IUCN Advisory Mission

Shiretoko (Japan)

23 – 25 September 2019

February 2020

Peter Rand (IUCN)

Acknowledgements

The mission representative would like to thank the Government of Japan, in particular the Forest Agency in Japan for the organisation and their warm hospitality and assistance throughout the duration of the visit. In particular, thanks to Mr. Yasushi Ueno, Assistant Director, Forestry Multiple Use and Conservation Division, Forest Agency for adeptly leading the mission, and Dr. Futoshi Nakamura, Hokkaido University, and the members of the River Construction Advisory Panel for sharing important information during the mission. The mission appreciated the opportunity to meet with the Rusha Gyoson (fishing cooperative) leader, Hatsusaburo Ose the mission thanks him for the information shared. Special thanks go to Kumiko Yoneda and Noriko Kamada of the Japan Wildlife Research Center for logistic preparation and coordination.

The mission representative also thanks the other members of the IUCN SSC Salmonid Specialist Group experts who were consulted in connection to this report.

Cover photo: Dam #2 on the Rusha River after initial phase of concrete removal (©IUCN/Peter Rand)

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Background

Shiretoko (hereafter referred to as 'the property') was inscribed on the World Heritage List in 2005 under criteria (ix) and (x), specifically noting the global significance of the property for a number of salmonid species.

At the 39th and 41st sessions of the World Heritage Committee (hereafter 'the Committee') in 2015 and 2017 respectively, the Committee recommended that the State Party of Japan invite an IUCN Advisory mission in conjunction with the IUCN Species Survival Commission's Salmonid Specialist Group to advise on the matter such as restoration of Rusha river for the migration and spawning of salmon.

The State Party invited an IUCN Advisory mission, which took place between 23 and 25 September 2019. IUCN was represented by Dr. Peter Rand, Chair of the IUCN Salmonid Specialist Group. The terms of reference of the mission are available in annex 2.

Mission findings

The mission takes note that there are a total of 100 low-head concrete and other step structures on a total of 14 separate rivers and streams within this property. The River Construction Working Group (formed to address the Committee's requests to the State Party for the property in 2005 at the time of its inscription on the World Heritage List), after inventorying all the structures and their overall impacts on the river, concluded that it would be reasonable to modify 13 structures in five streams (State Party of Japan, 2008). According to the 2008 State Party report, modifications to the riverine structures were determined based on studies of salmonid movement, their habitat and spawning environment. The impacts of infrastructure modifications on their function such as a disaster prevention mechanism were also considered (State Party of Japan, 2008).

The mission recognizes the importance of the Rusha River, as it is the largest river completely contained within the property boundaries and is known to support salmonids – many of the streams within the property are very small and high gradient with only very limited habitat for salmonids. The mission also realized that there is an absence of infrastructure downstream of the Rusha River dams, except for a bridge at the river mouth, which would be at risk under flood stage. Given these facts, the mission focused specifically on the Rusha River system. That said, it is important to acknowledge on-going efforts in other rivers within the property, and the mission had the opportunity to visit another river restoration site, the Okkabake River, for which details are provided later in the report.

Overall, the mission was very pleased to see the results of actions taken recently (mostly during 2019) to dramatically lower the height of two of the upstream dams in the Rusha River (see cover photo and Figure 1), and to see plans for future actions to remove additional concrete during 2019-2024.

During this visit, it was clear that the State Party of Japan was trying to reach some balance of restoring this river to a more natural state while still providing some protection to fishery and road infrastructure downstream. The mission was presented with a 19 page document entitled "IUCN Mission: Effort on the Rusha River" authored by the Forestry Agency and the Hokkaido Prefectural Government, the two agencies responsible for the work undertaken on the ground. The document (hereafter referred to as the "Rusha Restoration Document" (RRD); see annex 5) contains a description of past and current objectives, rationale for the approach taken, a description of work to date, and a plan for continued efforts through 2024. The report raises clear concerns of fishery stakeholders, including continued concerns about the risks of "sediment runoff and woody debris flows on fishery facilities such as stationary trap nets, and to secure the safety of local fishery stakeholders at the time of disaster as well as land routes for access and material transportation to fishery facilities in normal times" (from page 1 of the RRD).

The objective of the State Party of Japan now involves complete removal of concrete (above and below grade) of 40 m sections of each of the dams on the Rusha River, while leaving the concrete flanks intact (see schematic figures on pages 3-5 of the RRD). This plan was presented to the mission with the justification that the removal of the center portion of each dam will help increase salmon passage, restore some hyporheic (groundwater) flow, and encourage more natural stream channel formation, including river braiding, while still providing some protection to infrastructure downstream and protection of riparian trees on the flood plain.

The creation of this plan was guided by an indoor hydraulic experiment (described on pages 6-7 of the RRD) and interpreting the output from a numerical simulation that compared river flow dynamics in three different modelling scenarios: current condition, partial dam removal, or total dam removal (described on pages 8-11 of the RRD).

The RRD presents a one page summary of the modelling investigations (page 12). The authors state that modifications would indeed improve salmon passage. While there was no marked difference in the amount of spawning habitat between the current condition and the partial removal scenario, the authors suggest that there would likely be more spawning habitat created in the latter scenario due to small-scale changes to the river morphology and dynamics, including some expected subsurface flow restoration, that could not be fully represented in the simulation model (described on page 10 and 12 of the RRD). Further, the complete dam removal scenario would promote additional river braiding (that is, creation of a more complex network of channels) and restoration of subsurface flow. The most conspicuous change appears to be enhanced flow through the channel along the right bank of the river under a complete dam removal scenario (see figure on page 9 of the RRD). While they acknowledged that this represented a more natural state, there was concern about how this change in river morphology could increase risk of fishery infrastructure downstream and loss of existing riparian trees.

While the mission acknowledges that this simulation exercise represents a good faith effort by the State Party of Japan to balance risks, the mission raises a number of questions and concerns that should be considered as follows:

1. The simulations were presented in a very general way. It is difficult for someone not involved in their development to fully understand the key assumptions of the models and their overall limitations. During the field visit, the mission emphasized the lack of “biological realism” in the model – it is primarily a physical representation of the stream, and thus biological dynamics are not represented. Understanding the dynamics of fish passage, fish spawning, role of large woody debris, and, more generally, natural ecosystem dynamics requires some basic understanding of the biology of the river system.

2. In general, there are natural dynamics occurring in streams that promote retention of both sediment and debris, however these dynamics are not represented in the simulations. The thinking around stream ecology has evolved in recent years, particularly in the US Pacific Northwest, which now emphasizes how log jams (both natural and engineered ones) can serve as a means to reduce risks downstream, while creating and maintaining salmon habitat in the dam-affected zone of the Rusha River.

3. While not spelled out explicitly, it appears that complete dam removal would result in the greatest increase in both quantity and quality of salmon habitat across the lower Rusha River floodplain. However, the authors of the RRD claim that this scenario could threaten the bridge or any constructed riverbed path downstream and existing riparian trees (the trees are identified in the image on page 4 of the RRD and evident in Figure 1). The commercial fishermen in the area have an interest in maintaining road access to their facility just north of the Rusha River mouth (the road to “Rusha Banya”, pictured in Map 1 on page 1 of the RDD), although it appears that the primary means of travel is by fishing vessel from Utoro, Shari-town (~36 km southwest of the mouth of Rusha River).

While any decision about road decommissioning is beyond the remit of this mission, it would be worthwhile for stakeholders to discuss the benefits of establishing the Rusha River floodplain as a roadless zone to optimize natural river restoration efforts. During the field visit, the mission emphasized the idea that the fishery stakeholders could clearly benefit from increased wild pink salmon production resulting from complete dam removal. However, there were continued concerns about how large wood/logs from future, high discharge events in the river could damage fishing nets. The mission therefore suggested another means of retaining large wood (e.g. use of booms), which appeared to be of some interest as a means to reduce this risk.

4. The mission was shown a constructed riverbed path (described on pages 17 and 18 of the RRD) as an alternative to the bridge. A riverbed path would constrain the river less while still allowing fisherman's vehicles to pass across the stream. The process of construction involved excavation and transport of large rocks to serve as a foundation for vehicle passage. This is considered a pilot project, and it is unclear at this time how the path could withstand periods of high flow. The existence of this path would also introduce periodic disturbance to the stream benthic habitat, increase erosion, and dramatically change the slope of the riverbed which could affect fish passage in the future.

5. While there were some descriptions of on-going monitoring of the streams, it was clear this was focused mostly on physical, and not biological, monitoring. The Forestry Agency shared a 4-page document that described spawner surveys (number of fish and number of redds) conducted during August-October over four years (2012, 2013, 2015, and 2017). The number of pink salmon spawners ranged from a low of 4,287 (259 redds) in 2015 to a high of 58,236 (2,115 redds) in 2013. There has been no effort to date to determine the proportion of the run that is of hatchery-origin in the Rusha River. Redd densities were <0.06 (numbers per square meter) across the years of sampling. Earlier data on redd densities in this river system do exist (from 2006-2008, Yokoyama et al. 2010), and suggest that, with the exception of 2013, redd densities have been lower in recent years. Data from stable isotopes of stream biota in the Rusha River also suggest relatively low levels of escapements compared to studied salmon river systems in North America (Koshino et al. 2013). There may be additional data that exist on another salmonid (Dolly Varden, *Salvelinus malma*) in the Rusha River that could provide additional insight into abundance trends.

