

**The Republic of Indonesia  
Directorate General of Water Resources  
Ministry of Public Works**

**The Project for Capacity Development  
of Mt. Semeru Volcanic Disaster  
Structural Measure Planning  
in The Republic of Indonesia**

**Project Completion Report  
Annex (10)  
Capacity Development of  
Sabo Technical Center (STC)**

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**Japan International Cooperation Agency (JICA)**

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The Project for Capacity Development of Mt. Semeru Volcanic Disaster Structural  
Measures Planning in The Republic of Indonesia

**Capacity Development of Sabo Technical Center (STC)**

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## Abbreviations

Abbreviation	English	Bahasa Indonesia
ASEAN	Association of South East Asian Nations	-
BBWS	Large River Basin Agency	Balai Besar Wilayah Sungai
BBWS-SO	Serayu Opak River Basin Agency	Balai Besar Wilayah Sungai Serayu Opak
BINTEC	Directorate of Water Resources Engineering Development	Direktorat Bina Teknik Sumber Daya Air
BPSDMI	Department of Human Resources Development	Badan Pengembangan Sumber Daya Manusia Industri
BWS	River Basin Agency	Balai Wilayah Sungai
CoE	Center of Excellence on Water and Climate Resilience	-
DGWR	Directorate General of Water Resources	Directorat General Sumber Daya Air
ISDM	Integrated Sediment-related Disaster Management	-
ITB	Bandon Institute of Technology	Institut Teknologi Bandung
LiDAR	Light Detection And Ranging	-
MLIT	Ministry of Land, Infrastructure, Transport and Tourism	-
MOU	Minutes of Understanding	-
MP	Multiparameter	-
MPBA	Master in Natural Disaster Management	Magister Pengelolaan Bencana Alam
MPW	Ministry of Public Works	Kementerian Pekerjaan Umum
OJT	On the Job Training	-
PDM	Project Design Matrix	-
PPLPGB	Training Center Project for Countermeasures on Volcanoes	Proyek Pusat Latihan Penanggulangan Gunung Berapi
PU	Ministry of Public Works	Kementerian Pekerjaan Umum
SATREPS	Science and Technology Research Partnership for Sustainable Development	-
STC	Sabo Technical Center	-
UAV	Unmanned Aerial Vehicle	-
UGM	Gadjah Mada University	-
VSTC	Volcanic Sabo Technical Center	-
WIDE	Water Induced Disaster Engineering	-
WWF	World Water Forum	-

## **CHAPTER 1 BACKGROUND**

### **1.1 Background**

On May 22 2024 in Bali, Japan International Cooperation Agency (JICA) and Ministry of Public work and Housing (MPWH, at the time) signed the Memorandum of Understanding (MOU) on the Sabo Technical Centre (STC). The MOU signing took place during the 10th World Water Forum in Nusa Dua, Bali. Since its establishment with the assistance of Japan, STC is currently taking role on data analysis, technical guidance and engineer training programs as well as technology development of Sabo for sediment control and disaster risk reduction in Indonesia.

Minister of MPWH Mochamad Basuki Hadimuljono showed the intention to strengthen STC and expanding its scope to other developing countries to play a key role to contribute to the Centre of Excellence for Water and Climate Resilience (CoE4WCR) in the field of sediment-related disaster risk management.

This MOU agrees on the future cooperation for STC including assistance on formulation of roadmap, upgrading of equipment and assistance for training program to realize the vision.

### **1.2 Objectives and Scope of Work**

Based on the above MOU, the following works were carried out to strengthen the functions of STC:

- 1) Set the goals and analyze the current situation to develop human resources in the Sabo field and to develop Sabo technology to reduce the risk of sediment disasters in Indonesia
- 2) Prepare a roadmap (draft) for enhancing Sabo technology in Indonesia based on the goals and analysis
- 3) Develop a technical training curriculum and syllabus based on the aforementioned roadmap (draft)
- 4) Investigate the equipment and facilities upgrades necessary for STC to fulfil its role as defined in the roadmap (draft) in the medium and long term

### **1.3 Related Organizations**

Following the inauguration of President Prabowo Subianto on October 20, 2024, a Presidential Decree was issued on October 21 for the reorganization of ministries. As part of the restructuring, the Ministry of Public Works and Housing (PUPR) was reorganized into the Ministry of Public Works (PU). However, the organizational structure from the Directorate General of Water Resources through to the Directorate of Water Resources Engineering Development and Sabo Technical Center was unaffected by this reorganization.

Therefore, in this report, the relevant agencies will be referred to as follows:

- Ministry of Public Works (MPW) / Kementerian Pekerjaan Umum (PU)
- Directorate General of Water Resources (DGWR) / Direktorat General Sumber Daya Air
- Directorate of Water Resources Engineering Development (Bintek) / Direktorat Bina Teknik Sumber Daya Air
- Sabo Technical Center (STC) / Balai Teknik Sabo

## CHAPTER 2 CURRENT SITUATION ANALYSIS AND GOAL SETTING

### 2.1 Definition of the Sabo Technical Center (STC)

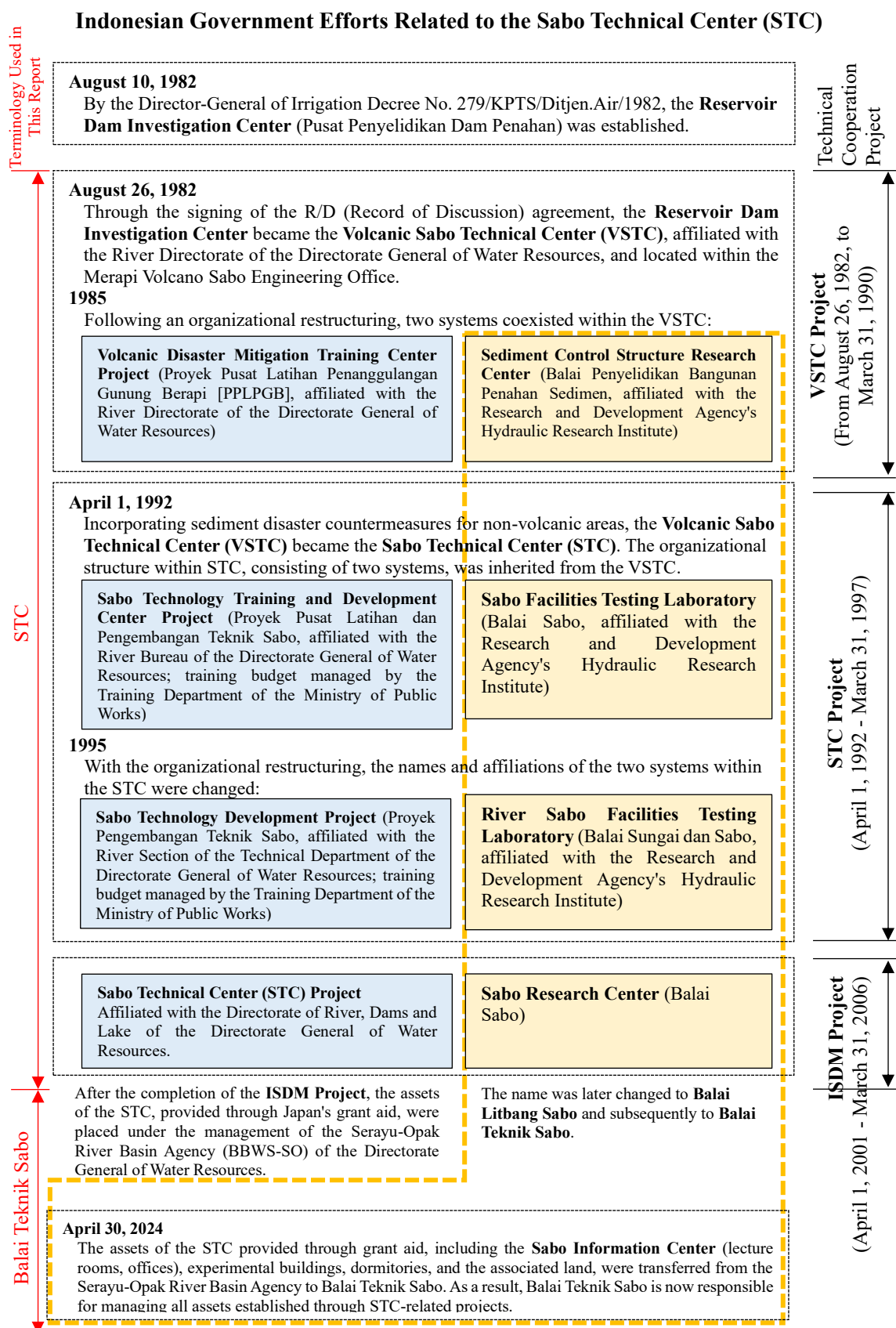
In this report, the Sabo Technical Center (STC) and *Balai Teknik Sabo* are treated as synonymous. However, when describing activities from past VSTC (Volcanic Sabo Technical Center) projects to the ISDM (Integrated Sediment Disaster Management) project, the term “STC” is used, whereas when describing activities after the completion of the ISDM project up to the present and discussing the future direction, the term “Balai Teknik Sabo” is used.

The organizational transition from the Volcanic Sabo Technical Center (VSTC) project to the Sabo Technical Center (STC) project, followed by the Integrated Sediment Disaster Management (ISDM) project, is summarized in Figure 2-1.

The VSTC project primarily aimed to train engineers specialized in volcanic Sabo technology. However, starting from the STC project, the scope of technical focus expanded to include sediment movement phenomena in non-volcanic areas, such as landslides, debris flows, slope failures, and sediment deposition in multipurpose dams. Furthermore, following the Asian financial crisis that began in Thailand in 1997, Indonesia experienced socio-economic and political turmoil. As a result, the country shifted toward democratization and decentralization under a constrained financial environment. In response, the subsequent ISDM project carried out activities related to public-private partnerships for debris flow countermeasures. An overview of each project is provided in Section 2.2.

The broad STC framework, which originated from the VSTC project, consisted two coexisting systems for an extended period: (1) a river directorate-affiliated organization responsible for technical development, training, and public outreach (indicated by the blue hatched area in Figure 2-1), and (2) a research and development agency-affiliated organization (indicated by the yellow hatched area in Figure 2-1). The river directorate-affiliated organization operated as a subproject within technical cooperation projects, carrying out activities in collaboration with experts as described in Section 2.2. Meanwhile, the research and development agency-affiliated organization serves as a permanent research institution with roles similar to those of the current Balai Teknik Sabo. After the completion of the ISDM project, assets developed through grant aid, including the Sabo Information Center (lecture rooms and offices), experimental buildings, dormitories, and the associated land, were managed by the Serayu-Opak River Basin Agency (BBWS-SO) under the Directorate General of Water Resources. However, as of April 30, 2024, these assets have been officially transferred to Balai Teknik Sabo. With this asset transfer, Balai Teknik Sabo now manages all assets established through STC-related projects.

Therefore, in this report, while treating STC and Balai Teknik Sabo as synonymous, the term “STC” is used when referring to activities from the VSTC project to the ISDM project, whereas the term “Balai Teknik Sabo” is used when describing activities after the completion of the ISDM project and discussing future developments.



**Figure 2-1 History and organizational changes of STC**

**Source:**  
Japan Sabo and Disaster Prevention Association (2000): *30 Years of Japan-Indonesia Sabo Technology Cooperation*, 440p.  
Watanabe Fumito (2006): *ISDM Project in Indonesia*, Journal of the Japan Society of Erosion Control Engineering, Vol. 58, No. 5, pp. 26-34.  
Handover Minutes (Berita Acara Serah Terima) dated April 30, 2024.

## 2.2 STC Activities from the VSTC Project to the ISDM Project

From the VSTC Project to the ISDM Project, STC has carried out technical development activities, training programs, and public awareness and dissemination activities based on technical guidance from experts.

This section organizes the past activities conducted by STC into these three groups, based on existing literature sources [1, 2] to better understand the operations at STC.

### 2.2.1 Volcanic Sabo Technical Center (VSTC) Project

The VSTC Project was implemented from August 26, 1982, to March 31, 1990, with the objective of training engineers and developing technologies related to volcanic Sabo. During the project period, various public awareness and dissemination activities were also conducted (Table 2-1). Among the training programs, the general course provided a broad introduction to the overview, objectives, and effectiveness of Sabo projects for engineers involved in public works. Meanwhile, the advanced and comprehensive courses were designed to train engineers in leadership roles in volcanic Sabo projects, targeting senior Sabo engineers at the section chief level or higher from river bureau construction offices.

**Table 2-1 Activities of the VSTC project**

<b>Technical Development</b>	<p>a) <b>Development of appropriate construction methods</b></p> <ul style="list-style-type: none"> <li>• Countermeasures for abrasion of the Sabo dam crest</li> <li>• Appropriate construction methods using gabions</li> <li>• Structural reinforcement techniques utilizing vegetations</li> <li>• Sediment management measures combining Sabo facilities and intake structures</li> </ul> <p>b) <b>Hydraulic model experiments</b></p> <ul style="list-style-type: none"> <li>• Countermeasures for local scour</li> <li>• Design of flow control structures</li> <li>• Surface erosion control measures</li> <li>• Mechanism of debris flow initiation and movement</li> </ul> <p>c) <b>Debris flow early warning system</b></p> <ul style="list-style-type: none"> <li>• Establishment of model areas</li> <li>• Introduction of monitoring equipment</li> <li>• Setting of warning and evacuation rainfall thresholds</li> <li>• Delineation of anticipated inundation areas</li> <li>• Preparation of information dissemination manuals</li> </ul>
<b>Training</b>	<p>a) <b>General course:</b></p> <ul style="list-style-type: none"> <li>• Target participants: government officials and engineers engaged in public works in private companies</li> <li>• Objective: introduction to overview, objectives, and effectiveness of Sabo projects</li> <li>• Training duration: conducted four times per year, with 20 participants per session, lasting two weeks per session</li> </ul> <p>b) <b>Advanced course:</b></p> <ul style="list-style-type: none"> <li>• Target participants: experienced personnel at the section chief level from department of river construction offices</li> <li>• Objective: training engineers for leadership roles in Sabo projects by equipping them with skills in Sabo investigation, planning, design, and maintenance</li> <li>• Training duration: conducted once per year, with 15 participants per session, lasting six months per session</li> </ul> <p>c) <b>Comprehensive Course:</b></p> <ul style="list-style-type: none"> <li>• Target participants: experienced personnel from section chief to deputy director level in river bureau construction offices</li> <li>• Objective: training engineers capable of handling feasibility studies (F/S) and detailed designs (D/D) for volcanic Sabo projects</li> <li>• Training duration: conducted once every two years, with five participants per session, lasting two years per session</li> </ul>
<b>Public Awareness and Dissemination</b>	<p>a) Production and publication of booklets</p> <p>b) Issuance of “VSTC News”</p> <p>c) Organization of seminars</p>

Source: Japan Sabo and Disaster Prevention Association (2000): 30 Years of Japan-Indonesia Sabo Technology Cooperation, 440p.

## 2.2.2 Sabo Technical Center (STC) Project

The STC Project was implemented from April 1, 1992, to March 31, 1997, with the objective of human resource development and technical advancement in comprehensive Sabo engineering, including countermeasures for landslides, sediment flows, cliff collapses, and reservoir sedimentation, covering both volcanic and non-volcanic areas (

Table 2-2). Among the training programs, the public course aimed to help representatives of local communities and regional government agencies understand the concept, objectives, effectiveness, and necessity of sediment-related disaster prevention and restoration works. Meanwhile, the Sabo technology course and applied Sabo technology course were conducted to provide engineers engaged in Sabo projects with the knowledge and practical skills required for sediment disaster prevention and rehabilitations works.

**Table 2-2 Activities of the STC project**

<b>Technical Development</b>	<ul style="list-style-type: none"> <li>a) Landslide countermeasures</li> <li>b) Debris flow countermeasures</li> <li>c) Upstream Sabo measures for the protection of intake facilities</li> <li>d) Planning and design of multi-purpose Sabo facilities</li> <li>e) Reservoir sedimentation countermeasures</li> <li>f) Planning and design of debris flow early warning systems</li> <li>g) Follow-up on VSTC technical development topics (planning and design of bioengineering techniques; planning and design of gabion structures; countermeasures for Sabo dam crest abrasion)</li> </ul>
<b>Training</b>	<ul style="list-style-type: none"> <li>a) <b>Public course:</b> <ul style="list-style-type: none"> <li>• Target participants: representatives from local communities and regional government agencies</li> <li>• Objective: understanding the concept, objectives, effectiveness, and necessity of sediment disaster prevention and restoration works</li> <li>• Training duration: conducted twice per year, with 15-20 participants per session, lasting four days per session</li> </ul> </li> <li>b) <b>Sabo technology course:</b> <ul style="list-style-type: none"> <li>• Target participants: university researchers, government officials, and engineers from private companies</li> <li>• Objective: acquisition of fundamental knowledge and practical techniques for sediment disaster prevention and restoration works</li> <li>• Training duration: conducted once per year, with 15-20 participants per session, lasting 1.5 months per session</li> </ul> </li> <li>c) <b>Applied Sabo technology course</b> <ul style="list-style-type: none"> <li>• Target participants: mid-level engineers from the Indonesian government who have completed VSTC training</li> <li>• Objective: acquisition of advanced knowledge and practical techniques for sediment disaster prevention and restoration works</li> <li>• Training duration: conducted with five participants per session, lasting six months per session</li> </ul> </li> </ul>
<b>Public Awareness and Dissemination</b>	<ul style="list-style-type: none"> <li>a) Organization of seminars</li> <li>b) Issuance of “STC News”</li> <li>c) Development of a Sabo-related database</li> </ul>

Source: Japan Sabo and Disaster Prevention Association (2000): 30 Years of Japan-Indonesia Sabo Technology Cooperation, 440p.

### 2.2.3 Integrated Sediment Disaster Management (ISDM) Project

The ISDM Project was implemented from April 1, 2001, to March 31, 2006 (

Table 2-3), with the objective of enabling the planning and execution of comprehensive disaster prevention measures in volcanic regions. Considering Indonesia’s socio-economic conditions, including financial constraints at the central and regional levels, democratization, and decentralization, the project primarily focused on activities related to public-private collaboration for debris flow countermeasures. The training programs, consisting of the Water and Sediment Disaster Prevention Technology (WIDE) course and the On-the-Job Training (OJT) course, were designed to develop engineers capable of formulating regional comprehensive disaster prevention plans and providing technical support. Additionally, the Natural Disaster Management (MPBA) Course, established at Gadjah Mada University, initiated the training of high-level professionals who could lead and implement comprehensive disaster prevention measures within central and local government agencies.

