Promoting the Installation of Fish Passage in Potential Barriers in the Lower Mekong River Basin

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Under the Smart Infrastructure for the Mekong (SIM) Program of the United States Agency for International Development (USAID), the Lower Mekong Fish Passage Conference was organized in Vientiane, Lao PDR in November 2016 to demonstrate how applied research can be used to enhance policy and decision-making across the Lower Mekong River Basin. Attended by more than 160 participants from 14 countries including global experts in riverine development, fish passage, and aquatic ecosystem management, the Conference came up with key messages that included: 1) demonstration projects applied in the field, tested, and showcased facilitate large-scale adoption and acceptance of end users and donors; and 2) partnerships among the researchers, local people, district/provincial governments, and national management agencies lead to greater success (Baumgartner *et al.*, 2017). Along the line of such key messages, SEAFDEC in collaboration with the US Department of Interior (US-DOI) has been carrying out the activities of the project "Implementing the Lower Mekong Fish Passage Initiative in Cambodia, Thailand, and Vietnam" from 2018 until 2021 with the goal of enhancing the capacity of the SEAFDEC Member Countries in the Lower Mekong River Basin to design, construct, implement, and assess fish passage. Through this Project, one demonstration fish passage was installed in each of the participating countries.

The Mekong River (**Figure 1**) is one of the great rivers of the world flowing through six countries, namely: China, Myanmar, Thailand, Lao PDR, Cambodia, and Viet Nam with a distance of nearly 5,000 km from its source on the Tibetan Plateau in China to the Mekong Delta. The basin is one of the richest areas of biodiversity in the world, with more than 20,000 plant species and 850 fish species. In the Lower Mekong River Basin, about 80 % of the nearly 65 million people depend on the river and its rich natural resources for their nutrition and livelihoods. However, due to development infrastructures and climate change resulting in environmental degradation and loss of biodiversity, the Lower Mekong River Basin is threatened by worsening floods and droughts (Mekong River Commission, 2021).

In river systems around the world, water management structures or barriers such as weirs, dikes, dams, road prisms, irrigation canals, among others are built for flood control and agricultural development. However, most of these barriers are too high for fish to pass, thus, obstruct their migratory paths. Migration is a crucial part of the lifecycle of many riverine species to access spawning, feeding, and nursery habitats.

In order to address the adverse impacts of barriers on the migration of riverine species and rehabilitate the aquatic environment, fish passages (also known as fishways, fish ladders, or fish steps) are installed around barriers to facilitate fish migration. Fishways enable fish to pass the barrier by swimming and leaping up a series of relatively low steps into the waters at the other side of the barriers. Water flow over the fish ladder has to be strong enough to attract the fish to the ladder, but should not be too strong to wash the fish back downstream or exhaust them to the point of being unable to continue their journey upstream.

In the Southeast Asian region, the techniques to install effective fish passage had already been established and largely developed in Lao PDR. However, for other countries in the region, their capacity is still limited to be able to apply these techniques. Therefore, in order to support the countries in the Lower Mekong River Basin, SEAFDEC through its Training Department (TD) and partners organized several activities on knowledge transfer under this Project.

Figure 1. Upper and Lower Mekong River Basin
Source: *Mekong River Commission, 2011*

Fish Passage Master Class

As an initial activity of the Project, two sessions of Fish Passage Master Class were organized at SEAFDEC/TD in Samut Prakan, Thailand with support from the Australian Centre for International Agricultural Research (ACIAR), Crawford Fund, USAID, and Mekong River Commission (MRC), during 7–9 and 13–16 November 2018. While the first session focused on GIS Techniques and Fish Passage Barrier Assessment, the second session discussed the Fish Passage Engineering, Design, Construction, Ecology and Monitoring. The Master Class sessions had a total of 52 participants comprising engineers and fishery managers from fisheries and irrigation agencies in Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam as well as representatives from SEAFDEC, MRC Secretariat, and the National Mekong Committees (**Figure 2**), while the resource persons were from the Institute for Land Water and Society of Charles Sturt University, University of South Australia, Australasian Fish Passage Services (AFPS), and United States Department of the Interior (US-DOI). The Master Class sessions were aimed at enhancing the capacity of the participants to apply the techniques to install effective fish passage as well as to establish the network among irrigation and fisheries practitioners.