While not the focus of the Committee in the past, the mission had an opportunity to inspect progress on another river restoration effort on the opposite side of the peninsula, near the town of Rausu. A large, steel erosion control dam is being modified. It is upstream of an existing concrete erosion control structure, so it was one of the dams identified early by the River Construction Advisory Panel (formed in 2009 after the dissolution of the River Construction Working Group to inspect the effect of river infrastructure improvement on salmonid migration) as a candidate for modification. It was inspiring to see the enthusiasm and earnestness of the crew responsible for removing the dam. Because of rules against road building (or restoring existing roads) within the property boundaries, the crew is cutting steel members from the dam into pieces that they are packing out on foot with backpacks to a parking lot near the road for pickup. This stream is important habitat for the Blakiston's Fish Owl (*Endangered* on the IUCN Red List), along with a number of salmonids.

The mission takes note that there is a broader issue related to the presence of a commercial fishing operation within the property boundaries. Addressing the salmon fishery and related issues are beyond the remit of this mission. Indeed, there is a separate working group (the "Marine Management

Working Group") focusing on fishery-related issues in the marine environment. It is important to note that there has been a long term decline in catch of Pacific salmon (the vast majority are hatchery-origin chum salmon) in the Shiretoko region, and Hokkaido in general, and it is thought that it is a result of changing ocean conditions (hatchery release numbers have remained stable over this time). The fishery also annually culls Stellar sea lions (the Western Steller sea lion subspecies are categorized as *Endangered* by IUCN) to reduce interactions with fishing activity in Shiretoko.

Conclusions and Recommendations

Based on the mission's direct observations and review of information contained in the RRD, the mission provides the following conclusions and recommendations:

Conclusion 1: While the simulations that are being used to guide restoration actions in the Rusha River are helpful, the mission considers that the models do not adequately represent "natural functions" of river ecosystems or make explicit links to biological functions (particularly how changes relate to the quality of spawning habitat). Specifically, the role of large woody debris that serves to retain sediments, gravel, and woody debris in a natural stream appear not to have been fully appreciated. The mission encourages the continuation of physical monitoring, but importantly, also to strengthen the linkages to biological responses. Some recent work in the US has examined sediment and gravel grain sizes under different river scenarios and how these metrics relate to the quality of salmon spawning habitat (e.g. Riebe et al. 2014, Overstreet et al. 2015). This would allow a more direct estimate of the habitat benefits of different options regarding dam removal or modification.

- **Recommendation 1:** Enhance the simulation modelling for the Rusha River restoration to include biological variables such as the role of large woody debris and measures of spawning habitat quality, before deciding on how the dam will be modified.

Conclusion 2: Adaptive management is a useful construct in the context of river restoration efforts, and the mission strongly recommends adopting this approach in the context of dam removal in the property. The key to the success of such an approach is coupling monitoring and management response within a structured decision-making process. As new information is gathered, decision-making may change. The mission proposes such a process include dam removal activities, a boom system deployed at the river mouth to capture large woody debris, and physical and biological monitoring in the property. Regular full evaluation at periodic intervals, would allow for decisions to adapt the dam removal approach to best meet the overall objectives of the restoration effort. A recent example of this type of process can be found in Appendix 3 of the Review of the 2014 Columbia River Basin Fish and Wildlife Program (ISAB 2013). As this effort is unique in Japan, there is a great opportunity to understand how rivers and streams respond, both physically and biologically, to dam removal efforts. The mission encourages the State Party of Japan to continue to work closely with the River Construction Advisory Panel and other relevant researchers to better track changes in the Rusha River over time and evaluate different alternatives involving dam removal or modification.

- **Recommendation 2:** Adopt an adaptive management approach with periodic evaluation for dam removal and the physical and biological monitoring of the river system, working in close collaboration with the River Construction Advisory Panel and other relevant stakeholders.

- **Recommendation 3:** Assess the feasibility of the use of booms at the river mouth to capture large woody debris as a way to balance river restoration needs and the fishery stakeholder concerns.

- **Recommendation 4:** Closely monitor the impacts of the riverbed path pilot project, especially in relation to erosion, fish passage and disturbance to the benthic habitat, and take prompt remedial actions as necessary based on solid scientific understanding. This pilot project should not be replicated until there is sufficient evidence to support that there will be no impact on the ecosystem or that its impact can be satisfactorily mitigated.

Conclusion 3: To improve the tracking of progress and encourage stakeholder involvement, the mission suggests an annual or biennial research symposium that highlights on-going efforts and provides an opportunity for stakeholders to regularly express ideas and concerns about the river restoration effort.

- **Recommendation 5:** Organize periodic meetings for all relevant stakeholders and with invited specialists to exchange ideas and concerns, and to highlight the on-going efforts on river restoration.

Annexes

Annex 1. References

Independent Scientific Advisory Board (ISAB). 2018. Review of the 2014 Columbia River Basin Fish and Wildlife Program. ISAB 2018-3. https://www.nwcouncil.org/sites/default/files/isab-2018-3-review2014fwp23march.pdf

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Riebe, C.S., L.S. Sklar, B.T. Overstreet, and J.K. Wooster. 2014. Optimal reproduction in salmon spawning substrates linked to grain size and fish length. Water Resources Research https://doi.org/10.1002/2013WR014231

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Yokoyama, Y., Y. Koshino, K. Miyamoto, H. Kudo, S. Kitada, and M. Kaeriyama. 2010. Estimating the spawning escapement of pink salmon Oncorhynchus gorbuscha using the area-under-the-curve method in the Rusha River of the Shiretoko Peninsula, Hokkaido Island. Nippon Suisan Gakkaishi 76(3): 383-391 [Japanese, with English Abstract].

Annex 2. Mission Terms of Reference

At its 41st session, the World Heritage Committee reiterated its recommendation to the State Party of Japan to invite an IUCN Advisory mission to the World Heritage property Shiretoko (Decision 41COM 7B.30). The main objective of the Advisory mission is to assist the State Party with developing measures required to address Committee's requests regarding salmon migration. The World Heritage Committee noted that "the benefits of the three check dams on the Rusha River for disaster risk reduction are outweighed by their impacts on the Outstanding Universal Value (OUV) of the property" and urged the State Party "to continue and strengthen its efforts to restore the property to the most natural state possible". The main objective of the Advisory mission is to provide advice to the State Party on this matter. It was further recommended that the mission be undertaken in conjunction with the IUCN Species Survival Commission's Salmonid Specialist Group. The mission will be conducted by Dr. Peter Rand representing IUCN.

In particular, the mission should undertake the following:

1. Evaluate the progress achieved by the State Party in addressing the requests expressed by the World Heritage Committee with regards to salmon migration and the restoration of the Rusha River;
2. Provide advice on further actions required to fully address this matter;

The State Party should facilitate necessary field visits to key locations.

To enable the mission's preparation, the State Party should, as soon as possible and preferably no later than one month prior to the mission, provide IUCN with:

a. Updated information on the actions undertaken and planned for the restoration of the Rusha River;
b. Any relevant information and any recent relevant results of wildlife surveys and other monitoring activities;
c. The most recent versions of relevant management plans for the property.

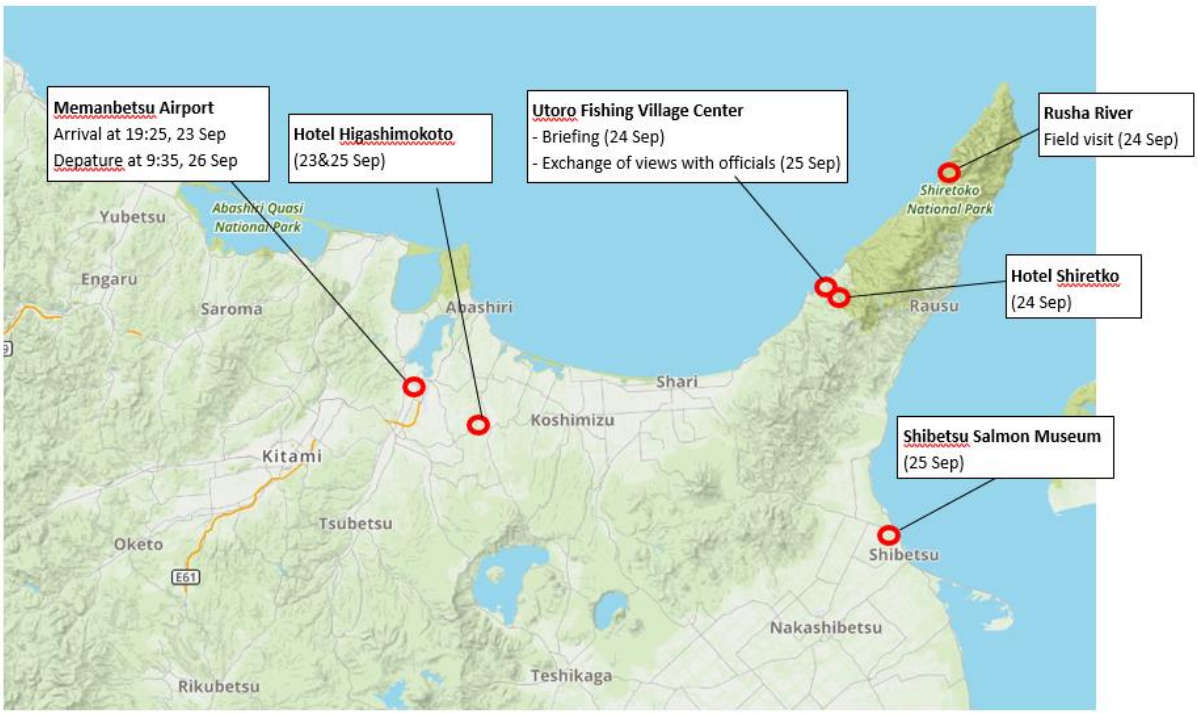
The mission should hold consultations with the relevant authorities, including the Forestry Agency, the Japan Wildlife Research Centre, and the relevant regional authorities, and other relevant stakeholders, including non-governmental organizations (NGOs), scientists, and experts.