**Table 2-3 ISDM project activities**

<b>Technical Development</b>	a) Establishment of an integrated disaster prevention model through collaboration between government and residents b) Development of regional disaster prevention organizations and systems c) Establishment of disaster recovery and countermeasure techniques d) Development of widely accessible rain gauges and other monitoring equipment e) Infrastructure development for the Sabo Information System
<b>Training</b>	a) <b>Water Induced Disaster Engineering (WIDE) Course</b> <ul style="list-style-type: none"> <li>• Target: provincial and district-level government officials</li> <li>• Objective: understanding the fundamentals of sediment disasters and Sabo engineering</li> </ul> b) <b>On-the-Job Training (OJT) course</b> <ul style="list-style-type: none"> <li>• Target: provincial and district-level government officials involved in model project areas</li> <li>• Objective: gaining insights into the planning process of integrated disaster prevention projects for model areas</li> </ul> c) <b>Establishment of the Natural Disaster Management (MPBA) course at Gadjah Mada University (UGM)</b> <ul style="list-style-type: none"> <li>• Target: engineers from the Ministry of Public Works, local public works agencies, and other ministries</li> <li>• Objective: training high-level professionals capable of leading and implementing comprehensive disaster prevention measures at both central and regional government levels</li> </ul>
<b>Public Awareness and Dissemination</b>	A) Development of the “Yokota Library” as part of the Sabo Information System infrastructure B) Organization of seminars

Source: Watanabe, Fumihito (2006): ISDM Project in Indonesia, Journal of the Japan Society of Erosion Control Engineering, Vol. 58, No. 5, p. 26-34

## 2.3 Overview of Balai Teknik Sabo

### 2.3.1 Mission and Functions

Based on information from the Balai Teknik Sabo website as of August 2024, the mission and functions of Balai Teknik Sabo are summarized as follows:

**Mission of Balai Teknik Sabo:**

Balai Teknik Sabo is tasked with the development, engineering, and implementation of technical services for testing, evaluation, inspection, and certification in the field of Sabo engineering.

**Functions:**

- (a) Preparation of plans, programs, and budgets (*Penyusunan rencana, program, dan anggaran*)
- (b) Implementation of development and engineering (*Pelaksanaan pengembangan dan perekayasaan*)
- (c) Implementation of dissemination activities (*Pelaksanaan diseminasi*)
- (d) Implementation of technical services, including testing, evaluation, inspection, and certification (*Pelaksanaan pelayanan teknis meliputi pengujian, pengkajian, inspeksi, dan sertifikasi*)
- (e) Facilitation of technology transfer (*Fasilitasi pelaksanaan alih teknologi*)
- (f) Preparation and management of data (*Penyiapan dan pengelolaan data*)
- (g) Management of laboratories (*Pengelolaan laboratorium*)
- (h) Implementation of monitoring, evaluation, and reporting (*Pelaksanaan pemantauan, evaluasi, dan pelaporan*)
- (i) Administration and financial management of the center (*Pelaksanaan urusan tata usaha dan rumah tangga balai*)

Source: Translation of information from the Balai Teknik Sabo website (<https://Sabo.pusair-pu.go.id/balai/teknikSabo/page/tugas-dan-fungsi>)

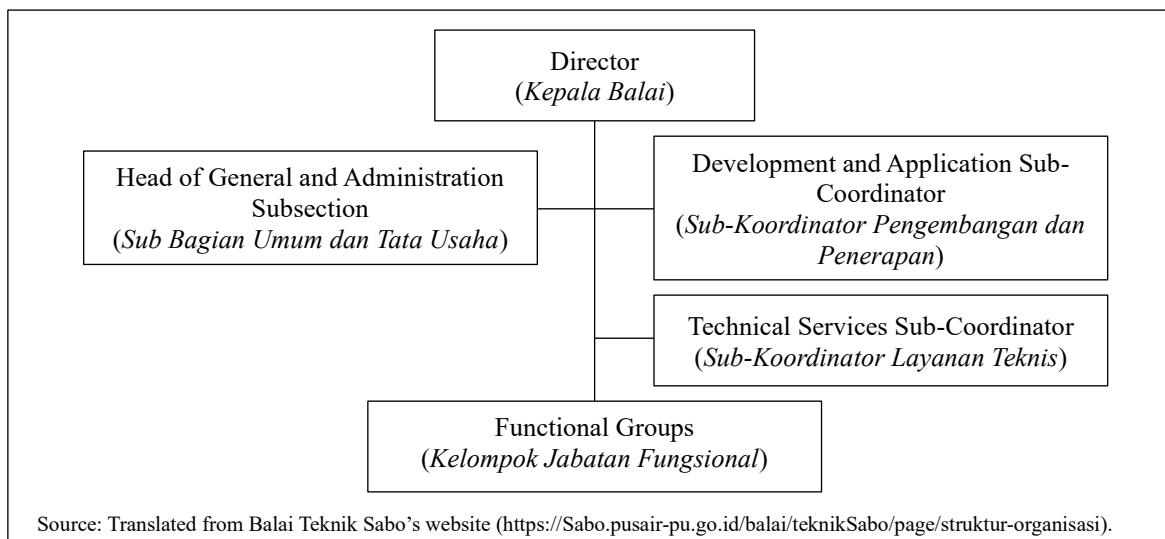
The functions of Balai Teknik Sabo, indicated by the grey hatching ((a), (f)-(i)), relate to administrative tasks for organizational management. In contrast, functions (b)-(e) align with the technical development, training, and dissemination activities previously carried out by STC, which will be elaborated upon in Section 2.4.1.

Although human resource development (*Pengembangan Sumber Daya Manusia*) is not explicitly defined within Balai Teknik Sabo's functions, an interview with the Director of the Water Resources Technical Directorate (Bintek), the higher authority of Balai Teknik Sabo, on August 29, 2024, revealed that the functions of (b) Implementation of development and engineering and (c) Implementation of dissemination activities include education. As part of this, human resource development could be carried out. Currently, human resource development for staff within the Ministry of Public Works is managed by the Ministry's Human Resources Development Agency (BPSDM). However, no specialized educational programs for Sabo engineering have been implemented. In this regard, it was noted that Balai Teknik Sabo could play a role in designing educational programs and providing technical guidance, while BPSDM would handle the administrative arrangements for implementing the educational programs.

In fact, Balai Teknik Sabo has already hosted experimental and practical sessions for the Public Works Polytechnic (Politeknik Pekerjaan Umum), which is under BPSDM, providing guidance in soil testing, concrete testing, and hydraulic model experiments for students (as detailed in Section 2.4.1). Therefore, the feasibility of this approach is considered high.

### 2.3.2 Organizational Structure

Based on the Balai Teknik Sabo website as of August 2024, the organizational structure of Balai Teknik Sabo is as follows. Balai Teknik Sabo consists of the following divisions: Technical Development & Application Division; Technical Services Division; Administration Division. Additionally, there are functional groups that support the operational tasks of each division. The Technical Development & Application Division and the Technical Services Division correspond to the functions of (b) Implementation of development and engineering, and (d) Implementation of technical services including testing, evaluation, inspection, and certification, respectively.



**Figure 2-2 Organizational structure of Balai Teknik Sabo**

### 2.3.3 Human Resources

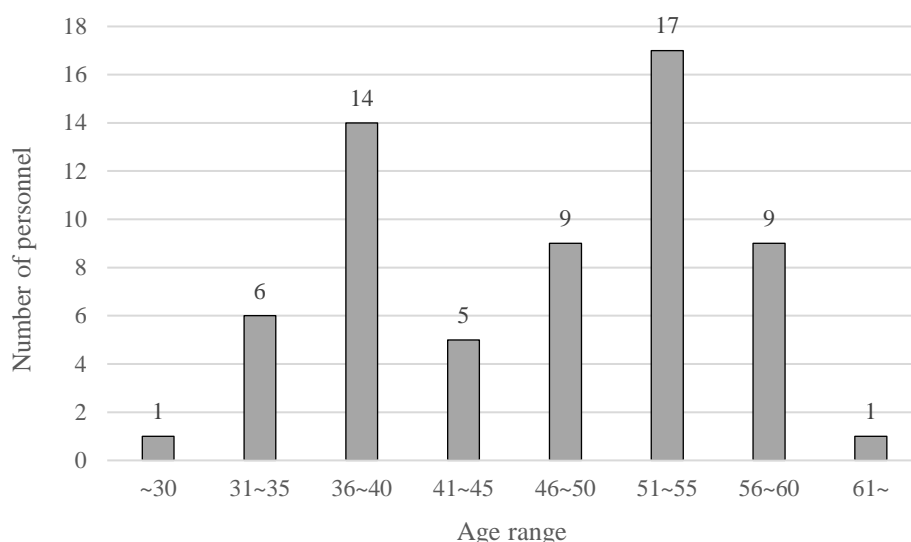
Based on the information from the Balai Teknik Sabo website as of August 2024, the personnel at Balai Teknik Sabo are classified into three categories: specialized civil servants (*PNS Jabatan Fungsional Tertentu*), general civil servants (*PNS Jabatan Fungsional Umum*), and non-civil servant staff (*Non PNS*). The respective numbers in each category are 12, 36, and 14 respectively. Below is the breakdown of the specialized civil servants, consisting of engineers and researchers involved in development, engineering, technical services, and testing, evaluation, inspection, and certification tasks.

#### Breakdown of Specialized Civil Servants:

- Chief Engineer (*Perekayasa Utama*): 1 person
- Intermediate Engineers (*Perekayasa Ahli Muda*): 4 persons
- Junior Engineers (*Perekayasa Ahli Pertama*): 1 person
- Irrigation Intermediate Engineer (*Teknik Pengairan Ahli Muda*): 1 person
- Intermediate Researchers (*Peneliti Muda*): 3 persons
- Junior Researchers (*Peneliti Pertama*): 1 person
- Junior Building & Housing Engineer (*Teknik Tata Bangunan & Perumahan Ahli Pertama*): 1 person

Source: translated from the Balai Teknik Sabo website  
(<https://Sabo.pusair-pu.go.id/balai/teknikSabo/page/sumber-daya-manusia>)

Figure 2-3 shows the age distribution of all employees at Balai Teknik Sabo. From this figure, it can be seen that the staff are biased towards the 51-55 and 36-40 age ranges, with few young people in their 20s and mid-career people in their 40s.



**Figure 2-3 Age composition of all staff at Balai Teknik Sabo**

Source: Balai Teknik Sabo website (<https://Sabo.pusair-pu.go.id/balai/teknikSabo/page/sumber-daya-manusia>)

## 2.4 Current Status Analysis

As of August 2024, the mission, functions, organizational structure, and human resources composition of Balai Teknik Sabo have been compiled, and an analysis of its functions and activities has been conducted. In order to provide an objective evaluation, sources have been cited wherever possible.

### 2.4.1 Activities of Balai Teknik Sabo

#### (1) Technical Development

Referring to the function of Balai Teknik Sabo in section 2.3.1, the activities of Balai Teknik Sabo that correspond to the technical development activities previously conducted by STC are considered to be (b) Implementation of development and engineering, and (d) Implementation of technical services including testing, evaluation, inspection, and certification. A review was conducted using Balai Teknik Sabo’s official website and academic literature search engines such as Google Scholar to examine the organization’s technical development activities, formulation of technical standards, academic publications, and provision of technical advisory services as of August 2024. These findings have been compiled in Table 2-4 to Table 2-7. The data in Table 2-4 covers technical development activities conducted over the past five years (as of August 2024). The data in Table 2-5 to Table 2-7 spans a broader period, from 2010 to August 2024. All of these activities took place during the organizational transitions from Balai Sabo to Balai Litbang Sabo, and ultimately to the current Balai Teknik Sabo, following the termination of the ISDM project. The activities were primarily conducted based on requests from the Directorate General of Water Resources and its affiliated Directorate of Water Resources Technology, indicating that they were demand-driven.

**Table 2-4 Examples of technical development activities by Balai Teknik Sabo**

Initiative	Source
a) Application of Steel Fiber Reinforced Concrete to the Spillway and Stilling Basin Cover of Sabo Dams (Trial Construction: Togurara River, Gamalama Volcano (2017))	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/penerapan-teknologi-beton-serat-baja-pada-selimut-Sabodam">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/penerapan-teknologi-beton-serat-baja-pada-selimut-Sabodam</a>
b) Trial Implementation of Modular Sabo	<a href="https://Sabo.pusair-">https://Sabo.pusair-</a>

Capacity Development of Sabo Technical Center (STC)

Initiative	Source
Dams Using Concrete Blocks (Trial Construction: Konto River, Kelud Volcano)	pu.go.id/balai/teknikSabo/berita/detail/penerapan-teknologi-Sabodam-modular
c) Application of Ring Net Barrier Technology for Debris Flow Mitigation (Trial Construction: Rejali River, Semeru Volcano (2018))	https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/penerapan-teknologi-ring-net-barriers-untuk-pengendalian-aliran-debris
d) Sediment Transport Analysis Using Powersim Studio 10 Software (Analysis Conducted: Modeling of sediment transport in torrents of Agung Volcano (2018); Verification: Comparison with actual measured data)	https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/mitigasi-bencana-banjir-lahar-di-gunungapi-agung-dengan-teknoSabo

Source: Balai Teknik Sabo Website (Compiled from activity reports of the past five years, retrievable as of August 2024).

**Table 2-5 Examples of technical standards developed by Balai Teknik Sabo**

Field	Title
1) Sabo Soil Cement	Permen PUPR No. 03/PRT/M/2011 Tahun 2011: Implementation Guidelines for Using Soil Cement as a Primary Component in Sabo Structures

Source: Regulatory Database (<https://peraturan.bpk.go.id/Details/144822/permen-pupr-no-03prtm2011-tahun-2011>)

**Table 2-6 Examples of academic papers published by researchers at Balai Teknik Sabo**

Field	Paper Title
[1] Reservoir sedimentation control	Soewarno, C. Bambang Sukatja (2010): <i>Kinerja Dam Sabo K. Lumajang untuk Pengendalian Sedimentasi Waduk Mrica</i> (Performance of Sabo Dam in K. Lumajang for Controlling Sedimentation of Mrica Reservoir), Jurnal Sumber Daya Air, Vol. 6, No. 1
[2] Reservoir sedimentation control	Agus Sumaryono, Djudi, Dyah Ayu Puspitosari (2011): <i>Penerapan Teknologi Sabo Pada Sungai di Wilayah Gunung Kelud untuk Mengurangi Sedimentasi Waduk Wlingi</i> (Application of Sabo Technology to Rivers in the Kelud Mountain Region to Reduce Sedimentation of the Wlingi Reservoir), Jurnal Sumber Daya Air, Vol. 7, No. 1
[3] Reservoir sedimentation control	Singgih Haryono, Arif Rahmat Mulyana, Soewarno, Arif Subagyo (2012): <i>Penerapan Teknik Sabo untuk Pengendalian Daya Rusak Air di Dataran Tinggi Dieng</i> (Application of Sabo Technique in Controlling the Water Destructive force in Dataran Tinggi Dieng), Jurnal Teknik Hidraulik, Vol. 3, No. 2
[4] Reservoir sedimentation control	Ardian Alfianto, Soewarno (2014): <i>TeknoSabo untuk Mengatasi Sedimentasi di Daerah Tangkapan Air Waduk (Kasus Waduk Mrica)</i> (Techno Sabo for Overcoming Reservoir Watershed Sedimentation (Case Reservoir Mrica)), Jurnal Teknik Hidraulik, Vol. 5, No. 1
[5] Embankment materials	Jati Iswardoyo (2016): <i>Studi Pemanfaatan Steel Slag sebagai Bahan Bangunan Sabo Dam</i> (The Study of Utilization of Steel Slag to Sabo Dam), Jurnal Teknik Hidraulik, Vol. 7, No. 2
[6] Landslides	Rokhmat Hidayat, Samuel Jonson Sutanto, Moh. Deddy Munir (2016): <i>Kondisi Geologi dan Pola Hujan sebagai Pemicu Longsor di Jawa Tengah Bagian Selatan Pada Juni 2016</i> (Geological and Rainfall Condition as Landslide Causative Factors in Southern Part of Central Java in June 2016), Jurnal Teknik Hidraulik, Vol. 7, No. 2
[7] Mapping	Samuel Jonson Sutanto, Banata Wachid Ridwan (2016): <i>Teknologi Drone untuk Pembuatan Peta Kontur: Studi Kasus Pada Kawasan P3SON Hambalang</i> (Drone Technology for Contour Mapping: Case Study at P3SOM Hambalang), Jurnal Teknik Hidraulik, Vol. 7, No. 2

Field	Paper Title
[8] Surface erosion	Moh. Dedi Munir (2017): <i>Aplikasi Green Sabo Dalam Pengendalian Erosi di Kawasan Lahar Bagion Atas</i> (Green Sabo Application for Erosion Control in Upper Land Area), Jurnal Teknik Hidraulik, Vol. 8, No. 2
[9] Debris flow (volcanic areas)	Rokhmat Hidayat, Akhyar Musthofa, Perdi Bahri (2017): <i>Pengaruh Intensitas Hujan terhadap Kecepatan dan Tinggi Banjir Lahar berdasar Pemodelan SIMLAR 2.1</i> (Influence of Rainfall Intensity to Lahar Flood Velocity and Height based on SIMLAR 2.1 Modelling), Jurnal Teknik Hidraulik Vol. 8, No.1
[10] Debris flow (volcanic areas)	Cosmas Bambang Sukatja, Ardian Alfianto (2017): <i>Revitalisasi Sabodam Sebagai Pengendali Aliran Lahar (Studi Kasus di Daerah Gunungapi Merapi)</i> (Revitalisation of Sabo Dam as Lahar Flow Controller (Case Study in Merapi Volcano Area)), Jurnal Teknik Hidraulik, Vol. 8, No. 1
[11] Reservoir sedimentation control	Santosa Sandy Putra, Soewarno, Dwi Kristianto (2017): <i>Perencanaan Lokasi Mini Sabodam dengan Metode Imbangan Sedimen pada Area Hulu dari Rencana Waduk Ciawi, Ciliwung</i> (Mini Sabodam Placement Planning by Sediment Balance Method in the Upstream Area of the Proposed Ciawi Reservoir, Ciliwung), Jurnal Sumber Daya Air, Vol. 13, No. 2
[12] Landslides	Rokhmat Hidayat (2018): <i>Analisis Stabilitas Lereng pada Longsor Desa Caok, Purworejo, Jawa Tengah</i> (Slope Stability Analysis in Caok Village Landslide, Purworejo, Central Java), Jurnal Sumber Daya Air, Vol. 14, No. 1
[13] Landslides	Rokhmat Hidayat, Moh. Dedy Munir (2019): <i>Longsor di Sungai Cipunagara dan Desain Penanganannya</i> (Landslide at Cipunagara River and its Handling Design), Jurnal Lingkungan dan Bencana Geologi, Vol. 10 No. 1
[14] Sabo structures utilization (geo-tourism)	Moh. Dedi Munir (2019): <i>Bangunan Sabo Dam, Fungsi dan Potensinya Sebagai Pendukung Geowisata Gunung Merapi</i> (Sabo Dam Structure, Its Function and Potency as part of Geotourism in the Merapi Volcano), Jurnal Lingkungan dan Bencana Geologi, Vol. 10, No. 2
[15] Debris flow (volcanic areas)	Ardian Alfianto, Jati Iswardoyo, Cosmas Bambang Sukatja (2019): <i>Efektivitas dan Kelengkapan Bangunan Sabo di Sungai Togurara Daerah Gunungapi Gamalama</i> (Effectivity and Instrumentation of Sabodam in Togurara River Gamalama Volcano Area), Jurnal Teknik Hidraulik, Vol. 10, No. 2
[16] Reservoir sedimentation control	Ardian Alfianto, Shandy Cecilia, Banata Wachid Ridwan, Chitra Widyasani Surya Putri (2020): <i>Penerapan Teknologi Sabo sebagai Penahan Laju Sedimentasi Pada Muara Danau Limboto</i> (The Implementation of Sabo Technoloty in Limboto's Estuary Sedimentation Flow Retainment), Jurnal Teknik Hidraulik, Vol. 11, No. 1
[17] Debris flow (volcanic areas, experimental models)	Bayu Seto Waseso Utomo, Jati Iswardoyo, Ruzardi (2020): <i>Uji Laboratorium Pengaruh Kemiringan Lereng Terhadap Kejadian Longsoran Aliran Debris Pasir Merapi</i> (Laboratory Test of Slope Effect toward Landslide Event on Merapi Sand Debris Flow), Jurnal Sumber Daya Air, Vol. 16, No. 1
[18] Landslide mitigation	Rokhmat Hidayat (2020): <i>Analisis Pengaruh Infiltrasi Hujan terhadap Stabilitas Lereng di Pangkalan, Sumatera Barat</i> (Rainfall Infiltration Effect on Slope Stability in Pangkalan, West Sumatera), Jurnal Teknik Hidraulik, Vol. 11, No. 1
[19] Landslide mitigation	Rokhmat Hidayat, Avidah Amalia Zahro (2020): <i>Penentuan Ambang Curah Hujan untuk Memprediksi Kejadian Longsor</i> (Rainfall Treshold Determination for Landslide Events Prediction), Jurnal Sumber Daya Air, Vol. 16, No. 1
[20] Reservoir sedimentation control	Ardian Alfianto, Shandy Cecilia, Banata Wachid Ridwan (2020): <i>Pemodelan Potensi Erosi dan Sedimentasi Hulu Danau Limboto dengan WaTEM/SEDEM</i> (Potential Erosion and Sedimentation Modeling of the Upstream Limboto Lake using WaTEM/SEDEM), Jurnal Teknik Hidraulik, Vol. 11, No. 2
[21] Reservoir sedimentation	Ardian Alfianto, Shandy Cecilia, Alidina Nurul Hidayah, Anjelita, Cosmas Bambang Sukatja (2021): <i>Perencanaan Sabo untuk Mengendalikan Laju Sedimentasi di Rawapening</i> (Sabo Plan for Controlling Sediment Rate of