Figure 2. Participants of the Fish Passage Master Class observing a fish passage prototype

Installation of Demonstration Fish Passage

The working teams in the respective participating countries, comprising personalities who have expertise in biology and engineering as well as local knowledge, undertook the barrier assessment procedures (**Figure 3**) and followed the steps to construct the demonstration fish passage (**Box**) with technical assistance from the USAID in partnership with ACIAR.

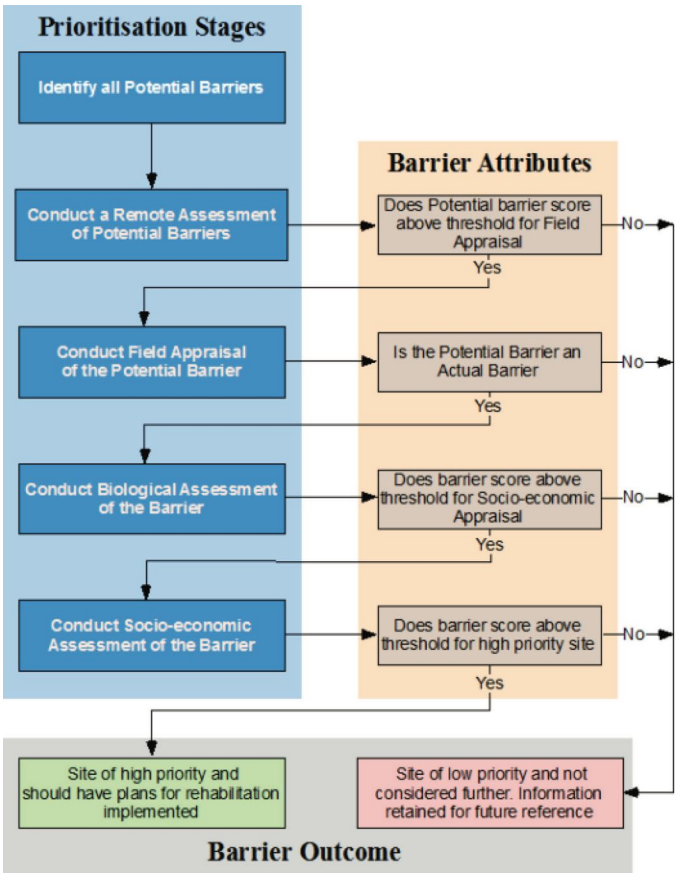

Figure 3. Flowchart of the process of barrier prioritization
(***Source:*** *Marsden* et al., *2014)*

Cambodia

The Inland Fisheries Research and Development Institute (IFReDI) of Cambodia assessed the barriers in the Pursat River in May–June 2018. Based on the assessment, the Kbal Hong Weir (Latitude 12°32'53" N, Longitude 103°51'18" E) was selected as the most suitable barrier to install the demonstration fish passage. During the provincial consultation workshop organized by IFReDI in October 2018, the key stakeholders supported the installation of fish passage. Designed by Charles Stuart University and Australasian Fish Passage Service, Australia (**Figure 4**), the demonstration fish passage (**Figure 5**) was completed in May 2019 and turned over by USAID to the Government of Cambodia during the handover ceremony in Pursat Province in October 2019.

The upstream and downstream areas of the fish passage installed at Kbal Hong Weir were monitored by IFReDI from May to November 2019, while water parameters (*e.g.* depth, flow, DO, pH, temperature) were measured. Also, fishes moving across the fish passage were collected using traps placed at different chambers of the fish passage baffles, and the species, abundance, and body length of collected fish were recorded.