Based on the results of the above-mentioned reviews, assessments and discussions with the State Party representatives, authorities and stakeholders, the mission should prepare a concise report on the findings and recommendations following the site visit. The mission's recommendations to the Government of Japan should have the objective of providing guidance to the State Party that should ensure the ongoing conservation of the property's OUV. It should be noted that recommendations should be provided within the mission report and not during the mission implementation.

Annex 3. Mission itinerary and map

Time	Event	Notes
23-Sep (Mon)		
14:25	Arrival at Narita airport	
	Move to Haneda airport	by airport shuttle bus
17:45-19:25	Haneda-Memanbetsu (JAL 569)	Meeting with officials of the Hokkaido Regional Forest Office
	Stay in Ozora town	
24-Sep (Tue)		
09:30-11:00	Move to Utoro	
11:00-11:30	Briefing at Utoro Fishing Village Center	Meeting with members of the River Construction Advisory Panel, Hokkaido Government & Forestry Agency
11:30-12:00	Lunch at Utoro Fishing Village Center	
12:00-13:15	Move to Rusha	
13:15-16:45	Field visit to Rusha River	Meeting with Mr. Hatsusaburou OSE
16:45-18:00	Move to Utoro	
18:45	Reception at Hotel Shiretoko	sit-down dinner
	Stay in Utoro	

Time	Event	Notes
25-Sep (Wed)		
09:00-10:30	Exchange of views with officials at Utoro Fishing Village Center	
11:00-12:00	Site visit, Okkabake River	
12:00-13:00	Lunch at Utoro Fishing Village Center	
13:00-14:30	※If exchange session ends in the morning ※Move to Shibetsu town	
14:30-15:30	※Visit to Shibetsu Salmon Museum	Exchange of information with curator
15:30-17:30	※Move to Ozora town	Members of the River Construction Advisory Panel, Hokkaido Government & Forestry Agency will leave
	Stay in Ozora town	
26-Sep (Thu)		
	Departure of mission team	



Annex 4. Photographs

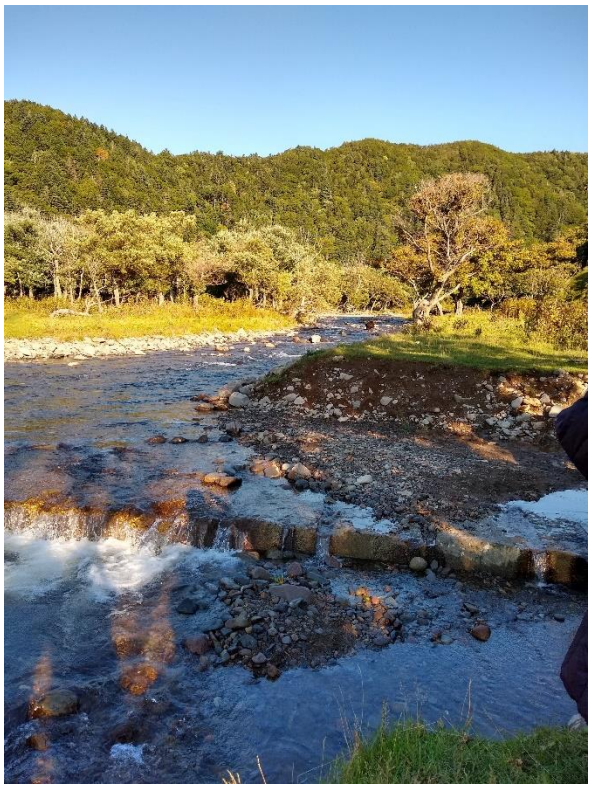


Figure 1. Image of Rusha River Dam #3 following initial phase of concrete removal (foreground). Some of the upstream riparian trees that are perceived to be at risk are evident in the upper part of the image. A brown bear appearing in the upstream reach was also observed foraging during the visit (©IUCN/Peter Rand).

Figure 2. Image taken upstream of the Okkabake River dam that is being modified (©IUCN/Peter Rand).

Figure 3. Two members of the River Construction Advisory Panel (on the left, Dr. Kentaro Morita, with Dr. Hitoshi Araki) inspecting stream habitat immediately upstream of the Okkabake dam. Note the build-up of sediment and rocks along the bank – it is expected that this material will eventually be displaced downstream following high flow events (©IUCN/Peter Rand).

Figure 4. Representatives of the District Forest Office, Forestry Agency responsible for dam modification on the Okkabake River in the Shiretoko World Heritage property. Field crews are seen

taking the steel dam down in pieces and carrying them in backpacks to a field for later pickup (©IUCN/Peter Rand).

Annex 5. Rusha Restoration Document (RRD)

IUCN Mission: Effort on the Rusha River

Forestry Agency
Hokkaido Prefectural Government

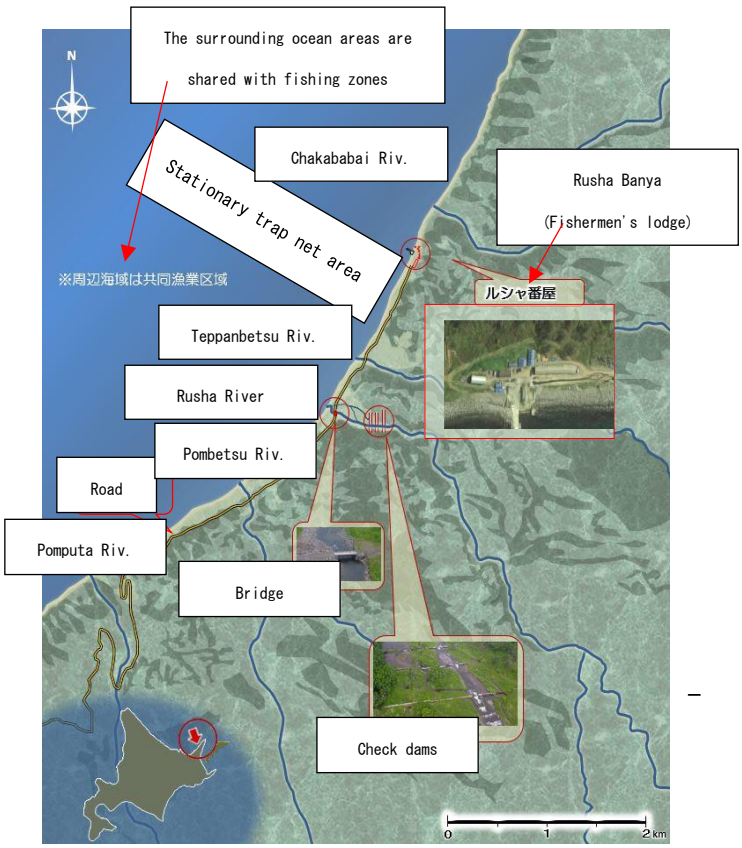
In response to the paragraph 6 of Decision 39 COM 7B.13 in 2015, and to the paragraph 5 of Decision 41 COM 7B. 30 in 2017 by the World Heritage Committee, Forestry Agency and Hokkaido Prefectural Government have been considering how to treat the three check dams and the bridge crossing the Rusha River, under the basic policy mentioned below, with technical advice from the River Construction Advisory Panel established under the Shiretoko Natural World Heritage Site Science Council. We intend to keep this basic policy into the future.

Basic policy on the treatment of the Rusha River

The Shiretoko Natural World Heritage has been highly evaluated for its interaction between marine and terrestrial ecosystems, and we recognize that the improvement of migration and spawning habitats of salmonids which convey marine-derived nutrients to the terrestrial ecosystem is very important.

Therefore, in the Rusha River basin located in the core of Shiretoko, we will make every effort to restore the natural environment as much as possible, which will lead to such improvement for salmonids. On the other hand, coastal fishery, which is the major industry in the region, is operated at the mouth of the river. Thus, it is required to prevent impacts by sediment runoff and woody debris flows on fishery facilities such as stationary trap nets, and to secure the safety of local fishery stakeholders at the time of disaster as well as land routes for access and material transportation to fishery facilities in normal times.

Based on these points as well as on the assumption that the improvement of spawning habitats of salmonids would be beneficial for the maintenance of fishing resources, we made it our basic policy to realize a balance between the improvement of salmonids migration and their spawning habitats, and the securement of the fishing activities as well as the safety of fishery stakeholders.



Map 1: Location Map of Rusha District

Ⅰ. Utilization of Rusha district

Rusha district is located approximately 36 km northeast from downtown of Utoro, Shari-town, along the northern coastline of the Shiretoko Peninsula.

The bridge crossing the Rusha River is currently used for management and patrol of Shiretoko Natural World Heritage by Forestry Agency, Hokkaido Prefectural Government and other organizations, and for fishing activities by local fishermen as well.

In this area, which is blessed with abundant fishing resources in the Sea of Okhotsk, salmon fishing is thriving. There is a fishermen's lodge at a point further ahead from the Rusha River along the coastline, and about 15 fishermen are engaged in stationary trap nets fishing for salmon, using the lodge as the fishing base, from June to December every year. The bridge crossing the Rusha River is an essential facility for fishing activities by these fishermen.

(More photographs should be added and the currently used ones may be exchanged to the latest ones.)

Ⅱ.Overview of the check dam Improvement Policy for Rusha River

1. Evaluation, etc. from the World Heritage Site Committee Sessions

The Committee recognized the effects actualized by past modifications of river constructions (structures). However, the dams had a negative impact on the salmon spawning environment in the downstream area as the additional improvements requested by the Commission were not realized.

The natural state of salmonid upstream migration and spawning is considered an "important example of ecological interaction between marine and terrestrial ecosystems" and considered absolutely essential to this heritage site.