Field	Paper Title
control	Rawapening), Jurnal Sumber Daya Air, Vol. 17, No. 1
[22] Debris flow (non-volcanic area)	C. Bambang Sukatja, Banata W.R, Perdi Bahri (2021): <i>Mitigasi dan Penanggulangan Bencana Banjir Debris Pasca Gempa Palu 2018</i> (Mitigation and Countermeasures of Debris Flow Disaster Post Palu Earthquake 2018), Jurnal Teknik Hidraulik, Vol. 12, No. 1
[23] Landslide	Rokhmat Hidayat, I Putu Eddy Purna Wijaya, Moh. Dedi Munir (2023): <i>Mekanisme Longsor Akibat Infiltrasi dari Genangan Air (Studi Kasus Longsor di Lahat, Sumatera Selatan)</i> (Landslide Mechanism due to Infiltration from Water Ponding (Case Study of Landslide in Lahat, South Sumatera)), Jurnal Teknik Hidraulik, Vol. 14, No. 1
[24] Flash flood	Jati Iswardoyo, Hafizh Satria (2023): <i>Analisis Daerah Terdampak Banjir Bandang Menggunakan HEC-RAS 2 Dimensi di Sungai Sat, Kabupaten Pati, Jawa Tengah</i> (Analysis of Flash Flood Affected Area using the HEC-RAS 2D at Sat River, in Pati Regency, Central Java), Jurnal Teknik Hidraulik, Vol. 14, No. 1
[25] Debris flow (volcanic areas)	Yutaka Gonda, Djoko Legono, Bambang Sukatja, <u>Untung Budi Santoso</u> (2014): Debris flows and flash floods in the Putih River after the 2010 eruption of Mt. Merapi, Indonesia, International Journal of Erosion Control Engineering Vol. 7, No. 2
[26] Debris flow (volcanic areas)	<u>Santosa Sandy Putra</u> , Banata Wachid Ridwan, Kazuki Yamanoi, Makoto Shimomura, Sulistiyani, Dicky Hadiyuwono (2019): Point-Based Rainfall Intensity Information System in Mt. Merapi Area by X-Band Radar, Journal of Disaster Research, Vol. 14, No. 1

Note: The literature extracted from the Google Scholar site (<https://scholar.google.co.jp/schhp?hl=ja>) was based on searches using the keywords “balai,” “Sabo,” and “site:go.id.” Among the documents that appeared in the search results, those authored by individuals affiliated with Balai Sabo, Balai Litbang Sabo, or Balai Teknik Sabo were selected. The two final papers related to SATREPS are based on the conclusion report of the SATREPS project titled “Comprehensive Research on Disaster Mitigation due to the Release of Volcanic Eruptions” (<https://projectdb.jst.go.jp/grant/JST-PROJECT-13803203/>).

**Table 2-7 Examples of technical advisory services provided by Balai Teknik Sabo**

Field	Title
<b>2011-2012</b>	
1) Surface erosion	Erosion control in Ambon (BWS Maluku)
2) Landslides	Technical audit of landslide at Jatigede multipurpose dam (DGWRD)
3) Landslides	Countermeasures against landslides and drainage in the area of General Sudirman Museum in Pacitan (Minister of Defense)
4) Slope failure	Slope Failures in Wasior, Papua (Central Government)
5) Debris flow (volcanic area)	Debris flow prevention in Tanah Datar (Local Government of Tanah Datar Regency)
6) Debris flow (non-volcanic area, Sabo facility design)	Design of Sabodam in Cibatu, Garut (BBWS Cimanuk)
7) Debris flow (volcanic area, model experiment)	Modeling shortcut of Putih river after Mt. Merapi eruption in 2010
8) Reservoir sedimentation control	Sedimentation control at Limboto Lake in Gorontalo Province (Sulawesi) (BWS Sulawesi II)
9) Natural dams	Countermeasures against Way Ela natural dam break in Ambon, Maluku
<b>2013- 2015</b>	
10) Landslides	Countermeasure against landslide disaster in Banjarnegara, Central Jawa
11) Slope failure	Countermeasures against slope failures and debris flows in Padang, West Sumatera
12) Debris flow (non-volcanic area)	Countermeasure against debris flows disaster at Amahusu and Nusaniwe villages, Ambon, Maluku Province
13) Flash floods	Contribution of Sabo technology to combat flash flood in Manado, North

Field	Title
	Sulawesi
14) Flash floods	Countermeasure against flash flood in Aceh
15) Debris flow (volcanic area)	Sabo works for emergency response in Mt. Sinabung, North Sumatera
16) Reservoir sedimentation control	Reservoir sedimentation in Mrica Dam, Banjarnegara, Central Jawa
17) Reservoir sedimentation control	Sediment disaster management and water resources problem of Kedungwringin dam in BBWS Serayu-Opak, Central Jawa

Note: Quoted from the materials created by Mr. Chandra Hassan, the former head of Balai Teknik Sabo, in 2015.

To understand the scope of Balai Teknik Sabo's technical development activities, a mapping was carried out from both technical fields and project implementation stages, based on the content of the references organized in Table 2-4, Table 2-6, and Table 2-7, and this was summarized in Table 2-8. The facts confirmed from this table and the referenced content are as follows:

- a. Among the duties and functions of Balai Teknik Sabo (see section 2.3.1), the activities corresponding to (b) Development and engineering implementation are those related to the design and construction stages, represented by the activities shown in Table 2-4. Other activities correspond to d. Implementation of technical services, including testing, evaluation, inspection, and certification. There were no activities related to maintenance management.
- b. In terms of technical fields, the activities with the highest frequency, in order, were reservoir sedimentation control, landslides, volcanic debris flows, embankment materials, and flash floods. In contrast, activities related to non-volcanic debris flows, surface erosion, natural dams, and slope failures were less frequent. Activities concerning natural dams (a phenomenon where landslides block rivers and create dams) were limited to a case study in Ambon Island, Maluku.

**Table 2-8 Mapping of the technical development activities of Balai Teknik Sabo**

Field	Survey/Testing	Analysis/Evaluation	Planning	Design	Construction	Maintenance
Embankment materials	0	1	0	4	3	0
Reservoir sedimentation control	4	11	4	1	0	0
Landslides	5	9	1	2	0	0
Debris flow (volcanic area)	4	10	2	0	0	0
Debris flow (non-volcanic area)	1	2	0	1	0	0
Flash floods	1	3	0	0	0	0
Surface erosion	2	1	0	0	0	0
Natural dams	1	1	0	0	0	0
Slope failures	1	2	0	0	0	0
Mapping	1	1	0	0	0	0
Utilization of Sabo facilities	1	1	0	0	0	0

Legend:  1-2 activities,  3-4 activities,  5-6 activities,  7+ activities

Among the fields with low frequency of occurrence in Table 2-8 (natural dams are excluded since the main causative i.e., large-scale landslides are rare), debris flow in non-volcanic area, surface

erosion, and slope failures (cliff collapses) are generally high-frequency hazards that occur frequently in Indonesia. These hazards are believed to occur in large numbers annually across the country. While the potential demand for technical development related these hazards is likely high, the number of activities is less.

The reason for this may be that in Indonesia, disasters caused by these hazards are statistically mixed in with landslides and floods (refer to Table 2-9), and that MPW prioritizes the development of technologies related to reservoir sedimentation control, landslides, and debris flows in volcanic areas in terms of the magnitude of the social impact, the scale of the disaster, and the urgency of the disaster. The clear reason was not revealed.

**Table 2-9 Number of disaster incidents by type (2023)**

No.	Disaster Type	Number of Incidents
1	Flood ( <i>banjir</i> )	1,255
2	Landslide ( <i>tanah longsor</i> )	591
3	Storm surges and erosion ( <i>gelombang pasang dan abrasi</i> )	-
4	Extreme weather ( <i>cuaca ekstrem</i> )	456
5	Drought ( <i>kekeringan</i> )	1,011
6	Forest fires ( <i>kebakaran hutan dan lahan</i> )	2,052
7	Earthquake ( <i>gempa bumi</i> )	31
8	Tsunami ( <i>tsunami</i> )	-
9	Volcanic eruption ( <i>erupsi gunung api</i> )	4
10	Earthquake and tsunami ( <i>gempa bumi dan tsunami</i> )	-

Source: Indonesian National Disaster Management Authority (BNPB) Statistical Data ([https://dibi.bnpb.go.id/statistik\\_menurut\\_bencana](https://dibi.bnpb.go.id/statistik_menurut_bencana))

## (2) Training

Examples of training activities conducted by Balai Teknik Sabo is organized in Table 2-10.

This information is based on activity reports from the past five years, accessible on the website since December 2024. The reports span the period after the ISDM project, during which the organization transitioned from Balai Sabo to Balai Litbang Sabo and eventually to the current Balai Teknik Sabo. Most of the training activities involved demand-based guidance on testing and experimental methods, as well as lectures and equipment demonstrations on Sabo techniques for government staff. These were equivalent to introductory-level content in the general courses conducted under the VSTC project (Table 2-1) and the public courses under the STC project (

Table 2-2). However, by December 2024, a training course on the design of open type Sabo dams for practical-level personnel was held. This suggests that efforts are being made in Indonesia to strengthen the functions of Balai Teknik Sabo (see Table 2-11). Under the current organizational structure, the Ministry of Public Works' human resource development (*pengembangan sumber daya manusia*) is managed by the Ministry's Human Resources Development Agency (BPSDM). However, there are no training programs related to Sabo techniques or debris flow in the BPSDM's educational and training programs. The Public Works Polytechnic (*Politeknik Pekerjaan Umum*), listed at the top of Table 2-10, is under BPSDM. Therefore, it will be feasible for BPSDM and Balai Teknik Sabo to collaborate on implementing educational and training programs.

**Table 2-10 Examples of training activities by Balai Teknik Sabo:**

Initiatives	Source
<b>Acceptance of practical training for students of the Public Works Polytechnic</b> (5 days in December 2021, conducted at Balai Teknik Sabo, guiding 50 students in soil testing, concrete testing, and hydraulic model experiments).	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kegiatan-praktikum-mahasiswa-politeknik-pekerjaan-umum-di-balai-teknik-Sabo">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kegiatan-praktikum-mahasiswa-politeknik-pekerjaan-umum-di-balai-teknik-Sabo</a>
<b>Acceptance of Sabo training for staff from the West Java Provincial Public Works and Water Resources Agency</b> (July 2024, lectures on Sabo techniques and sediment control at Balai Teknik Sabo’s experimental facility and Merapi Volcano’s Gendol River, including demonstrations of experimental equipment).	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/studi-banding-dinas-pu-sda-provinsi-jawa-barat">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/studi-banding-dinas-pu-sda-provinsi-jawa-barat</a>
<b>Dissemination of Sabo techniques at Sulawesi 1 River Basin Agencies</b> (June 2024, a lecture on the dissemination of Sabo techniques at the River Basin Agency for Sulawesi 1 Office’s auditorium).	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/diseминаsi-teknologi-Sabo-di-bws-sulawesi-1">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/diseминаsi-teknologi-Sabo-di-bws-sulawesi-1</a>
<b>Training on the design of open type Sabo dams</b> (December 2024, a training session at Balai Teknik Sabo’s auditorium for Ministry of Public Works personnel at the Sabo engineer level).	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/pelatihan-desain-Sabodam-terbuka-untuk-bed-load-dan-suspended-load">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/pelatihan-desain-Sabodam-terbuka-untuk-bed-load-dan-suspended-load</a>

Source: Extracted from the activity reports available on the Balai Teknik Sabo website (from the past five years, accessible since December 2024).

**Table 2-11 Mapping of training activities by Balai Teknik Sabo**

Level	Purpose	Target Audience			
		(PU senior managers and above)	(Mid-level PU staff)	(Junior PU staff)	(Local government staff)
Advanced	Development of human resources in leadership positions for Sabo projects (acquiring advanced knowledge and practical skills in Sabo investigation, planning, design, maintenance, etc.)	—	—		
Intermediate	Development of human resources at the Sabo engineer level for Sabo projects		√*	√*	
Basic	Development of human resources who understand the purpose of sediment disaster prevention, Sabo projects, and the effects and necessity of Sabo facilities			√	√
Basic	Training on testing and experimental methods			√	—

Note) PU: Ministry of Public Works, “√”: implemented, “—”: not implemented

\*: Refers to the results of training on the design of open-type sabo dams.

### (3) Public Relations and Awareness

Examples of the public relations and awareness activities conducted by Balai Teknik Sabo is organized in Table 2-12, based on information from their official website and official social media channels during the same period. Additionally, the content of these activities is categorized in Table 2-13, comparing them to the public relations and awareness activities carried out under projects like the VSTC project. From this information, it can be confirmed that although general seminars and booklets have not been created, efforts for public relations are conducted through the official website, various social media platforms, and video-sharing sites. Specialized information related to Sabo is provided to registered users through the official website, and there is a proactive effort to host university students for site visits, which will help secure future Sabo engineers.

**Table 2-12 Examples of public relations and outreach activities by Balai Teknik Sabo**

Activities	Source
Field Visit for Civil Engineering Students of Gadjah Mada University, River & Ecology Club (July 2024, at the Krasak River in Merapi Volcano): Lectures on the functionality, design, construction, and maintenance of Sabo facilities.	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/site-visit-river-and-ecology-club-dts-sv-ugm">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/site-visit-river-and-ecology-club-dts-sv-ugm</a>
Field Visit for Civil Engineering Students of Ahmad Yani University (July 2024, at the experimental facilities of Balai Teknik Sabo and Gendol River in Merapi Volcano): Lectures on the structure and functionality of Sabo facilities.	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kunjungan-lapangan-mahasiswa-teknik-sipil-universitas-jenderal-achmad-yani">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kunjungan-lapangan-mahasiswa-teknik-sipil-universitas-jenderal-achmad-yani</a>
Visit by Master’s Students of the Water Resources Management Program, Civil and Environmental Engineering Department, Bandung Institute of Technology (ITB) (November 2021, at Balai Teknik Sabo’s experimental facilities): Lectures on Sabo technology and hydraulic model experiments.	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kunjungan-lapangan-fieldtrip-karyasiswa-ss-program-studi-magister-psda-itb">https://Sabo.pusair-pu.go.id/balai/teknikSabo/berita/detail/kunjungan-lapangan-fieldtrip-karyasiswa-ss-program-studi-magister-psda-itb</a>
Public Relations Services via Balai Teknik Sabo’s Official Website: Publicizing activity news, providing registered users with hydrological data, map data, and survey activity data from the Merapi Volcano region, as well as a list of technical standards related to Sabo.	<a href="https://Sabo.pusair-pu.go.id/balai/teknikSabo/katalog">https://Sabo.pusair-pu.go.id/balai/teknikSabo/katalog</a>
Information Distribution via SNS (Facebook, X, Instagram) and Video Sharing Sites (YouTube).	Facebook: <a href="https://www.facebook.com/pupr.sda.btSabo">https://www.facebook.com/pupr.sda.btSabo</a> X: <a href="https://twitter.com/pupr_sda_btSabo">https://twitter.com/pupr_sda_btSabo</a> Instagram: <a href="https://www.instagram.com/pupr_sda_btSabo/">https://www.instagram.com/pupr_sda_btSabo/</a> YouTube: <a href="https://www.youtube.com/@BalaiSabo/">https://www.youtube.com/@BalaiSabo/</a>

Source: extracted from the activity reports available on the official Balai Teknik Sabo website, dated from December 2024 covering the past five years.

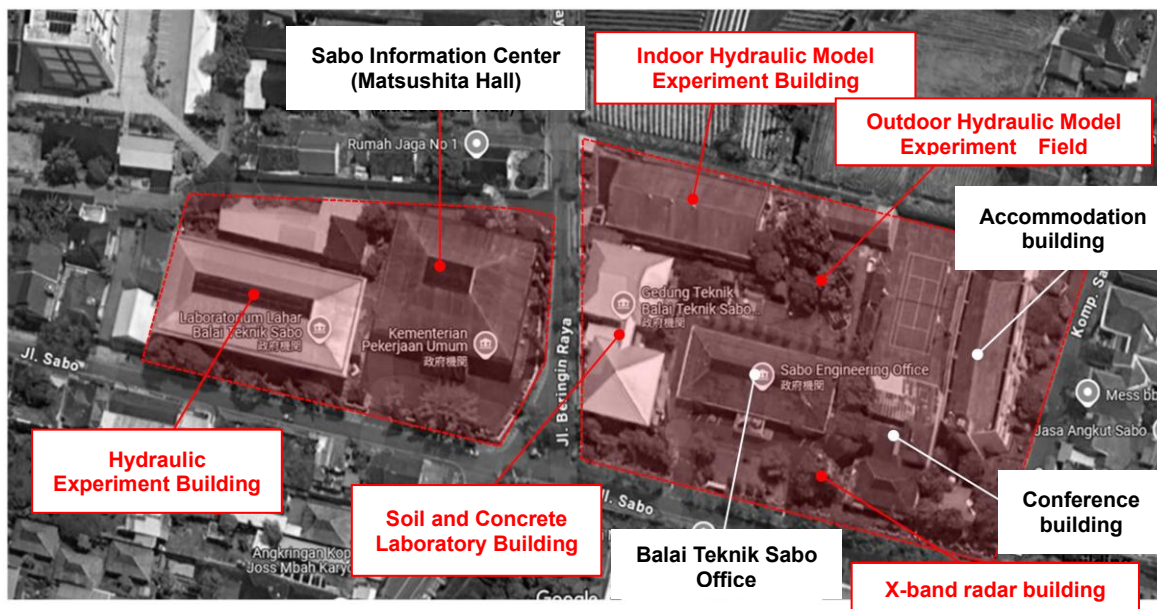
**Table 2-13 Mapping of public relations and awareness activities by Balai Teknik Sabo**

Target Audience for Public Relations & Awareness	Methods				
	News	Seminars	Database	Booklet	(Site Visits)
General Public	✓	—	—	—	—
University Students	✓	—	✓	—	✓
Sabo Specialists	✓	—	✓	—	*

Note: “✓”: Implemented “—”: Not implemented

## 2.4.2 Equipment and Facilities Managed by Balai Teknik Sabo

The observation, testing, and experimental facilities located on the premises of Balai Teknik Sabo are broadly categorized into the following: soil and concrete testing building, hydraulic model experiment building, X-band radar building, indoor hydraulic model experiment building, and outdoor hydraulic model experiment field (refer to the red text in Figure 2-4). The soil and concrete testing building consists of both a soil testing laboratory and a concrete testing laboratory.



