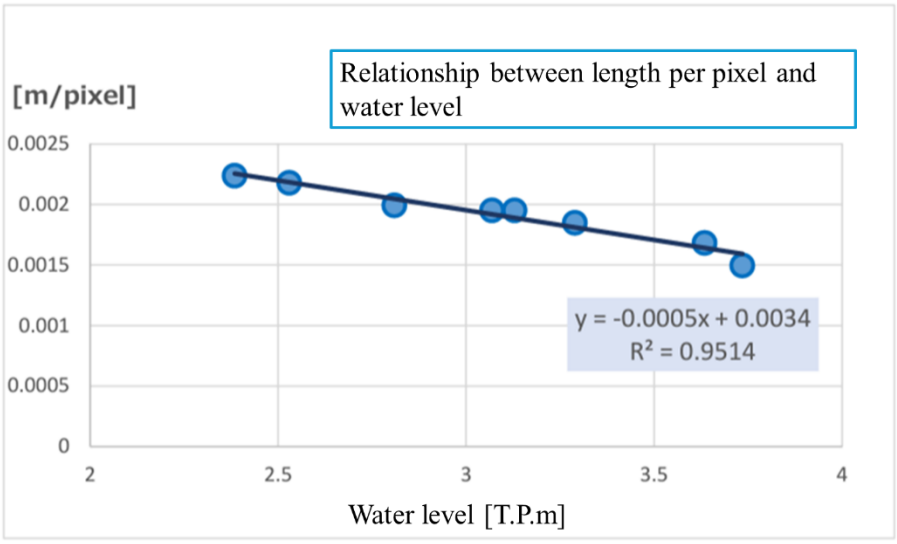


Figure 1.3.8. Example of a formula for the relationship between water level and the length of one pixel
(Translated and processed from Ministry of the Environment, 2020)

- It is desirable to shoot test litter (e.g. plastic bottles and caps whose size is known) to determine the lower detection limit size by the stationary camera.

(B) Measurement of data necessary for estimation of annual river litter

(a) Stage discharge rating curve (H-Q curve)

- If constant flow observation isn't conducted at the survey site, the flow velocity and cross-sectional area of the river are measured, and the H-Q curve is created from the observed flow rate and its water level (Figure 1.3.9).

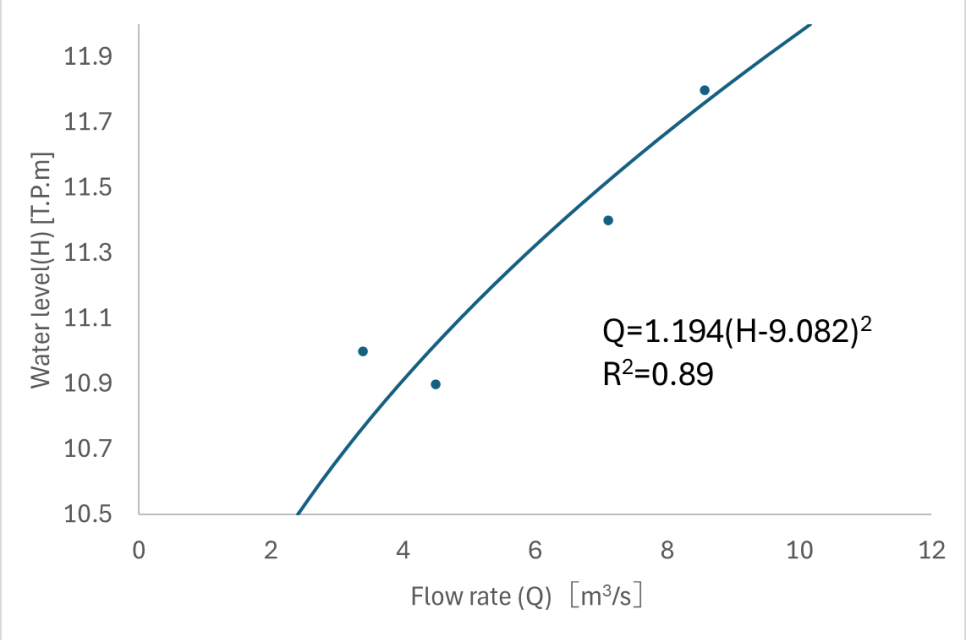


Figure 1.3.9. Example of H-Q curve

(b) L-Q curve

- A relational formula (L-Q curve) is created using the flow rate of the survey site and the amount (weight) of litter (Figure 1.3.10). It is recommended that the L-Q curve is prepared for high and normal water level periods, respectively.
- If it is difficult to prepare the L-Q curve for normal periods, calculate the average (or median) of the amount (weight) of litter during the observation period.