Recognizing that further discussion and analysis is currently advancing regarding the options for eliminating permanent obstacles to salmon migration and spawning, the Committee recalled that the impact of the 3 Rusha River dams have on the "Outstanding Universal Value" (OUV) of the heritage site is greater than the benefit they provide in terms of disaster prevention and has strongly encouraged the Japanese government to continue and enhance efforts to restore the original natural state to this heritage site as much as possible.

2. Investigation towards improvement

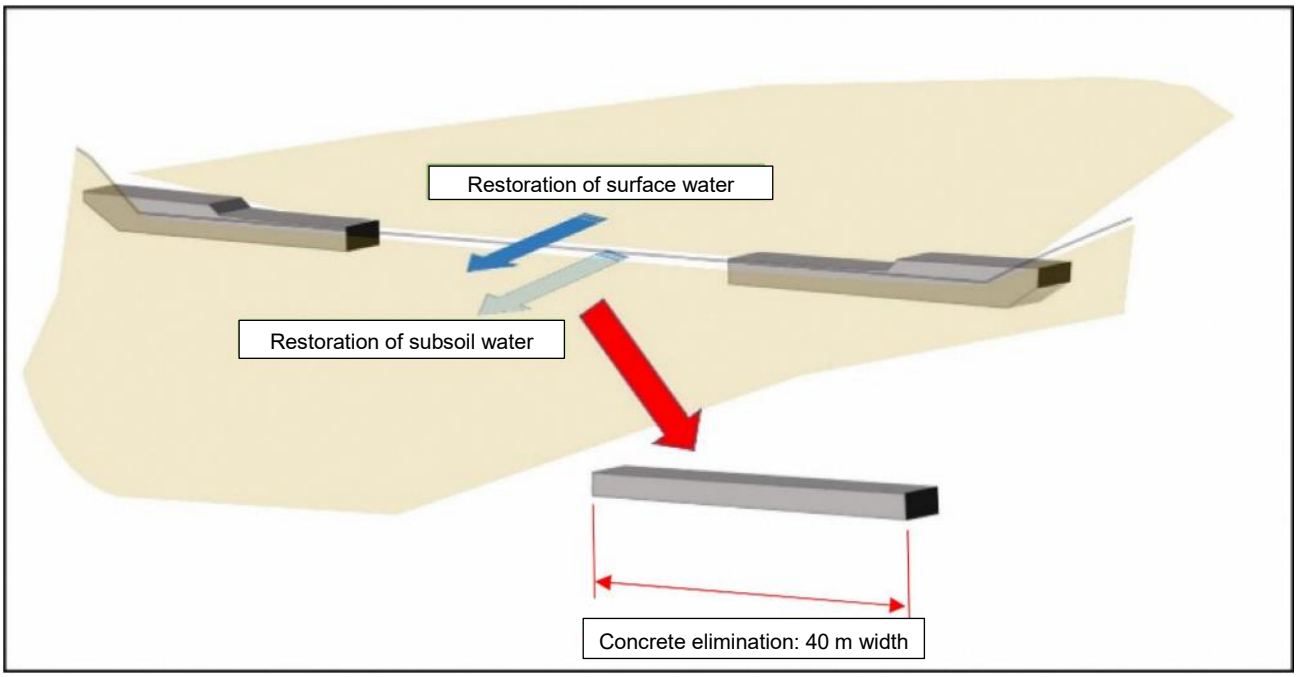
○Basic issues

The check dam installed in Rusha River was constructed from 1974 – 1979 with the purpose of controlling sudden sediment movement in torrent rivers, expanding the disaster prevention function maintained by riparian forests, and protecting hatchery facility at river mouth, forest roads, bridges crossing at those places, and set net fishery operated along river mouth / bank areas from sediment-related disasters.

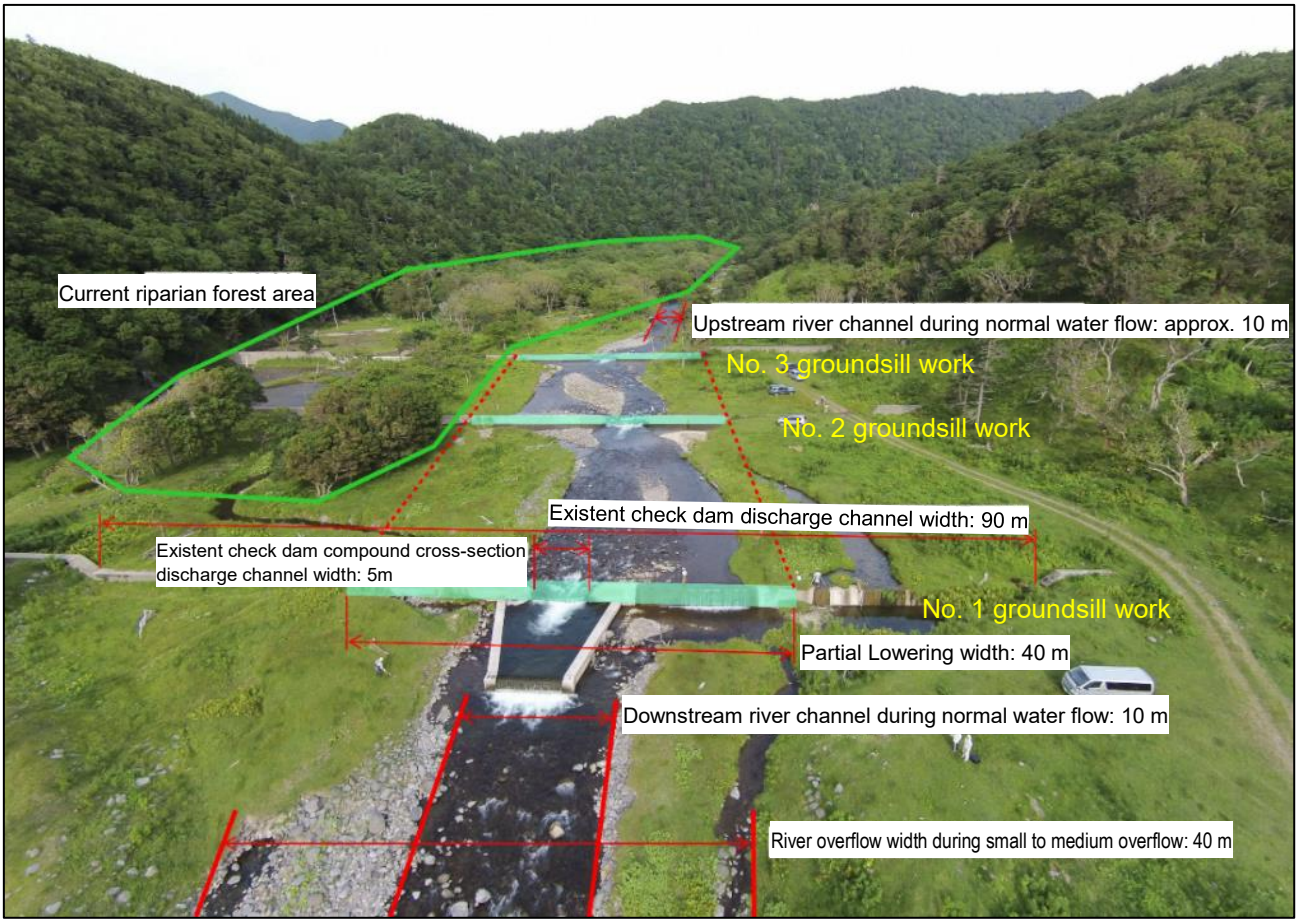
Though the hatchery facility was eliminated in 2012, because the set net fishery is still continued currently and forest road and bridge area is still in use, disaster risk mitigation through a check dam is still necessary in order to preserve these facilities, etc., from sediment disaster.

However, keeping in mind that Rusha River is located in the core region of the Shiretoko World Natural