Note: The area framed in red is the Balai Teknik Sabo site, and the red text is the observation, testing, and experiment facilities

Figure 2-4 Testing and experiment facilities

### (1) Equipment and facilities in the soil and concrete testing building and hydraulic experiment building

The status of the equipment installed in the concrete testing laboratory and soil testing laboratory within the soil and concrete testing building, as well as the equipment in the hydraulic experimentation building, is presented in Table 2-14 to Table 2-16. The equipment is generally in a usable condition and is used for various purposes such as technical development (Table 2-4), technical services related to testing and evaluation, material preparation for hydraulic model experiments, and experimental training (Table 2-10). However, many of the items are old and requires continued maintenance by the Indonesian side.

Table 2-14 Main equipment in Balai Teknik Sabo (concrete testing laboratory)

No.	Equipment name	Qty	Function	Specification	Condition
1	Concrete strength tester	1	Compressive strength test Tensile strength test	Made in Japan, 1985 Capacity: 200 tons	Aging but usable
2	Los Angeles testing machine	1	Aggregate wear test	Made in Japan, 1985	Aging but usable
3	Concrete abrasion tester	1	Concrete abrasion test	Made in Japan, 1987	Aging but usable
4	Aggregate oven	2	Preparation of aggregate in a completely dry state	Made in Japan, 1985	Aging but usable

No.	Equipment name	Qty	Function	Specification	Condition
			Adjusting the moisture content of aggregate		
5	Gravimetric weighers	1	Weight measurement	Precision: 0.1 g, maximum 30,000 g	Aging but usable
6	Coarse aggregate weighing scale	1	Measurement of specific gravity of coarse aggregate	Digital measurement	Usable
7	Aggregate sieving machine	3	Aggregate sieving test	---	Usable
8	Sieves shaker (various types)	>10	Aggregate sieving test	Various sieve sizes	Usable
9	Moisture chamber	1	Test sample moisture content ratio retention	---	Usable
10	Pycnometer	>10	Measurement of aggregate volume	500 ml	Usable
11	Compaction cone	3	Measurement of water absorption of fine aggregate	---	Aging but usable
12	Mold	>3	Sample molding	Various volumes	Aging but usable
13	Molding machine	1	Sample molding	---	Usable
14	Impact tester	1	Concrete impact resistance measurement	Made in Japan, 1985	Aging but usable
15	Concrete mixer	3	Mixing concrete materials	30 L	Usable
16	Caliper	2	Dimensions measurement of test sample	30 cm	Aging but usable
17	Sample cutting machine	1	Sample cutting	Made in Japan, 1986	Usable
18	Slump measurement machine	>2	Measurement of concrete slump	Made of steel	Usable
19	Concrete strength hammer testing machine	4	Measurement of concrete strength	Strength measurement range: 10 to 70 (N/mm <sup>2</sup> )	Usable: 2 Needs repair: 2

**Table 2-15 Main equipment in Balai Teknik Sabo (soil testing laboratory)**

No.	Equipment name	Qty	Function	Specification	Condition
1	Soil shear tester	1	Obtain soil direct shear strength (obtaining <i>c</i> value and <i>phi</i> value)	Made in Japan, 1986. Test ring capacity: 100 kg	Aging but usable
2	Soil uniaxial compression tester	1	Measurement of soil uniaxial compressive strength by USC	Made in Japan, 1984. Probing ring capacity: 50 kg	Aging but usable
3	Soil triaxial compression tester	1	Measurement of soil triaxial compressive strength	---	Aging but usable
4	Specific gravity meter	23	Soil grain size analysis test	---	Aging but usable
5	Liquid limit tester	2	Measurement of soil liquid limit value	---	Aging but usable
6	Oven	2	Drying test sample	---	Usable
7	Mass measuring	1	Measurement of test sample	Capacity: 420 g	Usable

No.	Equipment name	Qty	Function	Specification	Condition
	instrument		mass		
8	Mass measuring instrument	1	Measurement of test sample mass	Capacity: 2000 g	Aging but usable
9	Mass measuring instrument	1	Measurement of test sample mass	Capacity: 6000 g	Usable
10	Soil permeability tester	1	Measurement of soil permeability/infiltration coefficient (cm/sec)	---	Aging but usable
11	CBR tester	1	Measurement of soil CBR value	Paneil Sau product, 2013	Usable
12	Sieve vibrator	1	Sieve analysis test	Speed controller available. Electric operation	Aging but usable
13	Caliper	3	Dimension measurement	Digital, max 20 cm	Usable :1 Needs repair: 2
14	Extruder	1	Removal of test sample	---	Aging but usable
15	Cylinder	>10	Weighing	Various capacities	Usable
16	Load cell	2	Measure load	---	Usable
17	Dial gauge	>5	Measurement of sample dimensions	---	Usable
18	Pycnometer	>10	Density measurement in soil specific gravity test	100 ml	Usable
19	Soil compaction mold	>3	Soil density test	---	Usable
20	Sample container	2	Humidity control container for sample	---	Usable

**Table 2-16 Main equipment in Balai Teknik Sabo (hydraulic laboratory)**

No.	Equipment name	Qty	Function	Specification	Condition
1	Flume model	2	Flume model	Steel waterway model. Can model mudflows. Channel length 15 m. Channel gradient can be adjusted	Aging but usable
2	Artificial rainfall (rainfall model test)	1	Artificial rainfall	Discharge rate 25 liters/sec. Automatic panel. Demonstration test area with artificial slope	Aging but usable
3	Point gauge	2	Sediment runoff model caused by raindrops	---	Aging but usable
4	Ammeter	3	Water level measurement	---	Aging but usable
5	Rectifier	>2	For measuring water level and flow velocity	---	Aging but usable
6	Discharge volume measuring device	>2	Flow meter	---	Usable
7	Pump	>1	Flow meter	---	Usable
8	Water level gauge	1	Pumping up test water	---	Usable
9	Water level adjustment valve	3	Water level measurement	---	Usable

No.	Equipment name	Qty	Function	Specification	Condition
10	Field current meter	1	Water level adjustment	---	Aging but usable
11	Lifting load measuring device	1	Flow velocity measurement	---	Usable
12	Sampling device for moving soil and sand	2	Suspended sediment sampling	---	Aging but usable

Note: This is a summary of the equipment list created by Balai Teknik Sabo.

## (2) Equipment and facilities in the X-band radar building

An X-band MP radar was installed in 2014 through the International Science and Technology Collaboration Program for Sustainable Development (SATREPS) with research area on “Disaster Risk Reduction” and research project title of “Comprehensive Study on Mitigating Disasters Associated with the Release of Volcanic Ejecta”. According to interviews conducted with Balai Teknik Sabo, the facility is currently not fully operational due to frequent equipment malfunctions. As a result, repairs are being considered using the national budget.



**Figure 2-5 Condition of the X-band radar installation**

Source: SATREPS “Comprehensive Study on Mitigating Disasters Caused by Volcanic Eruption” Final Report (2019)

## (3) Equipment and facilities of the hydraulic model experiment

### 1) Equipment and facilities in the indoor hydraulic model experiment building

The indoor hydraulic model experiment building (area: 19 m × 40 m = 760 m<sup>2</sup>) is a facility for verifying the functionality of Sabo facilities through experiments (see Figure 2-6). According to the interview surveys, there is a high demand for this facility and it is in continuous operation. As of June 2024, the model section of the facility was under renovation in preparation for new model experiments (see Figure 2-7).

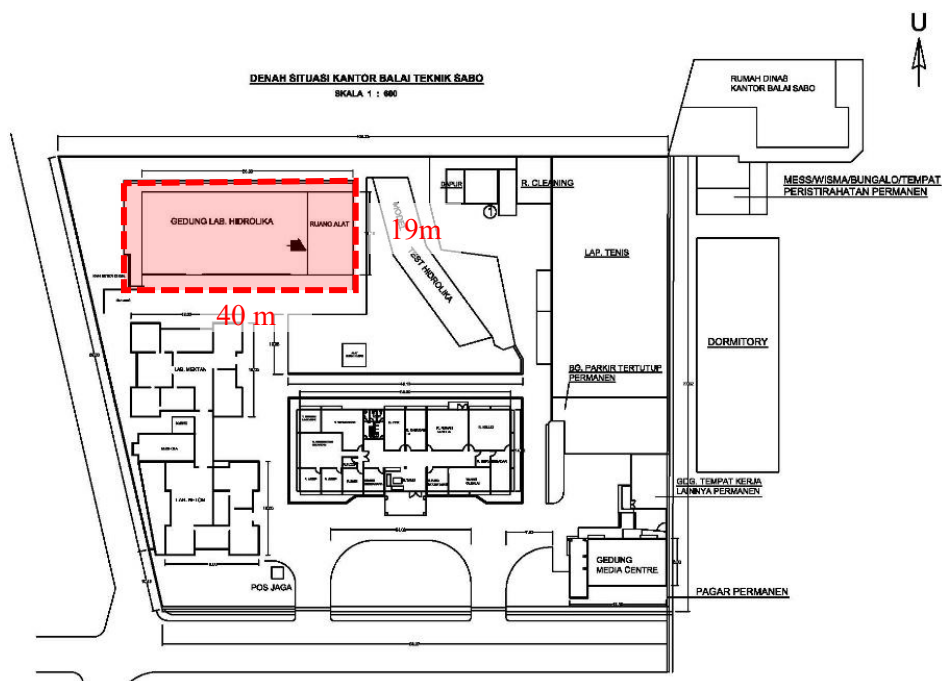


Figure 2-6 Location and size of indoor hydraulic model experiment building



Figure 2-7 Condition of the interior of the indoor hydraulic model experiment building (as of June 2024, the model area is currently under renovation)

## 2) Equipment and facilities of the outdoor hydraulic model experiment field

The outdoor hydraulic model experiment field (area:  $35 \text{ m} \times 30 \text{ m} = 1,050 \text{ m}^2$ ) is a facility designed to conduct multiple hydraulic model experiments in parallel with the indoor hydraulic model experiment building. Currently, the existing models occupy only about  $150 \text{ m}^2$  (approximately 15% of the total area) of the site ( Figure 2-8, Figure 2-9 ).

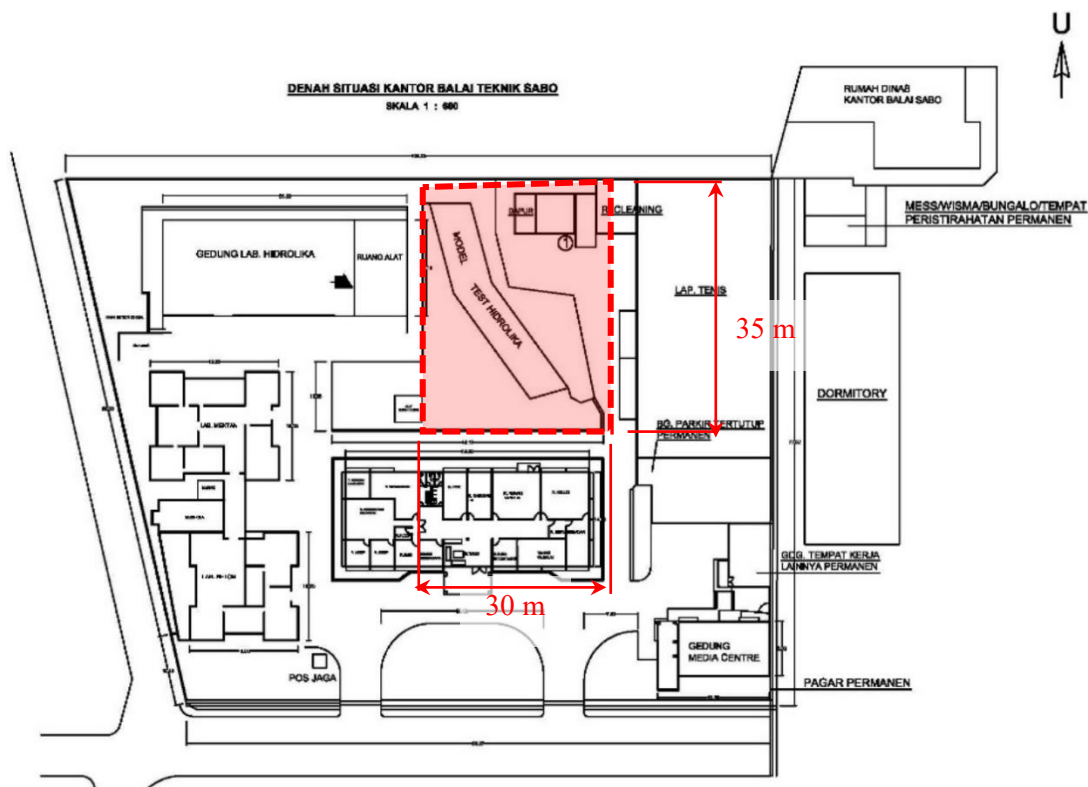


Figure 2-8 Location and size of outdoor hydraulic model experiment field



Figure 2-9 Condition of the outdoor hydraulic model experiment field as of June 2024

### 3) Current condition of implementation of hydraulic model experiment

#### Necessity of Hydraulic Model Experiments

The planning and design of river structures and Sabo structures in Indonesia are fundamentally carried out in accordance with the country’s technical standards and guidelines. However, when it is necessary to verify the functionality of structures for which no technical standards or guidelines exist, the functionality of structures installed in unique topographical conditions (Figure 2-10, left) or the combined functionality of multiple consecutive structures, hydraulic model experiments are conducted for functional verification.

For instance, during the detailed design of the flood diversion channel for debris flow control in the Putih River following the 2010 eruption of Mt. Merapi under the Japanese ODA loan project i.e.,

Progo River Basin Mount Merapi Emergency Disaster Management Project, Balai Teknik Sabo conducted hydraulic model experiments to verify its functionality. Since this was the first river structure in Indonesia designed to accommodate debris flow, the experiments confirmed that even when sediment accumulated within the flow channel under the design-scale debris flow, no flooding would occur (Figure 2-10, right)

### Usage of Hydraulic Model Experiment Facilities

In response to the frequent sediment-related disasters occurring in Indonesia, the Directorate General of Water Resources has been strengthening its measures against sediment and flood disasters under the disaster risk mainstreaming policy of the National Medium-Term Development Plan (RPJMN 2020-2024), leading to an increase in the national budget for disaster prevention (see the Completion Report, p. 5-5).

Additionally, there has been a growing demand from various river basin agencies for hydraulic model experiments to verify the functionality of designed structures. A hearing survey conducted in June 2024 with Balai Teknik Sabo confirmed that three projects are currently in the queue, awaiting experimentation.



(Verification of sediment deposition process in a meandering section of a Sabo dam, 2021)



(Functional verification of a flood diversion channel designed for debris flow, 2011)

Source:

(Left photo) : <https://sabo.pusair-pu.go.id/balai/tekniksabo/berita/detail/kegiatan-praktikum-mahasiswa-politeknik-pekerjaan-umum-di-balai-teknik-sabo>

(Right photo) : Yachiyo Engineering Co., Ltd.

**Figure 2-10 Implementation of Hydraulic Model Experiments**

#### (4) Evaluation of Current Condition

The current condition of Balai Teknik Sabo’s equipment and facilities, as summarized in (1) to (4) above, is summarized in Table 2-17. The facilities that currently require repair are the outdoor hydraulic model and the X-band radar.

**Table 2-17 Evaluation of the current condition of equipment and facilities**

Facility name	Summary of equipment and facility evaluation
Soil and concrete testing building	The equipment is generally in a usable condition and is used for technical development, technical testing and evaluation, preparation of material for hydraulic model experiments, and experimental training. However, many of the equipment are old and requires continuous maintenance by

Facility name	Summary of equipment and facility evaluation
	the Indonesian side.
Hydraulic testing building	Same as above
Indoor hydraulic model experiment building	The facility is in high demand and is constantly operational, with a significant number of ongoing hydraulic model experiments.
Outdoor hydraulic model experiment facility	Despite a high demand for experiments, the layout constraints of pumps and piping prevent the effective use of the entire site, limiting its full potential.
X-band radar building	The radar equipment frequently malfunctions and is not fully operational. Plans are underway for repairs using national budget funding to restore the facility's full functionality.

### 2.4.3 Analysis of needs for disaster risk reduction in the sediment disaster sector in Indonesia

#### (1) Analysis method

The analysis of needs for disaster risk reduction in the sediment disaster sector in Indonesia was conducted by identifying the needs from the Indonesian side and considering the needs based on the research findings from the Japanese side.

#### (2) Understanding of needs from the Indonesian side

The needs of Indonesian side were identified based on the intentions and requests for the strengthening of the Sabo Technology Center (STC), which were shared with the Japanese side by the Minister's Secretariat of the Ministry of Public Works and Public Housing (MPWH) on December 6, 2023. This was followed by discussions based on the Memorandum of Understanding (MOU) signed between the Indonesian Directorate General of Water Resources of MPWH and JICA at the 10th World Water Forum (WWF2024). During these exchanges with relevant Indonesian agencies, hearings on the strengthening of the STC were conducted, and the results were organized for further analysis. The events where discussions and hearings on strengthening the STC were held are summarized in Table 2-18.

**Table 2-18 Key discussions on strengthening the STC**

Date	Agenda	Participants	Main discussion points
December 6, 2023 (a)	Strengthening the STC capacity	Minister's Secretariat, Ministry of Public Works, Bintek, Balai Teknik Sabo, BBWS-SO, Embassy of Japan in Indonesia, JICA Jakarta Office, JICA Experts	The intentions and plans for strengthening the STC, as outlined by the Minister of Public Works, were shared and discussed.
January 15, 2024 (b)	Sabo technology and STC capacity enhancement	Bintek	There was an in-depth discussion on areas of Sabo technology that need to be strengthened and the Indonesian side's plans for strengthening the STC capacity.
February 28, 2024 (c)	Current Sabo projects and technology	BBWS-Brantas, Bintek, Balai Teknik Sabo	The application of Sabo technology to ongoing projects was discussed, with attention to improving technologies for broader sediment disaster issues other than volcanic Sabo.
March 8, 2024 (d)	Current functions and capacities of the STC	Balai Teknik Sabo	Indonesian officials shared information on plans and schedule for the renovation of the STC building and the jurisdiction plan for STC facilities.