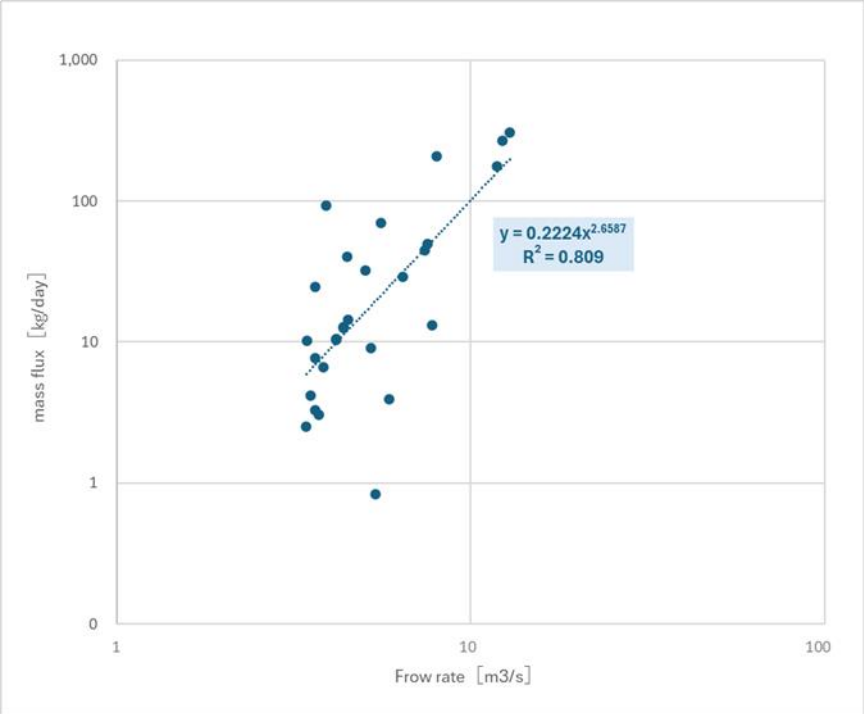


Figure 1.3.10. Example of a formula for the relationship between the flow rate of the survey site and the amount (weight) of litter (L-Q curve)

(C) Measurement of data required for extrapolation of measured values to the entire river width

- Methods for extrapolation of measured values of the stationary camera observation range to the entire river include the use of the river width and the river flow rate.
  - The use of the river width: Based on the amount of litter in the survey area, the total amount of litter is estimated by the ratio of the river width to the length of the video shooting width.
  - The use of the river flow rate: Based on the amount of litter in the survey area, the flow rate (or flow ratio) for each section is used to estimate the amount of litter in other sections.

Table 1.3.11. The types of data and measurement methods required for quantification of river litter

The Type of Data	Measurement Methods
Shooting scales	The installed camera shoots images of the scale at the river surface to determine in advance the desired water level and the number of pixels per unit length of the scale. Once the scale is lowered to the river surface and imaged, it is rolled up at a fixed length (e.g. 0.5 m pitch) and multiple images are shot in a pattern with different distances between the camera and the scale. A formula for the relationship between water level and the number of pixels per meter is created from the images shot.

Shooting test litter	It is desirable to shoot test litter (e.g. plastic bottles and caps whose size is known) to determine the lower detection limit size by the stationary camera.
River width (m)	Measure the distance in the cross-river direction using a tape measure or similar tool.
Flow velocity (m/s)	Generally, portable anemometers are used to measure the flow velocity. The cross-sectional section of the river is divided into several sections, and the flow velocity is measured in each section.
Cross-sectional area in cross-sectional direction of river (m^2)	The cross-sectional section in the cross-sectional direction of the river is divided into several sections, and the distance and water level are measured at each section.
Flow rate (m^3/s)	The flow rate is calculated by multiplying the flow velocity by the cross-sectional area. The cross-section in the cross-sectional direction of the river is divided into several sections, and the flow rate for each section is calculated. The sum of the flow rates of each section is the flow rate of the entire river.
Weight of litter (g)	Litter is collected at the riverbed during normal periods. Of the collected litter, about 20 samples should be weighed. It is recommended that dry weight be used for weight measurement.
Dimension of litter (m^2)	Measure the dimension of about 20 samples of collected litter with different types and conditions of litter (length and width for plastic bottles, spread out or tied up for plastic bags, etc.).
Weight per unit dimension of litter (g/m^2)	From the results of the weight and dimension measurements of the litter, the weight per unit dimension is calculated.
Dimension transport of river litter (m^2/s)	Calculate the dimension transport of litter based on the images shot by the camera. The calculation is based on the distance moved by comparing the images at time t and $t+\Delta t$ from the video divided by the frame images.
Composition ratio of river litter	Visually check the type of river litter (including condition if weight per unit dimension is to be calculated) for about 3 events of the video shot during the high water level to determine the actual composition of the litter.
Flux of river litter (g/s)	Multiply the dimensions transported by the weight per unit dimension of the river litter. To calculate the amount of litter transported per composition, multiply the composition ratio.