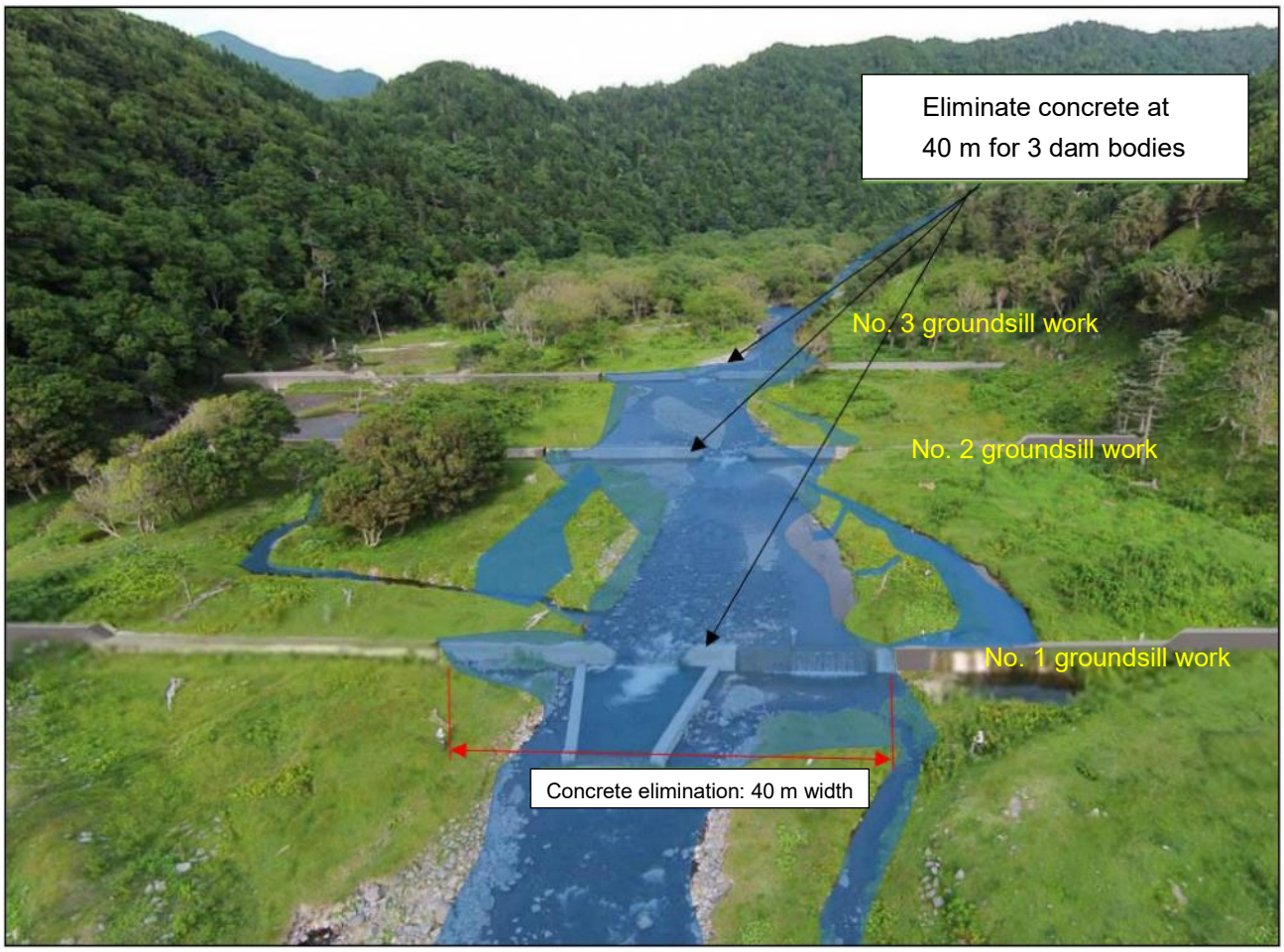
Heritage Site area, we considered that the spawning environment for salmonids should be restored as much as possible through improvements of the 3 dams based on advice from Advisory Panel members. As a result, the Hokkaido Government ,the dam installation manager, has decided to leave the check dam in place while partial removal of the check dam (an area 40 meters in width, including underwater concrete) due to a belief that this will promote the restoration of normal flow for surface and subsurface flows and promote river braiding and meandering.



In the investigation, the channel width is about 10m at the time of ordinary discharge, the width of the medium and small floods is about 40m, and the dam is partially removed with a width of 40m considering the width that does not affect the riparian forests. The hydraulic experiment and numerical simulation were carried out as follows.



○Visual Projection of Post Underwater Concrete Elimination



○Indoor hydraulic experiment

In 2015-2016, we conducted a hydraulic experiment with a 1/150 scale model recreating the current conditions of a 350 meter-long reach that includes the dam section. With this, we gathered basic data pertaining to changes in factors such as river channel and sediment movement that would occur from partial removal of dams in return period of once for 10 years rainfall (peak flow discharge 120 m3/s) and a 100 years rainfall (peak flow discharge 210 m3/s).

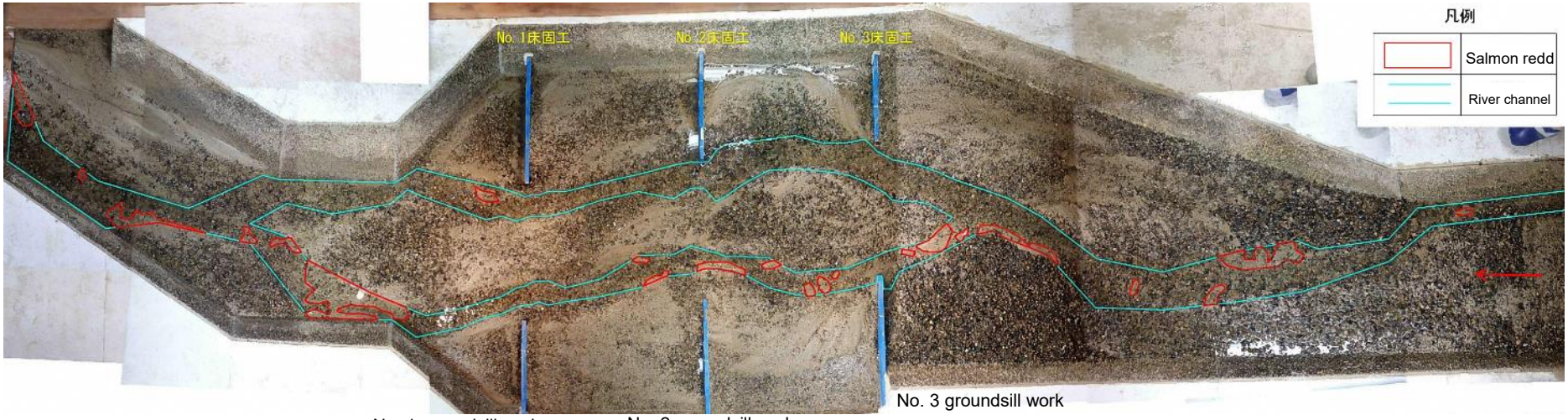
Regarding river environment improvement, diverse channel morphology such as braiding and meandering were found in the dam section at the stage when the water level returned to a standard level after flooding by a 10 year return period rainfall. Also, riverbed degradation that had been occurring immediately downstream Dam No. 1 was also shown to be eliminated through partial removal. This resulted in the formation of a longitudinally continuous flow regime, removing obstacles and facilitating the upstream migration of salmonids.

Furthermore, subsurface flows that ran through the sediment and pebbles where the dam cuts across water flow would also be restored by partial removal, and areas, where that subsurface water comes out, can be used by salmonids as redds.

Concerning the disaster prevention function of the dam, we created discharge during flooding for a 100 year return period rainfall and a 10 year return period rainfall and assessed the "sediment trapped volume" and "sediment released volume" in those conditions, but a significant difference between Current Condition and Partial removal was not confirmed in the resultant numerical values and characteristics.

In 2018 about the riverbed finish shape (shape to refill the sediment after dam partial removal) after dam partial removal was concerned about local scouring of the riverbed, so experimentally how the riverbed changes during planned scale flooding Verification was performed in 1/30 scale hydraulic model experiment.

As a result of the experiment, no excessive river bed scouring or excessive sediment runoff was confirmed. It was confirmed that the partial removal site of the dam was filled with sediments and stones of various gravel diameters left upstream, forming a natural river shape.



【Post-partial removal salmon redd estimated distribution】

【Current salmon redd distribution】

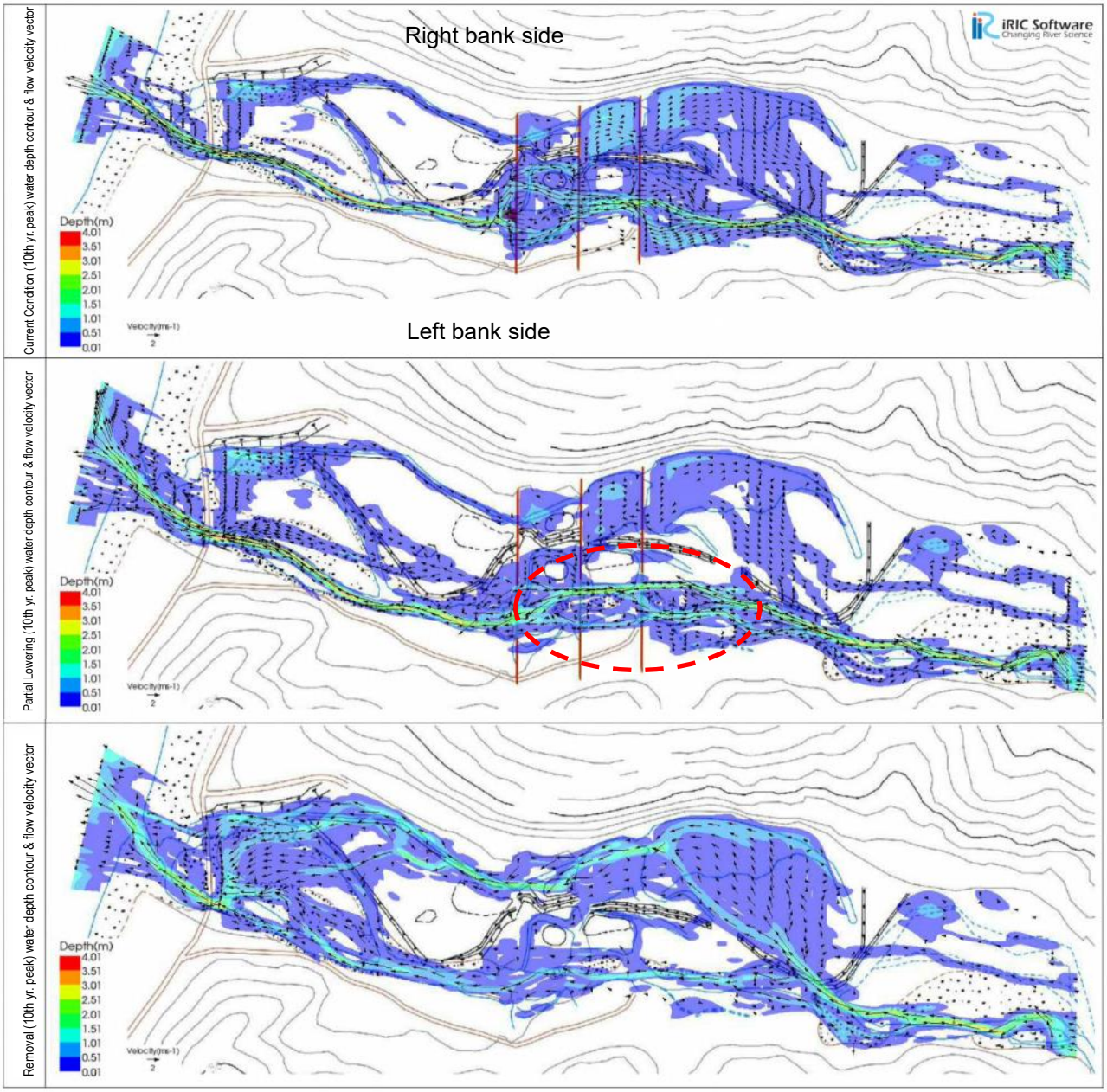
○Numerical simulation

Because the investigation in the hydraulic experiment was limited to a 350 m dam section, it was also necessary to investigate the impact on further downstream road and ocean area as well. Thus, during 2016-2017, we implemented a numerical simulation with a scope reaching up to 800 m upstream from the river mouth, gathered data pertaining to changes in factors such as river channel and sediment movement for the case wherein the flow discharge during the snow melting and flow increase period (peak flow discharge: 51.5 m3/s, daily rainfall return period for a period corresponding to 2 yrs.) continued continuously for 10 years, and performed an investigation comparing the [Current Condition] to the impact brought about by [Partial removal] and [Complete Removal] of the dam.