Date	Agenda	Participants	Main discussion points
May 22, 2024 (e)	MOU signing on STC capacity strengthening	Minister of Public Works, Directorate General of Water Resources, JICA	An MOU was signed between the Directorate General of Water Resources of the Ministry of Public Works and JICA regarding the formulation of a roadmap for capacity enhancement, strengthening the STC as an educational institution, and upgrading facilities and equipment.
June 25, 2024 (f)	Courtesy visit by the Ambassador of Japan to Balai Teknik Sabo	Balai Teknik Sabo, Embassy of Japan in Indonesia	Further exchanges of opinions on the necessity and urgency of strengthening the STC's function.
July 17, 2024 (g)	1st Joint Meeting on strengthening the STC	Bintek, Balai Teknik Sabo	The first national meeting on STC capacity strengthening was held in Indonesia. Topics such as the current state of Sabo technology, the need for strengthening the technology, sharing information on the Centers of Excellence (CoE), and the timeline for enhancing Sabo technology were thoroughly discussed.

Note: Bintek: Water Resources Technical Agency, BBWS-SO: Serayu-Opak River Basin Agencies, BBWS-Brantas: River Basin Agency for Brantas.  
The above meetings were attended by members of the Yachiyo Engineering Co., Ltd. Jakarta Office or the study team for the Project.

The results of the discussions and hearings at the events shown in Table 2-18 are summarized below and in Table 2-19.

**Intentions of the Minister of Public Works and Housing regarding the strengthening of STC functions (December 6, 2023) (a)**

- Restoration and upgrading of existing STC facilities are necessary.
- Effective utilization of Sabo technology materials held by STC is required.
- The Sabo technology field must cover a broad range of areas, extending beyond volcanic Sabo.
- Strengthening collaboration with other government agencies such as the Meteorological, Climatological, and Geophysical Agency (BMKG) and the Geological Agency (BG) is essential.
- Sabo technology support to third countries from Indonesia should be advanced.

**Items related to the strengthening of STC functions as stated in the MOU (MOU signed on May 1, 2024) (e)**

- Development of a roadmap for strengthening STC functions.
- Strengthening STC as an educational institution for Sabo technology.
- Strengthening STC functions through the upgrading of STC facilities and equipment.

**Table 2-19 Indonesia’s needs for strengthening STC functions**

Category	Contents	Related items
<b>Technical development</b>	Expansion of Sabo technology coverage beyond the volcanic Sabo field	(a) (b) (f)
	Promotion of “Green Sabo” (tentative name) <sup>1)</sup> Development and dissemination of rational methods for the design, construction, management, and evaluation of technologies	(b) (f) (g)
	Development of precast concrete products for Sabo dams	(c)
	Utilization of UAV-based LiDAR surveying technology for Sabo projects	(c)
	Development of simulation technology for analyzing debris flow dynamics in sand pockets	(c)
<b>Training</b>	Strengthening of human resource development in Sabo technology	(b)
	Enhancement of STC’s functions as an educational institution	(f)
	Development of Sabo technology instructors and continuous transmission of technical knowledge	(f)
<b>Public relations and awareness-raising</b>	Effective utilization of Sabo technology materials held by STC	(a)
	Improvement of library function	(b)
<b>Equipment and facilities</b>	Renovation of the outdoor hydraulic model experiment facility to meet the needs of numerous watershed management offices	(g)
<b>Other</b>	MOU: Expansion of functions as an essential organization contributing to the “Center of Excellence (CoE) for Water and Climate Resilience” research hub	(e)
	MOU: Strengthening of STC as a training center for Sabo technology for government officials, Sabo engineers, and institutions in all regions of Indonesia and third countries	(e)
	Strengthening collaboration with other countries and providing Sabo technology support to third countries	(a)
	Organizational strengthening and securing budget for international technical cooperation	(d)

**Note:**

<sup>1)</sup> In Indonesia, the term *Green Sabo* has not been precisely defined. However, a paper authored by Balai Teknik Sabo personnel<sup>2)</sup> describes it as “a technology that utilizes materials derived from naturally occurring vegetation to control soil erosion and sedimentation.” Specifically, it explains the following measures for surface soil erosion control:

- a) Planting vegetation such as bamboo and vetiver grass.
  - b) Applying mulching in fields using coconut fiber nets or straw (covering the base of crops with various materials).
- The paper also presents experiments and analyses on the effectiveness of method b).

<sup>2)</sup> Moh. Dedi Munir (2017): *Aplikasi Green Sabo Dalam Pengendalian Erosi di Kawasan Lahar Bagian Atas (Green Sabo Application for Erosion Control in Upper Land Areas)*, Jurnal Teknik Hidraulik, Vol. 8, No. 2.

**(3) Issues in the Sabo Sector of the Directorate General of Water Resources (DGWR)**

To address technical challenges in Indonesia's Sabo sector, an evaluation of the recent activities of Balai Teknik Sabo, which provides support to DGWR, was conducted. Based on this evaluation, key issues in the Sabo sector under DGWR were identified and summarized in Table 2-20. The procedure for this assessment is as follows:

**1. Technical Development**

The analysis was conducted based on the information presented in Section 2.4.2(1). Activities undertaken by Balai Teknik Sabo, including technical development (Table 2-4), technical standards (Table 2-5), academic publications (Table 2-6), and technical advisory services (Table 2-7), were examined. Challenges that need to be strengthened within the Sabo Technical Centre (STC) were identified for each type of hazard. The reference numbers in Table 2-20 correspond to the case numbers listed in Table 2-4 to Table 2-7.

2. Human Resource Development

The analysis was conducted based on the information presented in Section 2.4.1(2).

3. Equipment and Facilities

The analysis was conducted based on the information presented in Section 2.4.2.

4. Public Relations and Awareness Promotion

The analysis was conducted based on the information presented in Section 2.4.1(3).

Table 2-20 Summary of issues related STC

	Survey	Plan	Design	Construction	Maintenance
<b>I. Sediment Management in River Basins</b>					
Technical Development	<p>1) A review of collected literature and information has confirmed that STC has the following achievements and implementation capabilities:</p> <ul style="list-style-type: none"> <li>• Various surveys, including surface erosion assessment, sampling of suspended and bedload sediments, and sediment accumulation surveys in Sabo dams and reservoirs.</li> <li>• Various analyses, such as rainfall analysis, erosion simulation, and sediment runoff analysis.</li> <li>• Calibration of analytical results using observed data.</li> </ul> <p>2) Regarding sediment flushing from reservoirs, as implemented in reservoirs like the Wonogiri Multipurpose Dam, new technologies are being introduced based on Japanese expertise. However, sediment flushing in reservoirs falls under the jurisdiction of the Dam Technology Center of the Directorate General of Water Resources (DGWR) and is outside STC's scope.</p> <p>3) Based on the above, it is determined that the DGWR has a high level of capability in conducting research and analysis for sediment management in river basins. However, there is room for further improvement in the introduction of new technologies, such as sediment discharge from dams.</p> <p>References: [1][2][3][4][11][16][20][21][8]16)17)</p>	<p>1) It has been confirmed that STC has achieved the following:</p> <ul style="list-style-type: none"> <li>• Through the investigation and analysis of sediment transport, STC reviewed the effectiveness of Sabo facilities in reducing sedimentation rates in the Wlingi Reservoir, located downstream of Sabo facilities in the Kelud volcanic region of East Java. The analysis concluded that the Sabo facilities contributed to slowing down reservoir sedimentation.</li> <li>• Regarding sedimentation countermeasures for Lake Limboto under the jurisdiction of the Sulawesi II River Basin Agency, STC reviewed the Sabo facility plan developed by the agency and evaluated that the proposed facility volume was appropriate.</li> <li>• For sedimentation countermeasures in Lake Pening, Central Java, STC reviewed the existing Sabo facility plan, proposed the scale and location of additional Sabo facilities, and highlighted the necessity of regular dredging for maintaining their functionality.</li> </ul> <p>2) On the other hand, since there is still limited experience in developing plans based on new technologies, such as sediment discharge from dams, it is judged that there is room for further improvement (the Dam Technology Center of the Water Resources Bureau is responsible for this).</p> <p>3) Based on the above, it is determined that the DGWR has high capabilities in plan review for sediment management in river basins. However, there is room for further improvement in the formulation of plans that incorporate new technologies, such as sediment discharge from dams.</p> <p>References: [2][16][21][8]16)17)</p>	<p>1) The design of Sabo dams and bed stabilization works for sediment management in river basins can be addressed using existing design techniques based on current technical standards and guidelines.</p> <p>2) STC has been conducting design and experimental studies in a test field located in the Dieng Plateau, Central Java, focusing on improving cultivation methods, temporary storage of eroded sediments from farmland using micro Sabo dams, and check dams for riverbed erosion control. These techniques are similar to the sediment deposition and Sabo facilities implemented in Okinawa, Japan, as part of red soil erosion countermeasures.</p> <p>3) On the other hand, since there is still limited experience in designing new facilities, such as sediment bypass tunnels from dams, it is judged that there is room for further improvement (however, sediment discharge from dams falls under the jurisdiction of the Dam Technology Center of the Water Resources Bureau, and is outside the scope of STC).</p> <p>4) Based on the above, it is judged that the DGWR has high capabilities in the design of Sabo facilities for sediment management in river basins. However, there is room for further improvement in the design process incorporating new technologies, such as sediment discharge from dams.</p> <p>Reference: [3]</p>	<p>1) The construction of most Sabo facilities for sediment management in river basins can be carried out using existing construction techniques.</p> <p>2) On the other hand, there is limited experience in constructing new facilities such as sediment bypass tunnels. Therefore, it is determined that there is a room for further improvement. However, it should be noted that reservoir sediment flushing falls under the jurisdiction of the Dam Technology Center of the Directorate General of Water Resources (DGWR) and is outside STC's scope.</p>	<p>1) Maintenance and management of erosion control facilities for sediment management in river basins can be handled with existing technology.</p> <p>2) Inappropriate mining activities by the private sector are cited as a factor that hinders the proper removal of sediment captured by erosion control facilities. However, it is judged as an issue that should be considered by each river basin agency, taking into account the socio-economic characteristics of each region.</p>
Human Resource Development	<p>1) DGWR has personnel capable of conducting technical studies on sediment management in river basins. However, there is room for improvement in developing highly skilled personnel who can effectively handle new technologies related to sediment flushing from dams.</p> <p>2) Furthermore, as Indonesia's socio-economic development progresses, the demand for technical services related to sediment management measures in river basins is expected to increase. Therefore, it is judged necessary for DGWR personnel and related officials to play a key role as Sabo engineers who can technically manage sediment management projects at the River Basin Agency level. To achieve this, comprehensive training programs covering sediment management measures in river basins should be provided to develop a large number of Sabo engineers who understand Sabo engineering. Additionally, enhancing the technical capabilities of entry-level River Basin Agency staff through training and technical manuals is judged essential.</p> <p>References: A) B)</p>				
Equipment and Facilities*	<p>A) Soil and Material Testing Generally available for use.</p> <p>B) Hydraulic Model Experiments</p>	-	-	-	-
	-	-	There is a high demand for erosion control in cultivated lands and sediment storage within watersheds. Currently, these needs are being met through facilities such as the Hydraulic Experiment Building and the Indoor Hydraulic Model Experiment Building. However, It is judged that if the number of experiments increases in the future, it will be necessary to consider utilizing the outdoor hydraulic model testing facility.	-	-
<b>2. Landslides</b>					
Technical Development	<p>1) From the collected literature, the following achievements of the STC have been confirmed:</p> <ul style="list-style-type: none"> <li>• Various investigations, including surveys on landslide topography and morphology, geological conditions, rainwater infiltration, and rainfall intensity.</li> <li>• Analytical studies such as slope stability analysis for landslides, cause analysis of riverbank landslides, evaluation of the impact of rainwater infiltration on slope stability, prediction of critical rainfall thresholds for landslide initiation, and clarification of landslide mechanisms caused by rainwater infiltration.</li> </ul> <p>2) Based on the above, it is judged that the STC's capabilities in landslide research and analysis are sufficiently high, and the issues are being appropriately addressed. Therefore, it is judged that they are adequately meeting the needs of the DGWR.</p> <p>References: [6][12][13][18][19][23]2)3)10)</p>	<p>1) The following accomplishments of STC have been confirmed:</p> <ul style="list-style-type: none"> <li>• Establishment of threshold rainfall criteria for landslide warning and evacuation.</li> <li>• STC has evaluated countermeasures based on the analysis of landslide causes in Subang Regency, East Java, planned the proposed structural measures included impermeabilization of irrigation channels, anchored gabion retaining walls, and erosion control measures at the slope toe, and verified the effectiveness of these measures through slope stability analysis.</li> </ul> <p>2) Based on the above, it is judged that the STC's capabilities in landslide mitigation planning are sufficiently high, and the issues are being appropriately addressed. Therefore, it is judged that they are adequately meeting the needs of the DGWR.</p> <p>References: [6][13][19]</p>	<p>1) The following achievements of STC have been confirmed:</p> <ul style="list-style-type: none"> <li>• As part of structural countermeasures for the landslide in Subang Regency, East Java, STC designed anchored gabion retaining walls, spur dikes with tail structures, and drainage facilities.</li> </ul> <p>2) Although the ability to design all landslide prevention and mitigation works could not be fully confirmed, it is judged that the ability to adequately review the landslide mitigation designs carried out by contractors commissioned by the Ministry of Public Works is sufficiently high, and therefore, it is considered that they are adequately meeting the needs of the DGWR.</p> <p>References: [13]3)10)</p>	<p>The construction of landslide mitigation facilities can be handled using existing construction techniques.</p>	<p>The maintenance of landslide mitigation facilities can be handled using existing technologies.</p>
Human Resource Development	<p>1) STC has personnel capable of conducting technical assessments related to landslides.</p> <p>2) However, with Indonesia's future socio-economic development, the demand for technical services in landslide mitigation is expected to increase. Therefore, it is judged that in the future, staff primarily from DGWR and other relevant agencies will need to take on the role of Sabo engineers who can manage landslide mitigation projects from a technical perspective at each River Basin Agencies. To achieve this, it is determined that training programs that comprehensively cover landslide mitigation measures should be implemented to cultivate a large number of professionals with expertise in Sabo engineering. Additionally, efforts should be made to enhance the technical capacity of entry-level River Basin Agency staff who may become future technical Sabo engineers.</p>				
Equipment and Facilities	<p>A) A) Soil and Material Testing Generally usable.</p>				

	Survey	Plan	Design	Construction	Maintenance
<b>3. Debris Flow (Volcanic Regions)</b>					
Technical Development	<p>1) From the collected literature, the following achievements and implementation capabilities of the STC have been confirmed:</p> <ul style="list-style-type: none"> <li>• Various surveys, including topographic conditions, rainfall, sediment sampling, and sediment accumulation volume in Sabo dams and sand pockets.</li> <li>• Various analyses, such as rainfall analysis for debris flow occurrence, debris flow simulations, and analysis of Sabo dam failures after volcanic eruptions.</li> <li>• Reliability assessment of X-band radar.</li> </ul> <p>2) Based on the above, it is judged that the STC's capabilities in debris flow (volcanic regions) research and analysis are sufficiently high, and the issues are being appropriately addressed. Therefore, it is considered that they are adequately meeting the needs of the DGWR.</p> <p>References: d) [9][10][15][25][27][515]16)17)</p>	<p>1) Based on the collected literature, it has been clarified that STC possesses the following achievements and implementation capabilities:</p> <ul style="list-style-type: none"> <li>• Examination of early warning threshold rainfall for debris flows.</li> <li>• Advisory on the planning of Sabo facilities as an emergency measures for Mt. Sinabung.</li> <li>• Evaluation of the effectiveness of Sabo facilities in the Togurara watershed of Mt. Gamalama.</li> <li>• Proposal for facility arrangements to prevent the chain failure of Sabo dams after large-scale eruptions.</li> </ul> <p>2) On the other hand, many of the master plans for mitigating sediment-related disasters caused by volcanic eruptions have been developed primarily by Japanese experts through Japan's technical cooperation and yen loan projects, with knowledge transfer to STC engineers. However, since the number of technicians with this expertise is limited, it is judged that there is potential for improvement from the perspective of knowledge transfer. Additionally, it is judged that updating Sabo plans based on Japanese expertise is also necessary.</p> <p>References: [10][15][17] 15)</p>	<p>1) The design of Sabo facilities for debris flow countermeasures in volcanic regions can be addressed using the existing Indonesian technical standards, guidelines, and design reports of debris flow mitigation structures in volcanic areas.</p> <p>2) It has been confirmed that STC has a track record of conducting outdoor hydraulic model experiments to verify the functionality of designed debris flow diversion structures.</p> <p>3) Therefore, STC has a sufficiently high capability to appropriately review the design outcomes of volcanic debris flow countermeasure facilities conducted by consultants commissioned by the Ministry of Public Works. The challenges have been appropriately addressed, and STC is judged to adequately meet DGWR's needs.</p> <p>References: 7)</p>	<p>1) The construction of debris flow countermeasure facilities in volcanic regions can be carried out using existing construction technologies.</p> <p>2) Furthermore, STC has developed and conducted trial construction of concrete module Sabo facilities to support rapid construction within the short period before the rainy season following a volcanic eruption. Additionally, it has developed and tested steel fiber-reinforced concrete to reduce wear caused by frequent debris flows. In regards to these efforts, it is determined that technological development in construction methods is also being pursued by STC.</p> <p>References: a) b)</p>	<p>1) The maintenance and management of debris flow countermeasure facilities in volcanic regions can be carried out using existing construction technologies.</p> <p>2) One factor hindering the proper removal of sediment captured by Sabo facilities is inappropriate excavation activities by the private sector. However, it is judged that this issue should be addressed at the river basin agency level, taking into account the socio-economic characteristics of each region.</p>
Human Resource Development	<p>1) STC has a relatively large number of personnel capable of conducting technical studies on debris flow countermeasures in volcanic regions.</p> <p>2) However, as Indonesia's socio-economic development progresses, the demand for technical services related to debris flow countermeasures in volcanic regions is expected to increase. Therefore, it is judged that in the future, staff primarily from DGWR and other relevant agencies will need to take on the role of Sabo engineers who can manage debris flow mitigation projects in volcanic areas from a technical perspective at each river basin agencies. To achieve this, it is determined that comprehensive training programs should be implemented to develop a large number of Sabo engineers with a solid understanding of Sabo engineering. Additionally, efforts should be made to enhance the technical skills of entry-level river basin agency staff, who may become future technical professionals, through learning opportunities.</p>				
Equipment and Facilities	A) Soil and Material Testing Currently available for general use.	-	-	-	-
	B) Hydraulic Model Experiment	-	Based on the hearing survey results, the demand for hydraulic model experiments is increasing, and there is a need that indoor and outdoor model experiments can be conducted simultaneously. Therefore, it is considered that the enhancement of the currently underutilized outdoor hydraulic model testing facility should be considered.	-	-
	C) X-Band Radar	-	An X-band radar has been installed at STC for monitoring the Merapi volcano area. According to the hearing survey results, the radar frequently experiences equipment failures and is not functioning adequately. It was confirmed that repairs are being considered under the national budget.	-	-
<b>4. Debris Flow (Non-Volcanic Regions)</b>					
Technical Development	<p>1) From the collected literature, the following achievements and implementation capabilities of the STC have been confirmed:</p> <ul style="list-style-type: none"> <li>• Post-disaster topographic mapping using UAVs, sediment source investigations, rainfall analysis and runoff analysis, and debris flow simulation-based hazard mapping for watersheds where debris flow risks increased due to the Sulawesi earthquake.</li> </ul> <p>2) Considering STC's research achievements related to debris flow countermeasures in volcanic regions as well, its judged that STC's investigation and analytical capabilities are sufficiently high.</p> <p>3) In Indonesia, debris flow countermeasures in non-volcanic regions have been implemented in areas that have experienced large-scale disasters in the past or are located upstream of reservoirs. In the future, as Indonesia's economy continues to develop, the demand for debris flow countermeasures in small watersheds to protect villages from debris flows occurring in small watersheds may increase. Therefore, it is judged that the transfer of technology for survey methods combining the classification of valley numbers and the assessment of movable sediment volume, which is not currently used in Indonesia, will be necessary.</p> <p>References: [7][22]12)</p>	<p>1) Although STC has not provided many technical services for debris flow countermeasures in non-volcanic regions, it has the capability to review and propose measures for sabo facility placement plans for reservoir sedimentation countermeasures, as mentioned in the "Sediment Management in River Basins" section. Therefore, its capacity for reviewing plans is judged as sufficient to meet current needs.</p> <p>2) On the other hand, if the demand for debris flow countermeasures in small watersheds increases as mentioned above, it is judged that technology transfer related to debris flow mitigation planning in small watersheds will be necessary.</p>	<p>1) The design of debris flow countermeasure facilities in non-volcanic regions, similar to those in volcanic regions, can be carried out based on existing Indonesian technical standards and guidelines.</p> <p>2) Therefore, STC is assessed to have a sufficiently high capacity to appropriately review the design outcomes of debris flow countermeasure facilities in non-volcanic regions, as conducted by consultants commissioned by the Ministry of Public Works. The relevant issues have been adequately addressed, and STC is evaluated as fully meeting the needs of DGWR.</p>	<p>The construction of debris flow countermeasure facilities in non-volcanic regions can be carried out using existing construction techniques.</p>	<p>The maintenance of debris flow countermeasure facilities in non-volcanic regions can also be managed using existing construction techniques.</p>
Human Resource Development	<p>1) STC has personnel capable of conducting technical studies on debris flow countermeasures in non-volcanic regions.</p> <p>2) However, with Indonesia's ongoing socio-economic development, the demand for debris flow countermeasures in small watersheds to protect villages from debris flows in small catchments is expected to increase. Therefore, it is judged that staff from DGWR and other relevant agencies will be necessary to take on the role of Sabo engineers capable of managing debris flow countermeasure projects in non-volcanic regions from a technical perspective. To achieve this, comprehensive training programs should be implemented to equip these personnel with a thorough understanding of Sabo engineering. Additionally, efforts should be made to enhance the technical capabilities of entry-level River Basin Agency staff who may serve as future Sabo engineers.</p>				
Equipment and Facilities	A) Soil and Material Testing Generally available for use.	-	-	-	-
	B) Hydraulic Model Testing	-	According to hearing survey results, the demand for hydraulic model experiment is increasing. It has been identified that an environment capable of conducting both indoor and outdoor model experiments simultaneously is needed. Therefore, it is determined that the enhancement of the currently underutilized outdoor hydraulic model testing facility should be considered.	-	-