Box. Steps for fish passage installation (***Source:*** *Marsden* et al., *2014)*
Step 1: Locate potential barriers to fish migration - identifying all barriers that obstruct fish migration to be included in the barrier prioritization
Step 2: Conduct remote assessment of priority barrier - investigating the spatial and temporal habitat characteristics associated with each potential barriers identified in Step 1 without the need to visit the site through incorporation of data in a desktop GIS process
Step 3: Conduct field appraisal of highest priority potential barriers - undertaking field appraisals of the highest ranked potential barriers based on the remote assessment to determine whether the site is an actual barrier and define the actual characteristics of the barrier that cannot be determined by remote assessment
Step 4: Conduct refined biological assessment - identifying the highest priority barriers in terms of their effect on the biological productivity of a catchment
Step 5: Conduct socioeconomic assessment - identifying the most cost-effective barrier including expenses for repairs, with the greatest benefit to the local community
Step 6: Select sites for rehabilitation - identifying potential restoration sites that qualify based on the assessment criteria including ecological, socioeconomic, ownership, and maintenance factors by using tools such as GIS
Step 7: Implement a design process - assembling a team of experts who will undertake a multi-disciplinary process to design the site-specific and successful fish passage
Step 8: Undertake construction - constructing the fish passage according to the final design agreed by the design team, and any changes to the final design must be referred back to the team so that biological, engineering, and operational modifications can be made
Step 9: Operate and maintain fish passage - conducting inspection, maintenance, and repair regularly to retain the functionality of fish passage
Step 10: Evaluate the effectiveness of the fish passage rehabilitation - ensuring that the whole fish community (species and size classes) are successfully entering, traversing, and exiting the fish passage