In a 10 year [Partial removal] simulation, it was confirmed that the dam section river split at an extent greater than the initial state and subsequent braiding and expansion in splitting led to the general configuration of a braided river.

In the case of [Complete Removal], because the conducted river channel experienced drastic change and splitting and braided formation occurred across the entire river width, the improvement was predicted for the river environment. However, the main current experiences a transition further towards the right bank side compared to the [Current Condition], and it raised fear of the impact on existing riparian forest area and damage to downstream roads and bridges.

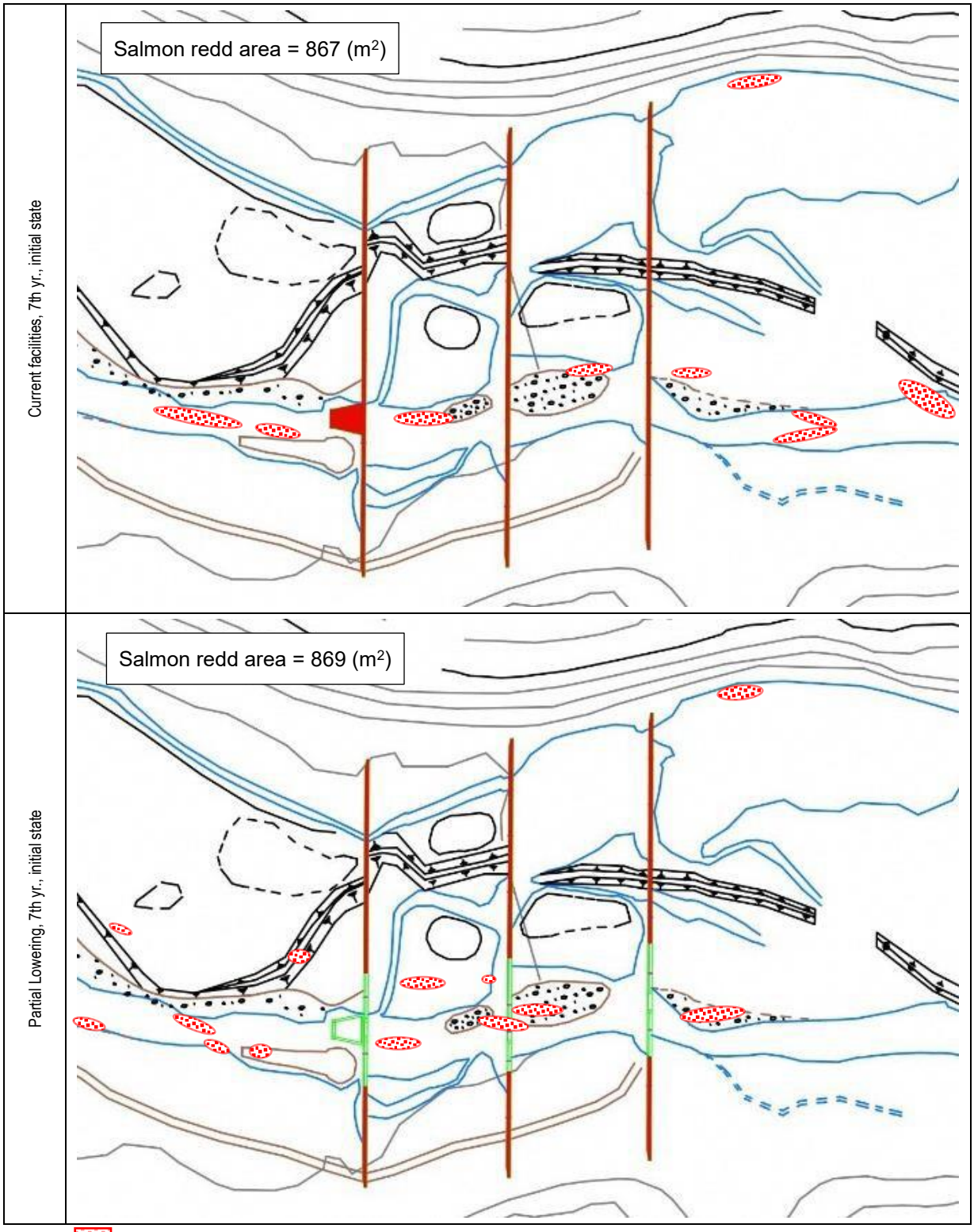
10th yr. peak


Current Condition (10th yr. peak) water depth contour & flow velocity vector
Partial Lowering (10th yr. peak) water depth contour & flow velocity vector
Removal (10th yr. peak) water depth contour & flow velocity vector
Right bank side
Left bank side
iRIC Software
Changing River Science
Depth(m)
4.01
3.51
3.01
2.51
2.01
1.51
1.01
0.51
0.01
Velocity(m/s-1)
2

Regarding the range of area suitable for salmon redds, there was almost no change between [Current Condition] and [Partial removal] due to low spatial-scale-resolution of the simulation analysis. However, for [Partial removal], the analysis suggested that meandering and braiding of channel formed by the dam removal would contribute to increasing small patches, which is suitable for salmon redds, and resulting in increase of the total amount of suitable area for spawning in the "Downstream Section" and "dam section" and, conversely, unifying in the "upstream section." Further, newly creating subsurface flow in response to the removal of structures beneath the riverbed and change of channel morphology would significantly contribute to enhancing the quality of spawning habitat.

Regarding the results for partial removal, while there was no difference in the total square area of area appropriate for salmon redds within the range, an increase in area appropriate for salmon redds is predicted due the prospect of salmon redds subdivision and the expectation of an increase in salmon redds due to factors that are not possible to recreate in a simulation, such as a small-scale spawning environment and subsurface flow restoration.

Diagram of areas appropriate for salmon redd



○Conclusion of investigation results

[Current Condition]

The above-ground portion of the dam that was installed in the river and generates water level variation, hinders salmonid migration. The concrete in the below-ground portion blocks subsurface flow.

Also, because the fixation of the river channel (single channel) by the dams increases flow velocity and stream power, the particle size of the gravel-bed increases, resulting in a fear that this will impact the salmonid spawning environment.

Incidentally, the dam mitigates the river slope and thus prevents abrupt riverbed fluctuation and promotes maintenance and creation of riparian forest area, which is the expected purpose of dam installation. Thus, the dam is thought to exhibit a disaster prevention function.

[Partial removal]

Through Partial removal of the dam, the water level variation that was occurring in the above-ground area is expected to dissipate, the river continuity is expected to be retained, and the subsurface flow will be restored for the lowered portion. Also, following an increase in freedom of river channel movement in the surface flow, river channel splitting and braided formation are predicted, and improvement as a river environment suitable as a salmonid spawning environment is predicted.

Incidentally, while the disaster prevention function of the dam shows a slight degradation compared to the Current Condition when looking at change over time, because sediment release during a disaster such as heavy rains shows the same level of performance in comparison to the Current Condition, we determined that the dam disaster prevention function is retained even after partial removal.

[Complete removal]

Through removal of the facilities, in the area of removal, the original and free river channel migration along the entire river width is estimated to naturally manifest, surface water splitting and braided formation are estimated to occur, and restoration is also estimated for the once cut-off subsurface flow. From these estimations, improvement as a river environment suitable as a salmonid spawning environment is predicted.

However, due to the elimination of disaster prevention functions provided by the dam such as sediment and river channel stabilization, there is a fear of damage occurring through events such as sediment release to downstream road and bridge area.