(D) Obtaining of other metadata

- It is desirable to obtain the following information (metadata) during a field survey such as equipment installation, as it will be useful in evaluating the video of observations made by the stationary camera. Since the metadata to be obtained varies depending on the river to be measured, the scale of the water level, and the time of year, it should be considered according to the survey.
- Data needed for quantification of beach litter is shown in Table 1.3.12 and Table 1.3.13. The characters listed in the "Category" column are as follows:
  - Fundamental minimum requirements to identify the abundance of litter, sampling time, and location. Letter “F” is put in the category column.
  - Essential minimum requirements to make the survey results comparable. Letter “E” is put in the category column.
  - Optional data items obtained optionally (specific purpose or instrument availability). No letter is put in the category column.

Table 1.3.12. Static information

Static Information (e.g. Camera Installation Details)			
Category	Data	Purpose of the Data	Remarks
F	Survey location	For result interpretation	
F	Survey date and time		
F	Detection threshold	For data accuracy verification	Record the higher value between the camera and AI
F	Camera resolution		
F	Camera installation height		Specify the camera resolution in the format 'width × height' (e.g., 4000×3000 pixels), instead of just megapixels.
F	Camera installation angle		
F	Camera shooting settings		e.g., interval settings
F	Focal length of camera		
F	Camera sensor width		
E	Model of camera		
E	Entire river width, camera observation range width		-The width of the river should be documented separately for the low-water channel and the high-water channel. -Since the main purpose of stationary beach cameras is to understand temporal variations at the same beachline, they should be listed as an optional item.
E	Distance from river mouth	For result interpretation	
E	Survey target		e.g., artificial objects, natural objects, plastics, etc.
	Population density around the survey site and upstream areas		
	Land use patterns around the survey site and upstream areas		Industrial zone, urban area, rural area, etc. should be specified.
	Utilization status of the survey area		e.g., whether the area is used as navigation, port, etc.
	Nearby hydraulic infrastructure		e.g., dams, canals, levees, irrigation facilities, ports, water treatment plants, etc.
	Overview of the survey site		Specify whether the survey was conducted from a bridge pier, riverside, or other structures.
	Effects of tide		
	Riverbed gradient		
	Specific values or variables to be measured (measured quantities)		Measurement quantities should be determined based on the purpose of the survey (e.g., whether the aim is to estimate the flux on the river

			water surface or to quantify the accumulation along the riverbank).
	GSD		
	Photographs and videos of site conditions		Photographs and videos considered useful for analysis should include camera observation areas, scattered litter distribution, types, density, and work conditions.

Table 1.3.13 Time series information

Time Series Information (e.g., Meteorological Data)			
Category	Items	Purpose of the Data	Remarks
	Preceding number of clear days around the survey site	For result interpretation	Refers to the number of consecutive days during which the daily precipitation falls below a certain threshold (e.g. less than 10 mm per day). The threshold may vary depending on the region.
	Cleaning history of the survey area		
	Temporary large-scale activities around the survey beach/river area (e.g., events)		
	Tide times		For stationary river cameras, applicable only for surveys conducted in the tidal reach of the river.
	Weather (sunny, rainy, cloudy, etc.)		
	Wind speed		
	Wind direction		Relative to north, e.g., 90°(east)
	Flow velocity		
	Water level		
	River discharge		

(3) Safety management

- For safety reasons, it is preferable that the installation work be conducted by two or more people.
- When installing equipment, it is recommended that the following equipment be worn for safety.
  - Helmet
  - Gloves with non-slip features
  - Safety belt
  - Life vest
- When installing a camera in a high place, take care to ensure safety of footing and falling equipment.
- When installing solar panels, metal parts and wiring may need to be fabricated. In such cases,

protective equipment necessary for metalworking, such as cut-resistant and heat-resistant protective gloves, protective goggles, and face shields, should be worn.

(4) Confirmation of measurement data

- It is recommended that data be checked on a regular basis so that any camera malfunctions can be detected immediately.
- The following items should be checked
  - State of power supply
  - Remaining battery capacity
  - Whether the image is shot successfully at the set interval and time.
  - Whether there is a deviation in the angle of view or water droplets or litter on the lens
  - SD card storage capacity

(5) Maintenance

- For webcams powered by solar panels, maintenance is not required as long as there are no abnormalities. However, after 1 - 2 years of installation, the equipment may deteriorate, in which case the equipment should be replaced.
- In the case of a battery-powered camera, the batteries need to be replaced regularly. In addition, if images are stored on the camera's SD card or other media, images need to be extracted from the SD card on a regular basis based on the capacity of the SD card and the size of the images stored.
- When the camera lens is fogged up due to humidity, or when clear images cannot be acquired due to dust or water droplets, or when images are not transmitted properly due to some abnormality, it is necessary to check the camera to resolve these problems.