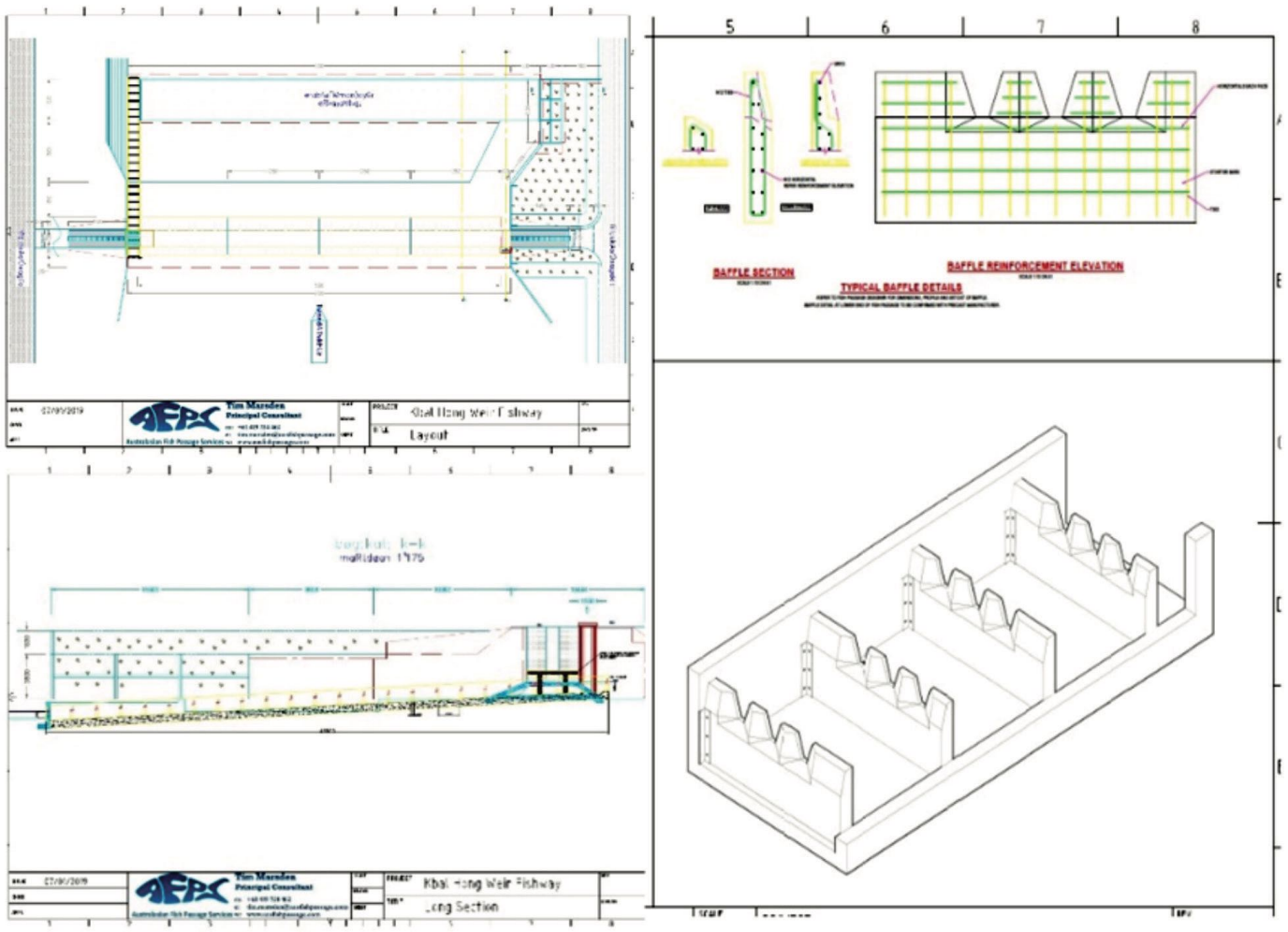

Figure 4. Design of the demonstration fish passage installed at Kbal Hong Weir in Pursat River, Pursat Province, Cambodia

Initial results indicated that there were fewer fishes captured when the water level was receding. With regard to fish migration, there was lesser at night while more fishes migrate at daytime or early morning. More than 60 fish species were recorded and the top five abundant species comprise: *Clupeichthys aesamensis*, *Parambassis apogonoides*, *Mystacoleucus greenwayi*, *Barbonymus gonionotus*, and *Macrobranchium niponese* (**Figure 6**). The demonstration fish passage installed at the Kbal Hong Weir was considered as one of the most effective in the Mekong Region and a product of effective regional collaboration.

Figure 5. Kbal Hong Weir in Pursat River, Pursat Province, Cambodia *(above)* and the installed demonstration fish passage *(below)*

1) *Clupeichthys aesamensis* 2) *Parambassis apogonoides* 3) *Mystacoleucus greenwayi*

4) *Barbonymus gonionotus* 5) *Macrobrachium niponese*

Figure 6. Top five abundant species collected from the demonstration fish passage installed in Kbal Hong Weir in Pursat River, Cambodia

Thailand

Based on the assessment made by the Department of Fisheries (DOF) of Thailand and the Royal Irrigation Department of Thailand of the existing barriers in Hauy Lung River in Udonthani Province during June–September 2018, the Hauy Wang Chang Weir (Latitude 17°48'35" N, Longitude 103°05'26" E) was selected as the suitable barrier for the installation of demonstration fish passage. A meeting was organized with the Sangkhom Municipality Committee to inform them on the proposed construction and seek their approval and support of the fish passage. Based on the design (**Figure 7**) prepared by the Australasian Fish Passage Services, the fish passage was constructed from December 2019 to 3 April 2020 (**Figure 8**). On 22 June 2021, the US-DOI transferred the ownership of the demonstration fish passage to the local government of Sangkhom Sub-district through an official letter.

The efficiency of demonstration fish passage installed at Hauy Wang Chang Weir was investigated, the water flow speed was measured using submerged-orifice channel between the baffle, and fish sampling was done using fish trap placed at