	Survey	Plan	Design	Construction	Maintenance
<b>5. Slope Failures</b>					
Technical Development	<p>1) There are few instances where STC has conducted investigations of slope failure locations. Although there is a demand for slope stabilization measures on roads, it is judged that the needs for such measures from the Directorate General of Water Resources (DGWR) are limited.</p> <p>2) However, STC has extensive experience in landslide investigations, which share common survey elements with slope failure assessments. Therefore, it is determined that STC's capability in investigating and analyzing slope failures is sufficiently high and adequately meeting the needs of DGWR.</p> <p>References: [6][12][13][18][19][23]2)3)4)10)11)</p>	STC has conducted several evaluations of slope failures and their countermeasures based on general civil engineering techniques. The planning, design, construction, and maintenance of slope stabilization measures associated with civil works in the water resources sector (such as irrigation, rivers, coasts, and Sabo) are also carried out based on general civil engineering techniques. Therefore, it is judged that these can be addressed using existing techniques.	Same as above	Same as above	Same as above
Human Resource Development	<p>1) STC has personnel capable of conducting technical assessments related to slope failures.</p> <p>2) As Indonesia's socio-economic development progresses, the demand for technical services in slope failure countermeasures is expected to grow. Therefore, it is judged that staff from DGWR and other relevant agencies will be necessary to take on the role of Sabo engineers capable of managing debris flow countermeasure projects in non-volcanic regions from a technical perspective. To achieve this, comprehensive training programs should be implemented to equip these personnel with a thorough understanding of Sabo engineering. Additionally, efforts should be made to enhance the technical capabilities of entry-level River Basin Agency staff who may serve as future Sabo engineers.</p>				
Equipment and Facilities	A) Soil and Material Testing Generally available for use.	—	—	—	—
<b>6. Surface Erosion</b>					
Technical Development	<p>1) From the collected literature, the following achievements and implementation capabilities of STC have been confirmed:</p> <ul style="list-style-type: none"> <li>As part of reservoir sedimentation countermeasures, STC conducted surface soil erosion rate surveys at a test field in the Dieng Plateau, Central Java, and analyzed the effectiveness of vegetation in suppressing soil erosion.</li> <li>STC also analyzed the effects of green Sabo techniques on soil erosion suppression at a test field in the upper Citarum River basin, West Java.</li> </ul> <p>2) Based on these achievements, it is judged that STC's research and analysis capabilities regarding surface erosion (including green Sabo) are sufficiently high, and the issues are being appropriately addressed. Therefore, it is determined that STC is adequately meeting the needs of DGWR.</p> <p>References: [3][8] 1)</p>	The surface erosion control plan is incorporated as part of the reservoir sedimentation countermeasure plan, and it can be addressed by utilizing this existing plan.	The results of trial and error in the aforementioned experimental fields are reflected in the facility design and proposed farming methods, and these can be addressed using the technologies accumulated so far.	The implementation of surface erosion countermeasures can be addressed by combining existing construction techniques.	The maintenance of surface erosion control facilities can be managed using existing technologies.
Human Resource Development	<p>1) STC has personnel capable of conducting technical assessments related to surface erosion.</p> <p>2) As Indonesia's socio-economic development progresses, the demand for technical services in slope failure countermeasures is expected to grow. Therefore, it is judged that staff from DGWR and other relevant agencies will be necessary to take on the role of Sabo engineers capable of managing debris flow countermeasure projects in non-volcanic regions from a technical perspective. To achieve this, comprehensive training programs should be implemented to equip these personnel with a thorough understanding of Sabo engineering. Additionally, efforts should be made to enhance the technical capabilities of entry-level River Basin Agency staff who may serve as future Sabo engineers.</p>				
Equipment and Facilities	A) Soil and Material Testing Generally in usable condition.	—	—	—	—
<b>7. Common Theme</b>					
Public Relations / Outreach Activities	<p>1) Activities are conducted through the website, social media, and video-sharing platforms; however, no seminars appear to be held for external participants.</p> <p>2) It is judged that effective utilization of the Sabo technology materials held by STC and improvements to the library function are necessary.</p>				

Indicators:	Indicators	Content of the Indicator (Technical Development)
	1	By implementing technical development in specific fields, functional enhancement can be achieved.
2	Sufficient achievements and knowledge are possessed.	
Indicators:	Indicators	Content of the Indicator (Human Resource Development)
	1	Improving engineer training will enable more effective human resource development.
2	An adequate environment for human resource development is well-established in both quality and quantity.	
Indicators:	Indicators	Content of the Indicator (Equipment And Facilities)
	1	Updating and repairing some of the owned equipment and facilities will allow for more effective utilization.
2	The existing equipment and facilities possess sufficient functionality, are well-maintained, and can be fully utilized.	

## References

### Examples of Technical Development Activities by Balai Teknik Sabo

- a) Application of steel fiber reinforced concrete on the sabo dam spillway and stilling basin cover concrete (Trial construction conducted in 2017 at the Togurara River, Gamalama Volcano)
- b) Trial of modular sabo dam using concrete blocks (Trial construction conducted at the Konto River, Kelud Volcano)
- c) Application of ring net barrier technology for debris flow mitigation (Trial construction conducted in 2018 at the Rejali River, Semeru Volcano)
- d) Implementation of sediment dynamics analysis using Powersim Studio 10 software (Conducted in 2018, modeling sediment dynamics in streams of Agung Volcano and verifying the analysis results against actual data)

### Examples of Technical Standards Developed by Balai Teknik Sabo

- 1) Permen PUPR No. 03/PRT/M/2011 Tahun 2011 – Guidelines for the Implementation of Soil Cement as a Primary Component in Sabo Structures

### Examples of Academic Papers Published by Researchers from Balai Teknik Sabo

- [1] Reservoir sedimentation countermeasures - C. Bambang Sukatja (2010): *Performance of Sabo Dam in K. Lumajang for Controlling Sedimentation of Mrica Reservoir* , Jurnal Sumber Daya Air, Vol. 6, No. 1
- [2] Reservoir sedimentation countermeasures - Agus Sumaryono, Djudi, Dyah Ayu Puspitosari (2011): *Application of Sabo Technology to Rivers in the Kelud Mountain Region to Reduce Sedimentation of the Wlingi Reservoir* , Jurnal Sumber Daya Air, Vol. 7, No. 1
- [3] Disaster mitigation - Singgih Haryono, Arif Rahmat Mulyana, Soewarno, Arif Subagyo (2012): *Application of Sabo Technique in Controlling the Water Destructive Force in Dataran Tinggi Dieng* , Jurnal Teknik Hidraulik, Vol. 3, No. 2
- [4] Reservoir sedimentation countermeasures - Ardian Alfianto, Soewarno (2014): *Techno Sabo for Overcoming Reservoir Watershed Sedimentation (Case: Mrica Reservoir)* , Jurnal Teknik Hidraulik, Vol. 5, No. 1
- [5] Material utilization - Jati Iswardoyo (2016): *The Study of Utilization of Steel Slag to Sabo Dam* , Jurnal Teknik Hidraulik, Vol. 7, No. 2
- [6] Landslide analysis - Rokhmat Hidayat, Samuel Jonson Sutanto, Moh. Deddy Munir (2016): *Geological and Rainfall Condition as Landslide Causative Factors in Southern Part of Central Java in June 2016* , Jurnal Teknik Hidraulik, Vol. 7, No. 2
- [7] Mapping technology - Samuel Jonson Sutanto, Banata Wachid Ridwan (2016): *Drone Technology for Contour Mapping: Case Study at P3SON Hambalang* , Jurnal Teknik Hidraulik, Vol. 7, No. 2
- [8] Erosion control - Moh. Dedi Munir (2017): *Green Sabo Application for Erosion Control in Upper Land Area* , Jurnal Teknik Hidraulik, Vol. 8, No. 2
- [9] Lahar flow analysis - Rokhmat Hidayat, Akhyar Musthofa, Perdi Bahri (2017): *Influence of Rainfall Intensity to Lahar Flood Velocity and Height based on SIMLAR 2.1 Modelling* , Jurnal Teknik Hidraulik Vol. 8, No.1
- [10] Disaster mitigation - Cosmas Bambang Sukatja, Ardian Alfianto (2017): *Revitalisation of Sabo Dam as Lahar Flow Controller (Case Study in Merapi Volcano Area)* , Jurnal Teknik Hidraulik, Vol. 8, No. 1
- [11] Sediment balance planning - Santosa Sandy Putra, Soewarno, Dwi Kristianto (2017): *Mini Sabodam Placement Planning by Sediment Balance Method in the Upstream Area of the Proposed Ciawi Reservoir, Ciliwung* , Jurnal Sumber Daya Air, Vol. 13, No. 2
- [12] Landslide analysis - Rokhmat Hidayat (2018): *Slope Stability Analysis in Caok Village Landslide, Purworejo, Central Java* , Jurnal Sumber Daya Air, Vol. 14, No. 1
- [13] Landslide countermeasures - Rokhmat Hidayat, Moh. Dedy Munir (2019): *Landslide at Cipunagara River and Its Handling Design* , Jurnal Lingkungan dan Bencana Geologi, Vol. 10 No. 1
- [14] Geotourism - Moh. Dedi Munir (2019): *Sabo Dam Structure, Its Function and Potency as Part of Geotourism in the Merapi Volcano* , Jurnal Lingkungan dan Bencana Geologi, Vol. 10, No. 2
- [15] Sabo dam effectiveness - Ardian Alfianto, Jati Iswardoyo, Cosmas Bambang Sukatja (2019): *Effectivity and Instrumentation of Sabodam in Togurara River Gamalama Volcano Area* , Jurnal Teknik Hidraulik, Vol. 10, No. 2
- [16] Sedimentation control - Ardian Alfianto, Shandy Cecilia, Banata Wachid Ridwan, Chitra Widyasani Surya Putri (2020): *The Implementation of Sabo Technology in Limboto's Estuary Sedimentation Flow Retainment* , Jurnal Teknik Hidraulik, Vol. 11, No. 1
- [17] Landslide laboratory testing - Bayu Seto Waseso Utomo, Jati Iswardoyo, Ruzardi (2020): *Laboratory Test of Slope Effect toward Landslide Event on Merapi Sand Debris Flow* , Jurnal Sumber Daya Air, Vol. 16, No. 1
- [18] Slope stability analysis - Rokhmat Hidayat (2020): *Rainfall Infiltration Effect on Slope Stability in Pangkalan, West Sumatera* , Jurnal Teknik Hidraulik, Vol. 11, No. 1
- [19] Landslide prediction - Rokhmat Hidayat, Avidah Amalia Zahro (2020): *Rainfall Threshold Determination for Landslide Events Prediction* , Jurnal Sumber Daya Air, Vol. 16, No. 1
- [20] Erosion modeling - Ardian Alfianto, Shandy Cecilia, Banata Wachid Ridwan (2020): *Potential Erosion and Sedimentation Modeling of the Upstream Limboto Lake using WaTEM/SEDEM* , Jurnal Teknik Hidraulik, Vol. 11, No. 2
- [21] Sedimentation control - Ardian Alfianto, Shandy Cecilia, Alidina Nurul Hidayah, Anjelita, Cosmas Bambang Sukatja (2021): *Sabo Plan for Controlling Sediment Rate of Rawapening* , Jurnal Sumber Daya Air, Vol. 17, No. 1
- [22] Disaster mitigation - C. Bambang Sukatja, Banata W.R, Perdi Bahri (2021): *Mitigation and Countermeasures of Debris Flow Disaster Post Palu Earthquake 2018* , Jurnal Teknik Hidraulik, Vol. 12, No. 1
- [23] Landslide mechanism - Rokhmat Hidayat, I Putu Eddy Purna Wijaya, Moh. Dedi Munir (2023): *Landslide Mechanism due to Infiltration from Water Ponding (Case Study of Landslide in Lahat, South Sumatera)* , Jurnal Teknik Hidraulik, Vol. 14, No. 1
- [24] Flash flood analysis - Jati Iswardoyo, Hafizh Satria (2023): *Analysis of Flash Flood Affected Area using the HEC-RAS 2D at Sat River, in Pati Regency, Central Java* , Jurnal Teknik Hidraulik, Vol. 14, No. 1
- [25] Disaster impact analysis - Yutaka Gonda, Djoko Legono, Bambang Sukatja, Untung Budi Santoso (2014): *Debris Flows and Flash Floods in the Putih River after the 2010 Eruption of Mt. Merapi, Indonesia* , International Journal of Erosion Control Engineering Vol. 7, No. 2
- [26] Rainfall monitoring - Santosa Sandy Putra, Banata Wachid Ridwan, Kazuki Yamanoi, Makoto Shimomura, Sulistiyani, Dicky Hadiyuwono (2019): *Point-Based Rainfall Intensity Information System in Mt. Merapi Area by X-Band Radar* , Journal of Disaster Research, Vol. 14, No. 1

### An Example of Technical Advisory Services Conducted by Balai Teknik Sabo

2011-2012

1. Surface erosion - Erosion control in Ambon (BWS Maluku)
2. Landslide - Technical audit of landslide at Jatigede multipurpose dam (DGWRD)
3. Landslide - Countermeasures against landslides and drainage in the area of General Sudirman Museum in Pacitan (Minister of Defence)
4. Slope failure - Slope failures in Wasior, Papua (Central Government)
5. Debris flow (volcanic area) - Debris flow prevention in Tanah Datar (Local Government of Tanah Datar Regency)
6. Debris flow (non-volcanic area, erosion control facility design) - Design of Sabo dam in Cibatu, Garut (BBWS Cimanuk)
7. Debris flow (volcanic area, model experiment) - Modeling shortcut of Putih river after Mt. Merapi eruption in 2010
8. Reservoir sedimentation countermeasure - Sedimentation control at Limboto Lake in Gorontalo Province (Sulawesi) (BWS Sulawesi II)
9. Natural dam - Countermeasures against Way Ela natural dam break in Ambon, Maluku

2013- 2015

10. Landslide - Countermeasure against landslide disaster in Banjarnegara, Central Java
11. Slope failure - Countermeasures against slope failures and debris flows in Padang, West Sumatra
12. Debris flow (non-volcanic area) - Countermeasure against debris flow disaster at Amahusu and Nusaniwe villages, Ambon, Maluku Province
13. Flash flood - Contribution of Sabo technology to combat flash flood in Manado, North Sulawesi
14. Flash flood - Countermeasure against flash flood in Aceh
15. Debris flow (volcanic area) - Sabo works for emergency response in Mt. Sinabung, North Sumatra
16. Reservoir sedimentation countermeasure - Reservoir sedimentation in Mrica Dam, Banjarnegara, Central Java
17. Reservoir sedimentation countermeasure - Sediment disaster management and water resources problem of Kedungwringin dam in BBWS Serayu-Opak, Central Java

Note: Cited from materials prepared by former Balai Teknik Sabo Director, Chandra Hassan, in 2015.

### JICA Reports

- A) Japan International Cooperation Agency, Nippon Koei Co., Ltd., Yachiyo Engineering Co., Ltd.: *The Study on Countermeasures for Sedimentation in the Wonogiri Multipurpose Dam Reservoir in the Republic of Indonesia: Final Report* , 2007.7.
- B) Japan International Cooperation Agency, Nippon Koei Co., Ltd.: *Basic Design Study Report on the Project for Urgent Countermeasures for Sedimentation in Wonogiri Multipurpose Dam Reservoir in the Republic of Indonesia* , 2001.12.
- C) Japan International Cooperation Agency, Nippon Koei: *Basic Design Study Report on the Project for Urgent Countermeasures for Sedimentation in Wonogiri Multipurpose Dam Reservoir in the Republic of Indonesia* , 2001.12.