3. Investigation results and policy towards improvement

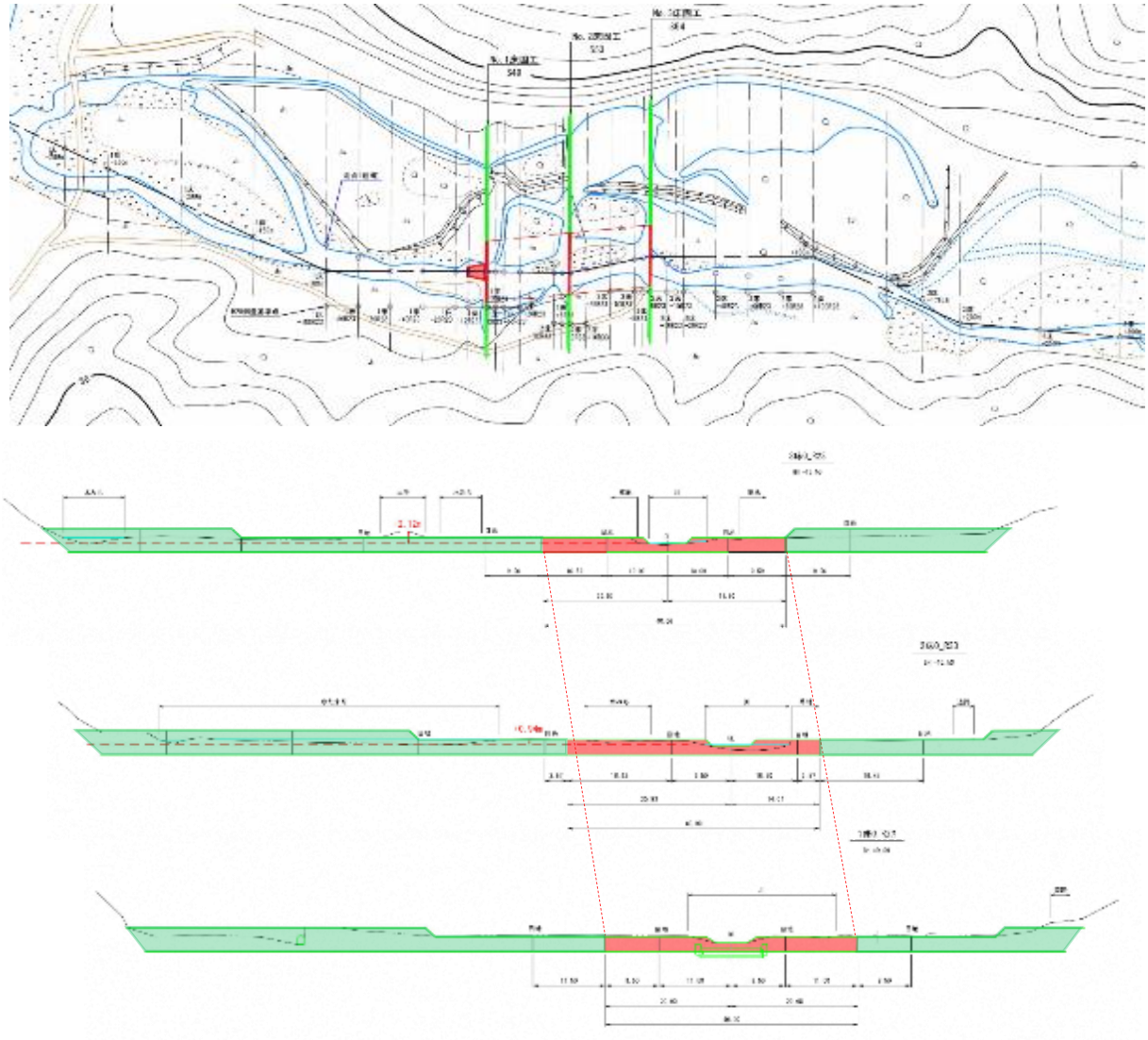
Results from hydraulic experiments and numerical simulations confirmed that even when a portion of the dam is removed, it would still offer a disaster prevention function at the same level as the [Current Condition] during irregular overflow situations such as in times of flooding, etc. Simultaneously, in the environmental aspect, expansion of areas suitable for salmon redds are predicted from factors such as surface water splitting and subsurface flow restoration. Thus, river environment improvement is also expected.

And in light of the continued expectation of the disaster prevention function of the dam from set net fishers still currently operating around the river mouth area as well, we establish as the Rusha River check dam improvement policy a system of [Partial removal] that will simultaneously actualize both river environment improvement and disaster prevention function.

※Partial removal of the dam overflow section

(40-meter section, including underwater concrete)

○Dam overflow section partial lowered area



The red represents the lowered area. The green represents the remaining check dam area.

○Visual Projection of Dam Overflow section Partial removal

【Current Condition】

【Partial removal】

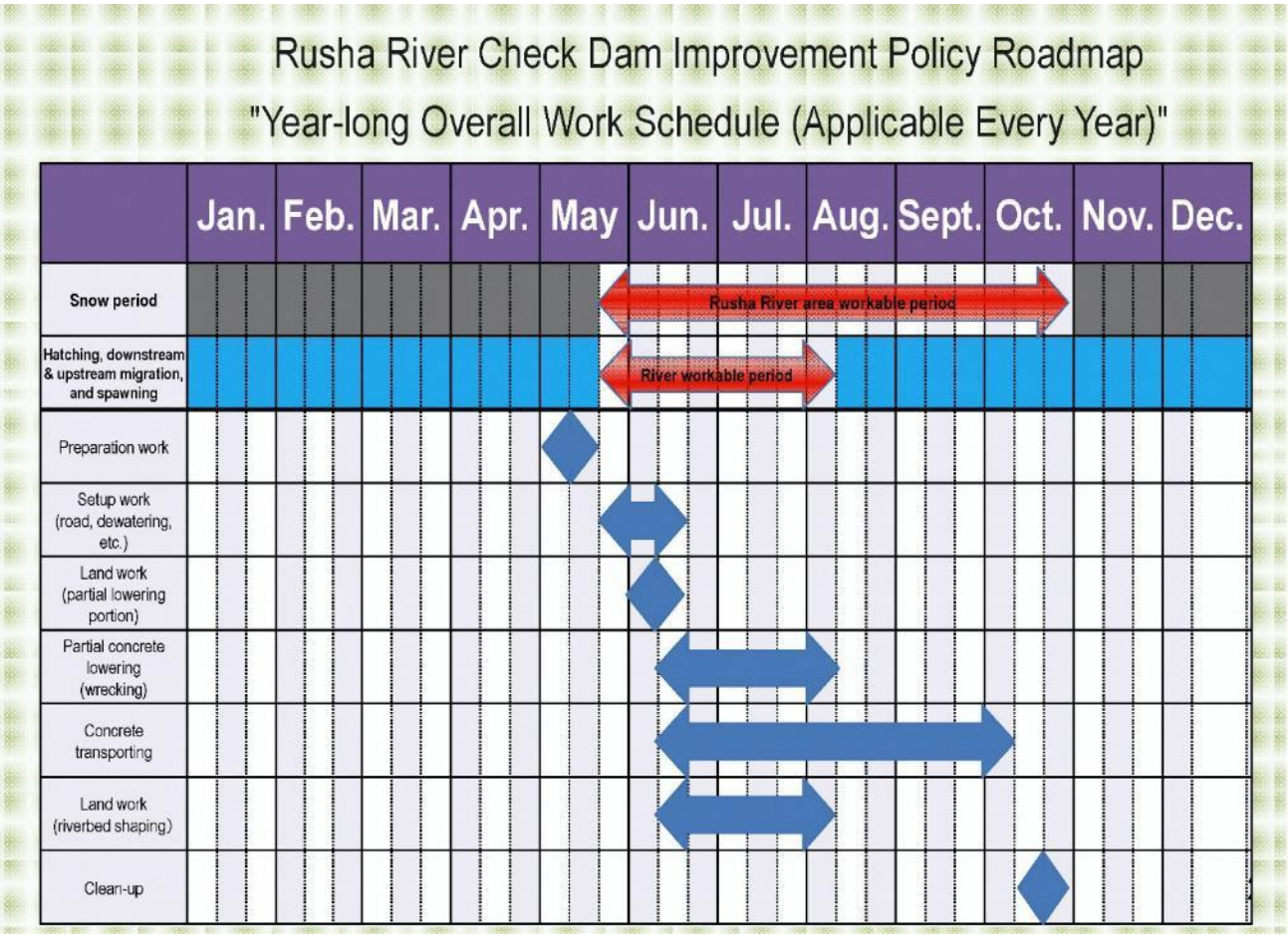
○Improvement plan

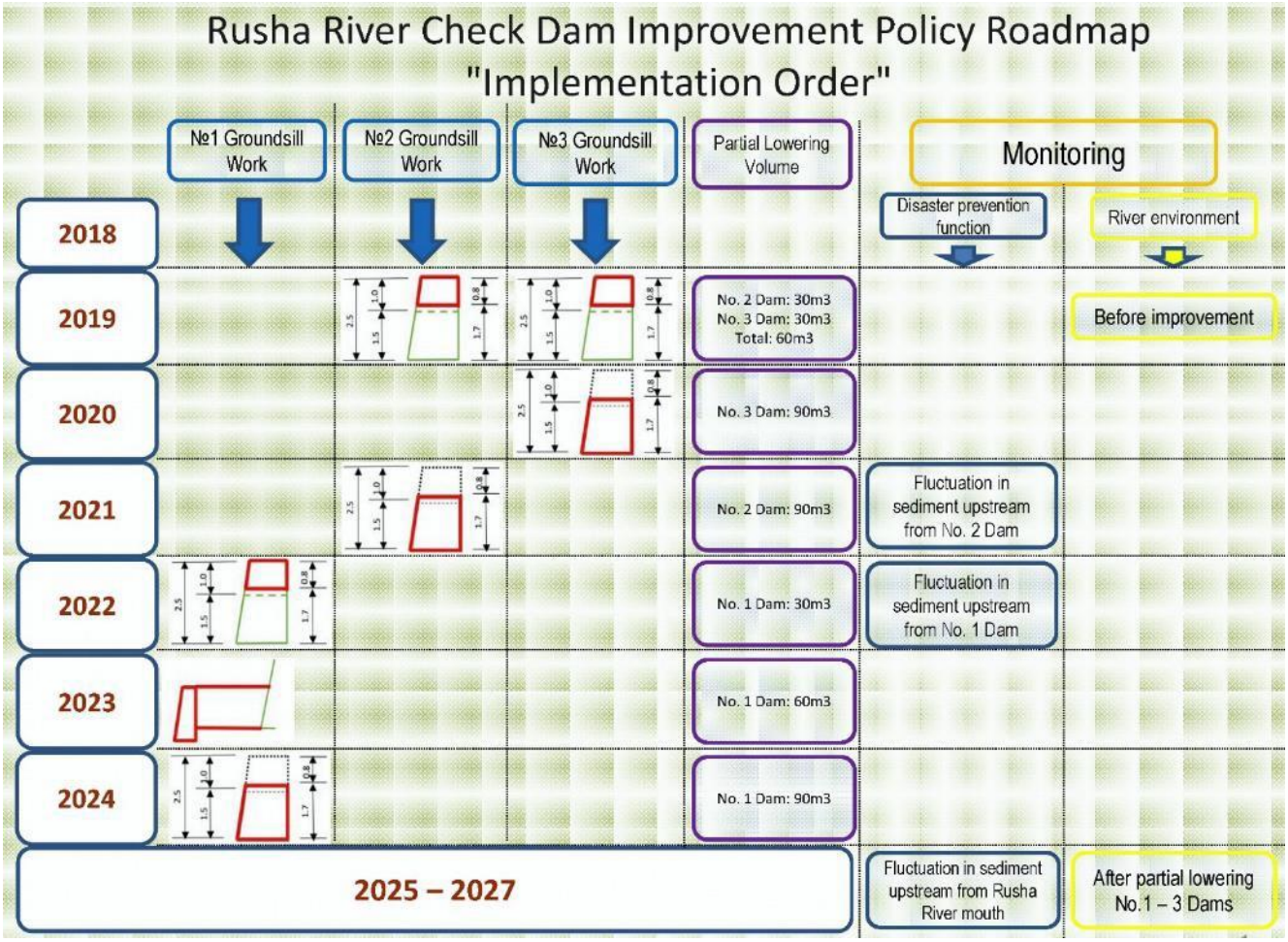
During the execution of Partial removal of the dam, the removed space will be filled up to return it to the format of the current riverbed. As a result of the hydraulic experiment, no excessive river bed scouring or excessive sediment runoff was confirmed. It was confirmed that the partial removal site of the dam was filled with sediments and stones of various gravel diameters left upstream, forming a natural river shape.