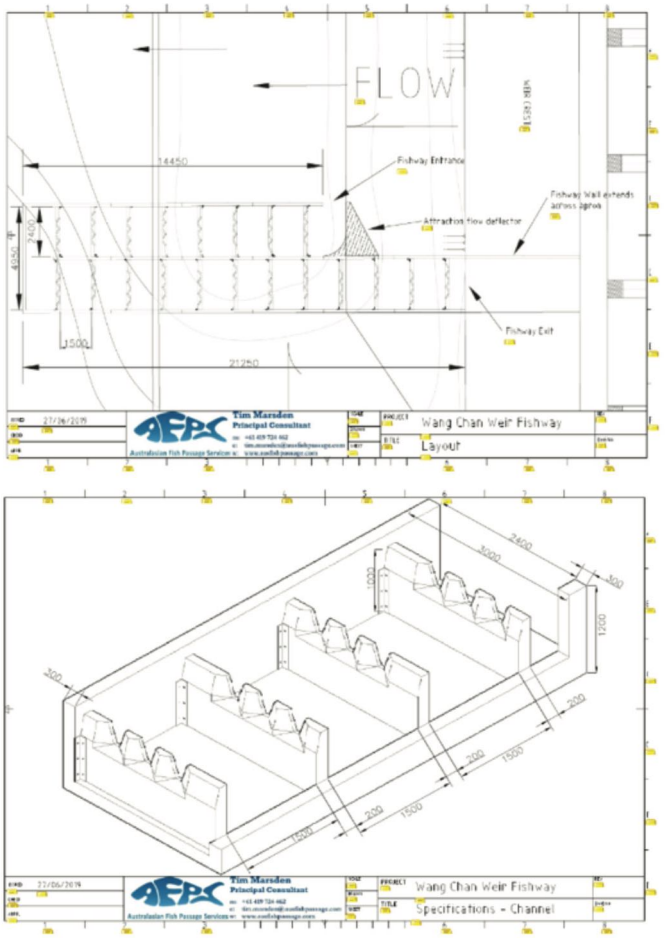

Figure 7. Design of the demonstration fish passage installed at Wang Chang Weir in Hauy Lung River, Udonthani Province, Thailand

Figure 8. Hauy Wang Chang Weir in Hauy Lung River, Udonthani Province, Thailand *(above)* and the installed demonstration fish passage *(below)*

the last exit pool of the fish passage. The results showed that the water flow speed at the second pool at the exit and second pool from the entrance of the fish passage was 1.1 m/sec, while the difference in water level (head loss) at each pool was 10 cm. From the fish samples, seven species were identified, namely: *Labriobarbus siamensis*, *Trichopodus pectoralis*, *Mystus mysticetus*, *Esomus longimana*, *Rasbora spilocerca*, *Channa striata*, and *Rasbora aurotaenia* (**Figure 9**). However, since travel across Thailand had been disrupted due to the COVID-19 situation of the country, monitoring of fish migration at the fish passage at Hauy Wang Chang Weir was halted and would be continued once the COVID-19 situation has improved.

Viet Nam

The Provincial Department of Agriculture and Rural Development (DARD) in Dac Lac Province, Viet Nam conducted the barrier assessment on 19–26 November 2018. After the assessment and consultation with various agencies, the Ea Tul Weir (Latitude 12°49'53" N, Longitude 107°53'45" E) was selected as the site for the installation of demonstration fish passage. The fish passage design prepared by the Provincial DARD was approved by the USAID-DOI and AFPS (**Figure 10**), but construction of the demonstration fish passage at Ea Tul Weir (**Figure 11**) which was supposed to be during July–December 2020 was postponed to June 2021 due to the COVID-19 pandemic.

Way Forward

The Project has successfully delivered the installation of demonstration fish passages at the potential barriers in target rivers in Cambodia, Thailand, and Viet Nam. The lessons learned demonstrated that partnership is crucial for the successful implementation of fish passage by engaging the local communities, local officers, local and national governments, and partner agencies. Although the COVID-19 pandemic had disrupted the monitoring and construction of the demonstration fish passages in Thailand and Viet Nam, respectively, these activities would be resumed when the COVID-19 situation improves. Despite the challenges, the key findings of the evaluation of the performance of the installed demonstration fish passage serve as scientific evidence for future endeavors in adopting fish passage installation as well as for effective fishery resources rehabilitation in the Lower Mekong River Basin.

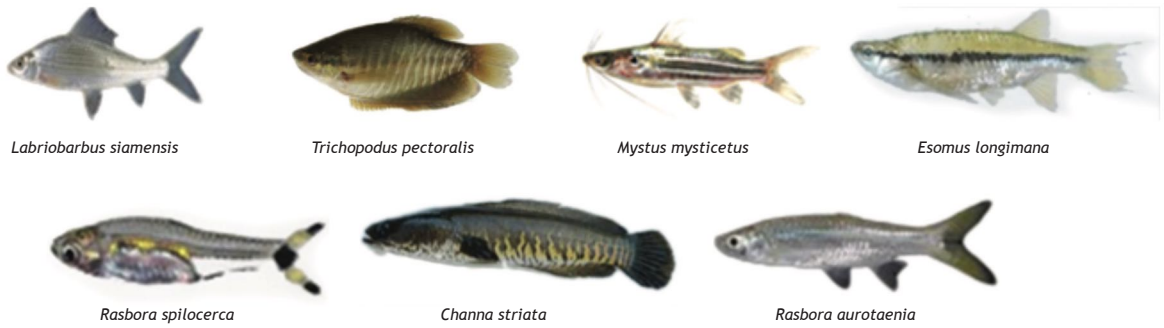

Figure 9. Fish species sampled from the demonstration fish passage installed at the Hauy Wang Chang Weir in Hauy Lung River, Udonthani Province, Thailand