## 2.5 Goal Setting

Based on the results of the issue analysis organized in the previous sections, the identified issues and goals are summarized below.

**Table 2-21 Issues and Goal Setting in DGWR**

Category	Challenges and Goals					
(1) Technology Development		Survey	Plan	Design	Construction	Maintenance
	Sediment Management In River Basins	B	B	B	B	A
	Landslides	A	A	A	A	A
	Debris Flow (Volcanic Areas)	A	B	A	A	A
	Debris Flow (Non-Volcanic Areas)	B	B	A	A	A
	Slope Failures	A	A	A	A	A
	Surface Erosion	A	A	A	A	A
	A: Possesses sufficient technical capability B: Room for technical improvement					
<b>Issues</b>						
<b>Sediment management in river basins:</b> Need for technical strengthening in survey, planning, design, and construction of new technologies such as reservoir sediment flushing						
<ul style="list-style-type: none"> <li>DGWR has a high capacity for sediment management in river basins.</li> <li>However, there is room for improvement in introducing new technologies, formulating plans, designing, and construction, particularly in relation to reservoir sediment flushing.</li> <li>However, the technology for reservoir sediment flushing is under the jurisdiction of the Dam Technology Center under the DGWR and is outside the scope of the STC. Therefore, it is excluded from the goal setting.</li> </ul>						
<b>Debris flow (volcanic areas):</b> Need for technical strengthening in Sabo planning at STC						
<ul style="list-style-type: none"> <li>STC has experience in planning-related activities, such as examining early warning rainfall thresholds for debris flow.</li> <li>However, many of the master plans for mitigating sediment-related disasters caused by volcanic eruptions have been developed mainly by Japanese experts through Japan's technical cooperation projects and Yen loan projects. While these technical skills have been transferred to STC engineers, the number of engineers possessing this expertise remains low, leaving room for improvement in terms of knowledge succession.</li> <li>Updating Sabo planning based on new insights is also desirable.</li> </ul>						
<b>Debris flow (non-volcanic Areas):</b> Need for technical strengthening in survey and planning at STC						
<ul style="list-style-type: none"> <li>With Indonesia's future economic development, the demand for "debris flow countermeasures in small watersheds" is expected to rise.</li> <li>In response, it will be necessary to transfer the technology for investigation and planning methods that integrate stream order classification with the assessment of sediment transport capacity currently not used in Indonesia.</li> </ul>						
<b>Goal Setting:</b>						
<b>Training experts capable of developing master plans for sediment disaster mitigation caused by volcanic eruptions</b>						
<ul style="list-style-type: none"> <li>First, STC will train experts with expertise in Sabo planning for debris flow countermeasures in volcanic regions. These trained experts will serve as instructors to enhance the capacity of river basin agencies managing basins with active volcanoes across Indonesia.</li> <li>The development of facility plans for emergency response following volcanic eruptions is currently led by senior retired officials of the Ministry of Public Works, and this remains a high-priority task.</li> </ul>						
<b>Training experts with investigation and planning capabilities for debris flow</b>						

Category	Challenges and Goals																																										
	<p>countermeasures in small watersheds of non-volcanic areas</p> <ul style="list-style-type: none"> <li>• First, STC will train experts with expertise in investigation and planning for debris flow countermeasures in small watersheds of non-volcanic areas. These trained experts will serve as instructors to enhance the capacity of river basin agencies across Indonesia.</li> <li>• Currently, debris flow countermeasures in non-volcanic areas are only implemented in regions affected by large-scale disasters (e.g., post-disaster reconstruction in Sulawesi). At present, there are no debris flow countermeasures being implemented in small watersheds of non-volcanic areas. However, with the expansion of urban areas, the potential demand for such measures is increasing. The priority level is considered moderate.</li> </ul>																																										
(2) Human Resource Development	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="background-color: #d9d9d9;"></th> <th style="background-color: #d9d9d9;">Survey</th> <th style="background-color: #d9d9d9;">Plan</th> <th style="background-color: #d9d9d9;">Design</th> <th style="background-color: #d9d9d9;">Construction</th> <th style="background-color: #d9d9d9;">Maintenance</th> </tr> </thead> <tbody> <tr> <td style="background-color: #d9d9d9;">Sediment Management In River Basins</td> <td colspan="5" style="text-align: center;">B</td> </tr> <tr> <td style="background-color: #d9d9d9;">Landslides</td> <td colspan="5" style="text-align: center;">B</td> </tr> <tr> <td style="background-color: #d9d9d9;">Debris Flow (Volcanic Areas)</td> <td colspan="5" style="text-align: center;">B</td> </tr> <tr> <td style="background-color: #d9d9d9;">Debris Flow (Non-Volcanic Areas)</td> <td colspan="5" style="text-align: center;">B</td> </tr> <tr> <td style="background-color: #d9d9d9;">Slope Failures</td> <td colspan="5" style="text-align: center;">B</td> </tr> <tr> <td style="background-color: #d9d9d9;">Surface Erosion</td> <td colspan="5" style="text-align: center;">B</td> </tr> </tbody> </table> <p style="text-align: right;">B: Human resource development is necessary</p> <p><b>Issue:</b></p> <p><u>The training of river basin agencies personnel as Sabo engineers is necessary.</u></p> <ul style="list-style-type: none"> <li>• Apart from the previously mentioned challenges related to debris flow countermeasures, STC possesses the capability to provide technical services for various sediment transport phenomena and its countermeasures.</li> <li>• With Indonesia’s socio-economic development, the demand for disaster risk reduction in the sediment-related disaster sector is expected to increase. To alleviate the burden on STC, it is desirable to assign Sabo engineers capable of managing disaster risk reduction projects from a technical perspective to river basin agencies.</li> </ul> <p><b>Goal Setting:</b></p> <p><u>A system will be established where STC instructors continuously and sustainably train RBA Sabo engineers capable of managing sediment-related disaster countermeasure projects from a technical perspective.</u></p> <ul style="list-style-type: none"> <li>• Currently, the review of technical studies for sediment-related disaster countermeasure projects is concentrated at Balai Teknik Sabo (STC). Given the increasing trend of sediment disasters due to extreme weather, the necessity of assigning Sabo engineers capable of managing such projects from a technical standpoint at RBOs is high. The priority level is considered high. New Sabo engineers will be trained and assigned to various river basin agencies across Indonesia.</li> <li>• In parallel with the training of Sabo engineers, it is desirable that the Indonesian side implements the training of entry-level engineers as a volume zone that will be candidates for the next generation of Sabo engineers.</li> <li>• Achieving this goal will require appropriate budget and personnel allocation by the Indonesian government.</li> </ul>		Survey	Plan	Design	Construction	Maintenance	Sediment Management In River Basins	B					Landslides	B					Debris Flow (Volcanic Areas)	B					Debris Flow (Non-Volcanic Areas)	B					Slope Failures	B					Surface Erosion	B				
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Category	Challenges and Goals
	<p>functionality should be considered.</p> <p>2) X-Band Radar</p> <p><u>Repair of the X-band radar is recommended.</u></p> <ul style="list-style-type: none"> <li>An X-band radar has been installed at the STC for debris flow (volcanic region) countermeasures, specifically for the Merapi volcano area. However, due to frequent malfunctions, it is not operating properly, necessitating repairs to restore its functionality.</li> </ul> <p><b>Target Goals:</b></p> <p><u>Outdoor hydraulic model experiment facility: Enable simultaneous preparation of multiple experiments.</u></p> <ul style="list-style-type: none"> <li>Given the increasing demand for hydraulic model experiments, this is a high priority.</li> </ul> <p><u>X-Band Radar: Restore functionality to ensure continuous operation.</u></p> <ul style="list-style-type: none"> <li>This is a low priority as Indonesia is currently working to secure national budget for repairs.</li> </ul>

## CHAPTER 3 ROADMAP (DRAFT) DESIGN FOR ENHANCING SABO TECHNOLOGY IN INDONESIA

### 3.1 Policy for Roadmap (Draft) Formulation

Based on the findings in Chapter 2, the following policies have been established for the creation of the roadmap (draft):

#### **Policy 1: The roadmap (draft) aims to strengthen Indonesia's technical development capabilities in the field of Sabo**

Within the technical development functions of DGWR, the focus will be on strengthening technical expertise in areas related to “Debris Flow (Volcanic Regions): Planning” and “Debris Flow (Non-Volcanic Regions): Survey and Planning”. To promote the advancement of Sabo technologies at DGWR in the future, it is essential to enhance the technical capabilities in this field at the STC.

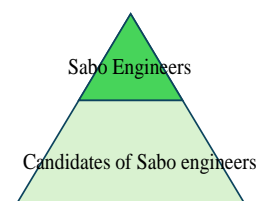
Within the STC, experts who have the ability to create master plans for the mitigation of sediment disasters caused by volcanic eruptions and "experts" who have the ability to investigate and plan debris flow countermeasures for small watersheds in non-volcanic areas are trained.

( The term "expert" here refers to a person who has the ability to play an active role as an instructor in the human resource development of the river .)

#### **Policy 2: The roadmap (draft) aims to strengthen the capabilities of personnel in the field of Sabo in Indonesia**

With the future socio-economic development of Indonesia, the need for disaster risk reduction in the field of sediment is expected to increase. Therefore, to promptly respond to these needs, a framework for human resource development will be established with the goal of training and assigning Sabo engineers to river basin agencies. These personnel will possess specialized knowledge of sediment-related disasters and disaster risk reduction and will be capable of managing disaster risk reduction projects from a technical perspective.

In addition, “Candidates of Sabo engineers” who understand basic knowledge of sediment disasters and countermeasures in general, support Sabo engineers, and become candidates for future Sabo engineers are also trained at the same time.



**Figure 3-1 Composition of engineers in the river basin agencies**

#### **Policy 3: The roadmap (draft) aims to enhance the functions of equipment and facilities required for technical development in the Sabo sector.**

The demand for hydraulic model experiment is increasing to verify sediment management in river basins and debris flow countermeasures in both volcanic and non-volcanic regions (Refer to Chapter 2, p. 2-20). To address this, improvements will be made to the existing outdoor hydraulic model testing facility at STC.

### 3.2 Setting of Phases for Formulation of Roadmap (Draft)

<b>Phase 1:</b> 2025–2026 (2 years) - Strengthening the Foundations of Sabo Technology in Indonesia
<b>Phase 2:</b> 2027–2030 (4 years) - Expansion of Sabo Technology

#### 3.2.1 Phase 1: 2025–2026 (2 years) - Strengthening the Foundations of Sabo Technology in Indonesia

##### (1) Technology Development

The foundation of Sabo technology will be strengthened, with a focus on the “Debris Flow (Volcanic Regions): Sabo Planning” and “Debris Flow (Non-Volcanic Regions): Survey and Planning”.

## **(2) Human Resource Development**

By completing a comprehensive program covering Sabo engineering, individuals will acquire expertise in Sabo techniques and be trained as Sabo Engineers, thereby strengthening Sabo engineering capabilities in Indonesia. Considering the current personnel rotations and reassignments across technical fields, a two-year phase will be implemented, with each cycle consisting of a one-year training program. Over two years (two cycles), the necessary personnel will be trained. As of October 2024, 41 departments are involved in Sabo projects, consisting of 4 departments within the Directorate of Rivers and Coasts and 37 river basin agencies. Initially, the goal is to continuously train 20 Sabo engineers per cycle each year, aiming to assign approximately 40 Sabo engineers (one per department) over a two-year phase (two cycles).

- For researchers at STC who already possess specialized knowledge in sediment-related disasters and disaster risk reduction, expertise on master plan formulation for mitigating sediment disasters caused by volcanic eruptions and on the investigation and planning of debris flow countermeasures in small watersheds of non-volcanic regions will be transferred from Japanese Sabo experts. These researchers will be further developed as instructors responsible for training Sabo Engineers and prospective Sabo engineers.
- In the first year, Japanese Sabo Experts will be involved as instructors and mentors through on-the-job training (OJT) in project planning and design within the yen-loan project framework, aiming to train 20 Sabo engineers.
- In the second year, the training activities will be the transition to being led primarily by Indonesian experts, with STC specialists taking the lead.
- Through two cycles of human resource development, 40 Sabo engineers will be trained, ensuring that each river basin agency responsible for sediment disaster countermeasures nationwide has at least one Sabo engineer.
- From the second year onwards, Indonesian experts will take the lead in expert development, and the training of Sabo engineers will be carried out by these experts.

## **(3) Equipment and Facilities**

During this phase, the improvement plan and design for the outdoor hydraulic model experiment field will be carried out, and the procurement process for construction will commence.

### **3.2.2 Phase 2: 2027–2030 (4 years) - Expansion of Sabo Technology**

#### **(1) Technology Development**

The foundation for debris flow mitigation technology will be established. The existing technical standards used in Indonesia will be updated, with reference to Japanese technical standards and recommendations, marking the beginning of the update process.

#### **(2) Human Resource Development**

In Phase 2, human resource development will be primarily driven by Indonesia. Personnel developed in Phase 1 will be deployed to various river basin agencies of DGWR, where they will engage in actual sediment disaster mitigation projects across Indonesia. The aim is for these trained personnel as Sabo engineers to actively contribute to sediment disaster mitigation efforts nationwide. However, since the personnel may experience transfers or changes in technical fields, human resource development activities will continue, ensuring the target number of 40 Sabo engineers is maintained. Human resource development activities will continue for one cycle (one year) under the leadership of Indonesian side.

#### **(3) Equipment and Facilities**

The operation, updating, and improvement of equipment and facilities will continue, including the

updated outdoor hydraulic model experiment facility.

### 3.3 Specific Achievement Targets for Each Phase and Required Actions on the Indonesian Side

Specific target values have been set for each phase under the categories of “Technical Development,” “Human Resource Development,” and “Equipment & Facilities.” Additionally, the role allocation between Japan and Indonesia in achieving these targets is outlined in Table 3-1 and Table 3-2.

**Table 3-1 Phase 1 (2025-2026) – Strengthening the foundation of Indonesia’s Sabo technology**

Target Period	Category	Details	Required Actions on the Indonesian Side	Remarks
Early Phase 1 (2025)	Technical Development	The foundation of Sabo technology will be strengthened, with a focus on the “Debris Flow (Volcanic Regions): Sabo Planning” and “Debris Flow (Non-Volcanic Regions): Survey and Planning”.	PU-DGWR, Bintek, and Balai Teknik Sabo staff will be involved. As needed, experienced personnel and researchers with expertise in Indonesia's Sabo projects will be added.	Support from Japanese consultants, etc.
	Human Resource Development	Sabo engineers, primarily among MPW staff, will be trained in debris flow mitigation measures. The expected number of trainees is 20.	The training program is mainly for Bintek and Balai Teknik Sabo staff. The target for human resource development is MPW staff and those responsible for Sabo projects.	Support from Japanese consultants, etc.
	Equipment & Facilities	Proceed with planning and procurement for the outdoor hydraulic model experiment facility. Necessary equipment for the facility will be installed and the construction will be completed.	Balai Teknik Sabo staff will be responsible for managing and operating the equipment and facilities.	Potential support through consulting services under the yen-loan project.
Late Phase 1 (2026)	Technical Development	The foundation for debris flow mitigation technology will be established. The existing technical standards used in Indonesia will be updated, with reference to Japanese technical guidelines and recommendations, beginning of the update process.	A compilation team will be formed, mainly consisting of PU-DGWR Bintek and Balai Teknik Sabo personnel.	Support from Japanese consultants, etc.
	Human Resource Development	Sabo engineers, primarily among Ministry of Public Works staff, will be trained. In addition to the engineers trained in the previous phase, the target is to achieve a total of 40 trained engineers.	The training program is mainly for Bintek and Balai Teknik Sabo staff. The target for human resource	Potential support through consulting services under the

Target Period	Category	Details	Required Actions on the Indonesian Side	Remarks
			development is MPW staff and those responsible for Sabo projects.	yen-loan project.
	Equipment & Facilities	Start the operation of the outdoor hydraulic model experiment facility.	Balai Teknik Sabo staff will be responsible for managing and operating the equipment and facilities.	Potential support through consulting services under the yen-loan project.

Note:

Consultant: Consultants procured under the Yen Loan Project for Volcanic Disaster Risk Reduction Sector Loan Project

**Table 3-2 Phase 2 (2027-2028) – Expansion of Sabo technology**

Target period	Category	Details	Required Actions on the Indonesian Side	Remarks
Phase 2 (2027-2030)	Technical Development	The update of Indonesian technical standards will continue.	A compilation team, primarily consisting of PU-DGWR, Bintek, and Balai Teknik Sabo staff, will carry out the updates.	Potential support through consulting services under the yen-loan project.
	Human Resource Development	The training of Sabo engineers, primarily from the MPW, will continue. Even with changes in the number of engineers due to personnel transfers or field reassignments, human resource development will ensure that a stable number of 40 Sabo engineers is maintained for Sabo projects. As part of international technical cooperation, the training of engineers from third countries will also begin.	The training program is mainly for Bintek and Balai Teknik Sabo staff. The target for human resource development are Ministry of Public Works staff and those responsible for Sabo projects.	Potential support through consulting services under the yen-loan project.
	Equipment & Facilities	The operation, renewal, and improvement of equipment and facilities will be continuously carried out.	PU-DGWR Bintek, Balai Teknik Sabo	

Note:

Consultant: Consultants procured under the Yen Loan Project for Volcanic Disaster Risk Reduction Sector Loan Project

### 3.4 Input from Indonesia Side Regarding the Roadmap (Draft)

On February 21, 2025, a seminar on Sabo technology was held at Balai Teknik Sabo in Yogyakarta, co-hosted by the Ministry of Public Works and the Japan Society of Sabo (Refer to Appendix 11 of the Project Completion Report). During this seminar, the project team presented the activities related

to strengthening the functions of STC, and Indonesian participants provided the following comments regarding key challenges:

- 1) Developing young Sabo engineers remains a critical issue.
- 2) Public awareness on the contribution of Sabo technology to disaster risk reduction is necessary.
- 3) Building an international cooperation network is essential for Indonesia to expand its role in Sabo-related cooperation with other Asian countries.
- 4) Adapting Japanese Sabo technology to Indonesia requires customization and localization, considering differences in natural and socio-economic conditions between the two countries. Universities could contribute to the necessary analytical studies.

Based on these comments, the following measures are proposed to address these challenges.

**Table 3-3 Issues raised and proposed measures from the Sabo technology seminar (Feb 21, 2025)**

No.	Issues presented by the Indonesian side at the seminar on February 21, 2025	Corresponding Measures
1	Development of young Sabo engineers	Expanded training programs for prospective Sabo engineers, increasing their number as the volume zone (Added in the Phase 2 of Roadmap (Draft))
2	Public awareness of Sabo technology's role in disaster risk reduction	Added a section on public outreach activities funded by Indonesia's national budget in the Roadmap (Draft)
3	Establishing a regional network with neighboring countries	Included network-building activities in the section on international technology dissemination.
4	Participation of academia	Added references to academic institutions' involvement in the development and dissemination of technical standards.