Expected to be formed as a natural river by excavated sediment, and stone gravel supplied from the upstream, it was decided not to take measures to prevent scouring, such as riverbed girdle constructed with stone.

Also, in the dam improvement plan, because partial removal of the dam can result in longitudinal and cross-sectional riverbed becoming steep in places, it is important to in such a way that sediment movement from the dam section does not have an impact on downstream road and bridge area, etc. Therein, instead of implementing modification for all 3 dams simultaneously, we will start with Dam No.3 upstream in a way that maintains the disaster prevention function of Dam No.1.

Since construction needs to exclude the snowy season and salmonid spawning period, the construction work period inside the river channel is limited. Based on the above, the construction period was determined to be 6 years from 2019 to 2024 in consideration of the scale and method of construction. We will proceed with construction while confirming the impact of the improvement plan.





Regarding the gap in the riverbed downstream the Dam No. 1, we implemented a temporary mitigation measure via building 3 riverbed girdle constructed using natural stone materials from 2016.

Incidentally, regarding these temporary measures, we plan to continue implementing measures as needed in response to the situation until the implementation of dam improvement.

○Monitoring

In order to verify the effects of improvement, monitoring before and after modification work is required. And, in order to confirm consistency with the aforementioned investigation content, we will implement monitoring concerning the river environment improvement effect and the maintaining of dam disaster prevention function.

Incidentally, concerning the monitored items for various investigations and the evaluation standards, we will examine them carefully and continuously.

Ⅲ. The Bridge crossing the Rusha River

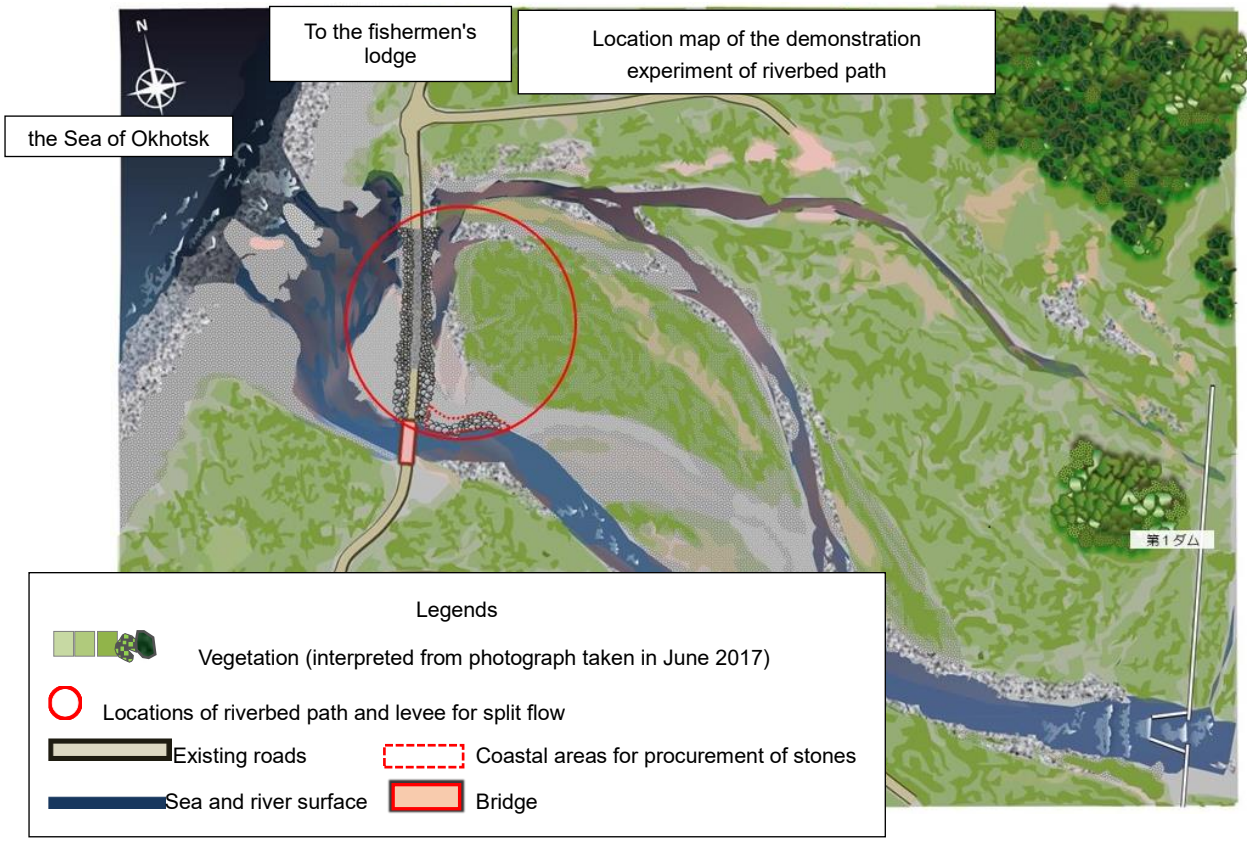
The Forestry Agency, which manages the bridge crossing the Rusha River, has been considering the treatment of the bridge, aiming to balance the upstream migration of salmonids and usage of the bridge by the local fishermen, based on the technical advice from the River Construction Advisory Panel. As a result, it was decided to examine a construction method of laying stones on the bottom of the river to make a riverbed path which would allow vehicles to cross the river without preventing the upstream migration of salmonids. With the consent of the fishery stakeholders, we have started a demonstration experiment to verify whether or not a riverbed path is able to function as an alternative to the bridge.

1. Construction of riverbed path

Construction of a riverbed path was started in the middle of October 2018.

As its material, stones around 0.5 to 0.9m in size were selected and procured from the coastline near the construction site, under the condition that the landform of the coastline would not be modified. The stones were laid in an inclined manner in the direction of the river flow in order to stable the structure of the path under running water.

The construction was finished in the late of November 2018. We carried out the construction of the riverbed path, getting on-site instructions from experts including a member of the River Construction Advisory Panel.



Photos of riverbed construction

A:　Before construction

B: Completion of excavation

C: Completion of laying of stones

D: Completion of construction
(Bluelines indicate the water flow
at high water level)

2. Monitoring of riverbed path

Since the riverbed path constructed for demonstration experiment is designed to be overflowed at high water level and water does not run over it at ordinary water level, we are trying to examine whether the riverbed path can function as an alternative to the bridge over the Rusha River through the following methods;

1. Recording in film the state of water flow over the riverbed path at high water level, and monitoring and verifying the performance of the riverbed path such as durability toward vehicle traffic, and
2. Running water over the riverbed path by damming up the main stream of the river for several weeks during the season identified as one which does not negatively affect upstream migration and spawning of salmonids, in case it is unable to evaluate the performance of the riverbed path sufficiently only with the natural overflow onto it.

The actual items to be monitored are as follows:

1. State of water flow over the riverbed at high water level due to rainfall or snow melting,
2. Stability and durability of the structure of the riverbed path,
3. Changes of the topography of both the upstream and downstream of the riverbed path, and
4. Drivability of vehicle traffic on the riverbed path.

Other items to be monitored should be added if necessary.

The results of monitoring are to be reported to the River Construction Advisory Panel, and to be used, with the technical advice from the Panel, for the establishment of an appropriate structure of riverbed paths.

3. Treatment of the bridge in the future

The purpose of the ongoing demonstration experiment of riverbed path is to evaluate basically the technique of riverbed paths. We will adaptively examine the next step hereafter taking into consideration the results of this experiment, and opinions on the riverbed path from local fishermen as users of the bridge.

We will eventually determine the treatment of the bridge, with technical advice from the River Construction Advisory Panel, verifying where to construct a permanent riverbed path according to the possible changes in water flow conditions of the Rusha River that may occur after the improvement of the three check dams upstream, while gaining the understanding of the fishery stakeholders and building a consensus with the local community.