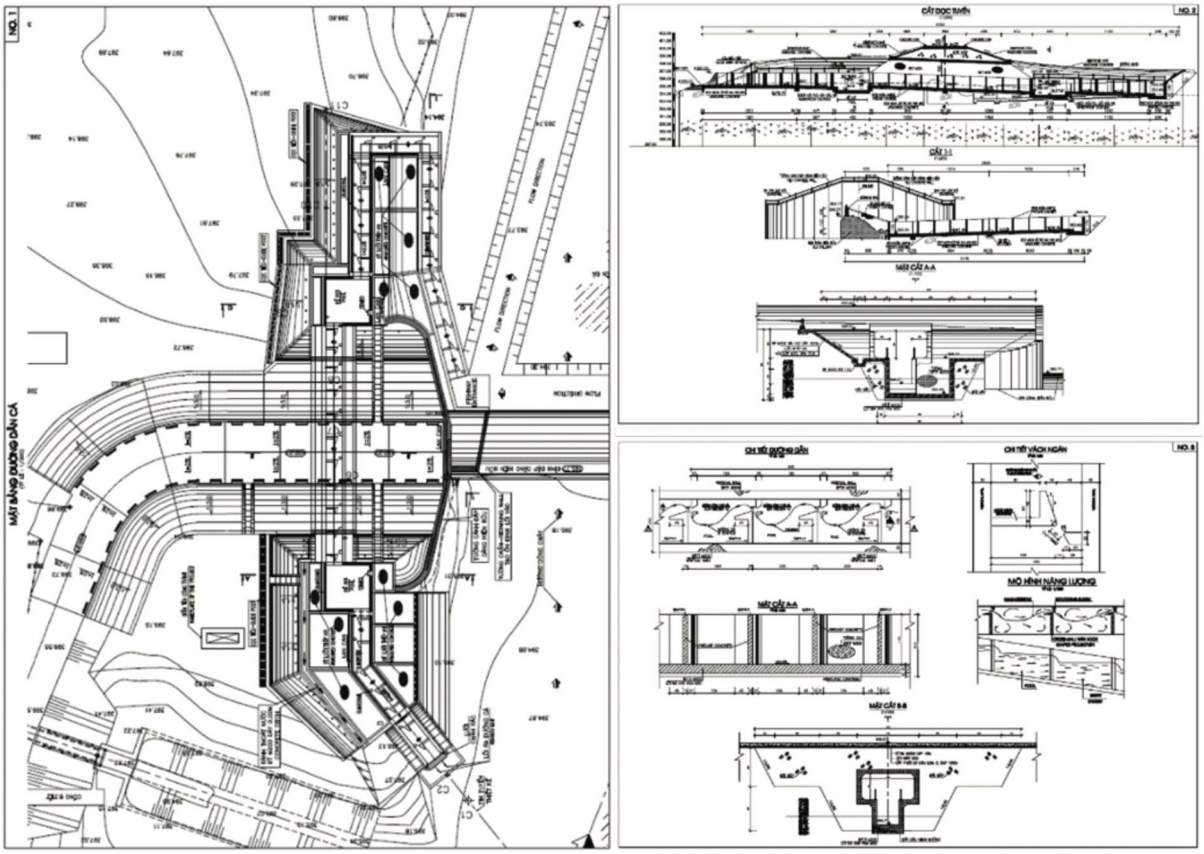

Figure 10. Design of the demonstration fish passage for installation at Ea Tul Weir in Srepok River, Dac Lac Province, Viet Nam

Figure 11. Ea Tul Weir in Srepok River, Dac Lac Province, Viet Nam *(above)* and the demonstration fish passage being installed *(below)*

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