### 3.5 Roadmap (Draft)

Based on the above points, the proposed roadmap for strengthening STC functions is shown in Figure 3-2.

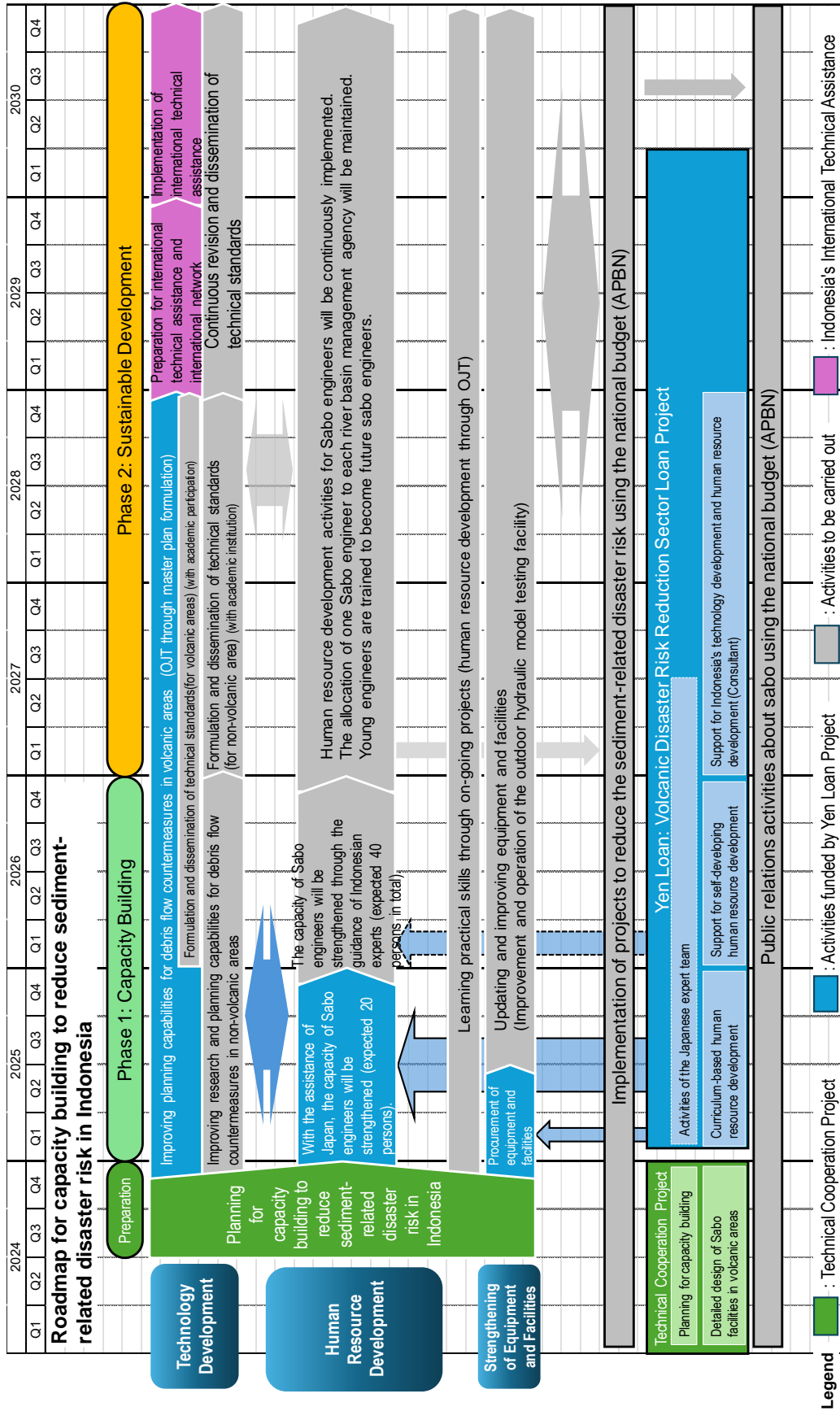


Figure 3-2 Draft roadmap for strengthening STC (BTS) functions through Japan's sabo technology support

## CHAPTER 4 CURRICULUM / SYLLABUS DESIGN

### 4.1 Target for Human Resource Development

The curriculum and syllabus proposed in this chapter are intended for STC experts, Sabo engineers assigned to river basin agencies, and candidates of Sabo engineers. Candidates for Sabo engineers are suggested to take only the "General Sabo Course" shown in Table 4.1.

### 4.2 Curriculum Development

The curriculum will focus on the survey and planning of debris flow control in non-volcanic areas, with the objective of strengthening fundamental Sabo engineering skills through four designated courses. Meanwhile, the training for planning on debris flow countermeasures in volcanic areas is proposed to be conducted through on-the-job training (OJT) for STC experts as part of the master plan development / revision works under the Project on Volcanic Disaster Risk Reduction Sector Loan.

**Table 4-1 Sabo Engineer training curriculum**

Course	Curriculum
Sabo in General	The curriculum will include the overview of Sabo technology and the fundamental principles necessary for implementing debris flow countermeasures. The course will focus on the essential aspects required for planning Sabo, considering the sediment dynamics across the entire river basin.
Sabo survey and planning	The course will cover the methods for conducting essential Sabo survey and planning key considerations when planning countermeasures. Additionally, it will include the approach and techniques for formulating debris flow countermeasure plans based on the survey and planning results.
Sabo Design	The course will include the study of design methods for debris flow countermeasure structures. It will also cover the principles and calculation methods for design parameters, such as the external forces as the basis for design condition.
Construction/maintenance/warning, etc.	This course will cover the construction methods and maintenance strategies for Sabo structures. Additionally, it will include the operation of management and monitoring system for prediction of sediment disasters.

### 4.3 Syllabus Design

The syllabus for human resource development has been proposed. For each part of the syllabus, the relevant standards and guidelines from Japan are listed as references.

**Table 4-2 Sabo Engineer training syllabus**

Course	Syllabus	References
Sabo in General	<ul style="list-style-type: none"> <li>• Overview</li> <li>• Basic considerations for sediment and driftwood runoff countermeasures planning</li> <li>• Basic considerations for countermeasures planning for abnormal landslides (deep-seated landslides, natural dams, etc.)</li> <li>• Basic considerations for soft countermeasures against sediment disasters</li> <li>• Coastal conservation planning</li> </ul>	<ul style="list-style-type: none"> <li>• Ministry of Land, Infrastructure, Transport and Tourism (MLIT): Technical Criteria for River Works, Practical Guide for Planning (Basic Planning)</li> </ul>

	<ul style="list-style-type: none"> <li>• Consideration of the natural environment, etc.</li> </ul>	
Sabo survey and planning	<ul style="list-style-type: none"> <li>• Survey and planning for comprehensive sediment management</li> <li>• Basic survey and planning</li> <li>• Survey and planning for sediment and driftwood runoff countermeasures</li> <li>• Survey and planning for non-structural (soft) measures against sediment disasters</li> <li>• Basics of debris flow and driftwood countermeasure planning</li> <li>• Debris flow and driftwood disposal planning</li> <li>• Debris flow and driftwood countermeasure facility layout planning</li> </ul>	<ul style="list-style-type: none"> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Survey and Planning</li> <li>• MLIT: Manual of Technical Standard for Establishing Sabo Master Plan for Debris Flow and Drift Wood</li> </ul>
Sabo design	<ul style="list-style-type: none"> <li>• Design of debris flow and driftwood countermeasures facilities</li> <li>• Setting of design external forces in the event of a debris flow</li> </ul>	<ul style="list-style-type: none"> <li>• MLIT: Manual of Technical Standard for Designing Sabo Facilities against Debris Flow and Drift Wood</li> </ul>
Construction/maintenance/warning, etc.	<ul style="list-style-type: none"> <li>• Construction of Sabo dams</li> <li>• Construction of stream conservation works</li> <li>• Construction of hillside conservation works</li> <li>• Construction of accessories (ancillary facilities)</li> <li>• Inspection and soundness evaluation of Sabo facilities</li> <li>• Maintenance and management of observation equipment, etc.</li> <li>• Maintenance and repair of Sabo facilities, etc.</li> <li>• Sediment removal plans (including removal of driftwood)</li> <li>• Identification of risk areas of sediment disasters</li> <li>• Establishment of a warning and evacuation system for sediment disasters</li> </ul>	<ul style="list-style-type: none"> <li>• General construction works, construction management standards, etc.</li> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Operation and Maintenance (Sabo)</li> <li>• MLIT: Manual of Technical Standard for Establishing Sabo Master Plan for Debris Flow and Drift Wood</li> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Planning (Basic Planning)</li> </ul>

#### 4.4 Proposed Training Curriculum

The training program consists of four courses, with one course to be completed each quarter within the fiscal year. Each course will last 4 to 6 days, and each lecture will be 90 minutes long. Further, a separate 90-minute project-based study session (including exercises) will be conducted for each lecture to ensure that participants fully understand and can apply the knowledge effectively.

The trainees will be selected by the Indonesian side, and as a principle, the same Sabo engineers should participate throughout the entire annual program. Aside from the training of Sabo engineers, the training of candidates of Sabo engineers in the general Sabo course will be conducted by the Indonesian side at appropriate opportunities. To be fully trained as professional Sabo engineers, the candidates must complete the remaining three courses in the following years.

##### (1) General Sabo

**Table 4-3 General Sabo course**

Item	Contents	Remarks
Purpose	Learn the general overview of Sabo technology and the basics of debris flow prevention measures. Review the basics necessary for Sabo planning, by considering the sediment dynamics of the entire river basin.	
Target participants and number of participants	<ul style="list-style-type: none"> <li>• Staff of DGWR, MPW</li> <li>• Staff of Directorate of Rivers and Coasts</li> <li>• Staff of river basin agencies</li> <li>• STC staff</li> </ul>	Participants will be selected within DGWR.
Lecturer	Japanese Sabo experts (to be implemented through the loan project in Early Phase 1, 2025) and STC experts	From the Late Phase 1 (2026 onwards), Japanese experts will participate as observers and lecturers when necessary.
Training period	32.0 hours 5 days	First quarter of the fiscal year
Curriculum contents and scheduled times	General-1: Overview <i>3.0 hours</i> General-2: Basic principles of sediment and driftwood flow countermeasure planning <i>3.0 hours</i> General-3: Basic principles for countermeasure planning of abnormal sediment disasters (deep-seated landslides, natural dams, etc.) <i>3.0 hours</i> General-4: Basic principles of soft countermeasures for sediment disasters <i>3.0 hours</i> General-5: Coastal protection planning <i>1.5 hours</i> General-6: Considerations for the natural environment <i>1.5 hours</i> Research project: <i>15.0 hours</i> Other guidance, opening ceremony, and closing ceremony: <i>2.0 hours</i> Total: 32.0 hours	
References	<ul style="list-style-type: none"> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Planning (Basic Planning)</li> <li>• Introduction to sediment disaster cases in Japan and Indonesia</li> </ul>	
Event format	<ul style="list-style-type: none"> <li>• Offline: STC lecture room.</li> </ul>	

Item	Contents	Remarks
and location	<ul style="list-style-type: none"> <li>Online: General lectures (excluding research assignments) will be available as webinars for DGWR officials.</li> </ul>	
Department in charge	BPSDM and STC	

Time	Day 1	Day 2	Day 3	Day 4	Day 5
08:00-09:00	Entrance ceremony				
09:00-10:30	General-1A	General-2A	General-3A	General-4A	General-5
10:30-12:00	Research project	Research project	Research project	Research project	Research project
12:00-13:00					
13:00-14:30	General-1B	General-2B	General-3B	General-4B	General-5
14:30-16:00	Research project	Research project	Research project	Research project	Research project
16:00-17:00					Closing ceremony

## (2) Sabo Survey and Planning Plan

Table 4-4 Sabo survey and planning course

Item	Contents	Remarks
Purpose	The curriculum will cover the methods for conducting survey and points to be noted. Additionally, the techniques for formulating plans for debris flow countermeasure based on the survey is learned.	
Target participants and number of participants	<ul style="list-style-type: none"> <li>Staff of DGWR, MPW</li> <li>Staff of Directorate of Rivers and Coasts</li> <li>Staff of river basin agencies</li> <li>STC staff</li> </ul> <p style="text-align: right;">Total: 20 participants</p>	Participants will be selected within DGWR
Lecturer	Japanese Sabo experts (to be implemented through the loan project in Early Phase 1, 2025) and STC experts	From the Late Phase 1 (2026 onwards), Japanese experts will participate as observers and lecturers when necessary.
Training period	36.5 hours 6 days	Second quarter of the fiscal year
Curriculum contents and scheduled times	<p>Survey and Planning-1: Comprehensive sediment management survey and planning <span style="float: right;">3.0 hours</span></p> <p>Survey and planning-2: Basic survey and planning <span style="float: right;">1.5 hours</span></p> <p>Survey and Planning-3: Survey and planning for sediment and driftwood flow countermeasures <span style="float: right;">3.0 hours</span></p> <p>Survey and planning -4: Survey and planning for non-structural countermeasures for sediment disasters <span style="float: right;">1.5 hours</span></p>	

Item	Contents	Remarks
	Survey and planning -5: Basic principles for debris flow countermeasure planning <i>3.0 hours</i> Survey and planning -6: Debris flow disposal planning <i>3.0 hours</i> Survey and planning -7: Debris flow countermeasures; facility layout planning <i>3.0 hours</i> Research project: <i>16.5 hours</i> Other guidance, opening ceremony, and closing ceremony <i>2.0 hours</i> Total: 36.5 hours	
References	<ul style="list-style-type: none"> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Survey and Planning</li> <li>• MLIT: Manual of Technical Standard for Establishing Sabo Master Plan for Debris Flow and Drift Wood</li> <li>• Introduction to sediment disaster cases in Japan and Indonesia</li> </ul>	
Event format and location	<ul style="list-style-type: none"> <li>• Offline: STC lecture room</li> <li>• Lectures other than research projects are open to Ministry of Public Works staff as online seminars.</li> </ul>	
Department in charge	BPSDM and STC	

Time	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
08:00-09:00	Entrance ceremony					
09:00-10:30	Survey and planning-1A	Survey and planning – 2	Survey and planning - 3B	Survey and planning - 5B	Survey and planning - 6B	Survey and planning - 7B
10:30-12:00	Research project	Research project	Research project	Research project	Research project	Research project
12:00-13:00						
13:00-14:30	Survey and planning - 1B	Survey and planning 3A	Survey and planning - 5A	Survey and planning - 6A	Survey and planning - 7A	Closing ceremony
14:30-16;00	Research project	Research project	Research project	Research project	Research project	
16:00-17:00						

(3) Sabo Design

**Table 4-5 Sabo design course**

Item	Contents	Remarks
Purpose	The curriculum will cover the design methods for debris flow countermeasure structures. Additionally, it will include the study of the design external forces and their calculation methods.	
Target participants and number of participants	<ul style="list-style-type: none"> <li>• Staff of DGWR, MPW</li> <li>• Staff of Directorate of Rivers and Coasts</li> <li>• Staff of river basin agencies</li> <li>• STC staff</li> </ul> <p style="text-align: right;">Total: 20 participants</p>	Participants will be selected within DGWR
Lecturer	Japanese Sabo experts (to be implemented through the loan project in Early Phase 1, 2025) and STC experts	From the Late Phase 1 (2026 onwards), Japanese experts will participate as observers and lecturers when necessary.
Training period	32.0 hours 5 days	The third quarter of the fiscal year.
Curriculum contents and scheduled times	Design-1: Design of debris flow countermeasure facilities <span style="float: right;">6.0 hours</span> Design-2: Setting design external forces during debris flow <span style="float: right;">6.0 hours</span> Research project: <span style="float: right;">18.0 hours</span> Other guidance, opening ceremony, and closing ceremony: <span style="float: right;">2.0 hours</span> <p style="text-align: right;">Total: 32.0 hours</p>	
References	<ul style="list-style-type: none"> <li>• MLIT: Manual of Technical Standard for Designing Sabo Facilities against Debris Flow and Drift Wood</li> <li>• Introduction to sediment disaster cases in Japan and Indonesia</li> </ul>	
Event format and location	<ul style="list-style-type: none"> <li>• Offline: STC lecture room</li> <li>• Lectures other than projects research are open to Ministry of Public Works staff as online seminars.</li> </ul>	
Department in charge	BPSDM and STC	

Time	Day 1	Day 2	Day 3	Day 4	Day 5
08:00-09:00	Entrance ceremony				
09:00-10:30	Design-1A	Design-1C	Design-2A	Design-2C	Research project
10:30-12:00	Research project	Research project	Research project	Research project	Research project
12:00-13:00					
13:00-14:30	Design-1B	Design-1D	Design-2B	Design-2D	Research project
14:30-16:00	Research project	Research project	Research project	Research project	Research project
16:00-17:00					Closing ceremony

(4) **Construction, Maintenance/Operation, Warning, etc.**

**Table 4-6 Construction, maintenance/operation, and early warning course**

Item	Contents	Remarks
Purpose	The curriculum will cover the construction and operation/maintenance methods for Sabo structures. Additionally, operation methods of monitoring facilities for early warning on sediment disasters are studied.	
Target participants and number of participants	<ul style="list-style-type: none"> <li>• Staff of DGWR, MPW</li> <li>• Staff of Directorate of Rivers and Coasts</li> <li>• Staff of river basin agencies</li> <li>• STC staff</li> </ul> <p style="text-align: right;">Total: 20 participants</p>	Participants will be selected within DGWR
Lecturer	Japanese Sabo experts (to be implemented through the loan project in Early Phase 1, 2025) and STC experts	From the Late Phase 1 (2026 onwards), Japanese experts will participate as observers and lecturers when necessary.
Training period	26.0 hours 4 days	Fourth quarter of the fiscal year
Curriculum contents and scheduled times	<p>Maintenance/Operation-1:Construction of Sabo dams and stream conservation works <i>3.0 hours</i></p> <p>Maintenance/Operation-2:Construction of mountainside conservation structures, etc. <i>3.0 hours</i></p> <p>Maintenance/Operation-3:Inspection and soundness evaluation of Sabo facilities <i>3.0 hours</i></p> <p>Maintenance/Operation-4:Maintenance/Operation of observation equipment, etc. <i>3.0 hours</i></p> <p>Research project: <i>12.0 hours</i></p> <p>Other guidance, entrance ceremony, closing ceremony: <i>2.0 hours</i></p> <p style="text-align: right;">Total 26.0 hours</p>	
References	<ul style="list-style-type: none"> <li>• MLIT: Technical Criteria for River Works, Practical Guide for Planning (Basic Planning)</li> <li>• Introduction to sediment disaster cases in Japan and Indonesia</li> </ul>	
Event format and location	<ul style="list-style-type: none"> <li>• Offline: STC lecture room</li> <li>• Lectures other than projects research are open to Ministry of Public Works staff as online seminars.</li> </ul>	
Department in charge	BPSDM and STC	

Time	Day 1	Day 2	Day 3	Day 4
08:00-09:00	Entrance ceremony			
09:00-10:30	Maintenance /Operation -1A	Maintenance /Operation -2A	Maintenance /Operation -3A	Maintenance /Operation -4A
10:30-12:00	Research project	Research project	Research project	Research project

<b>Time</b>	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>
12:00-13:00				
13:00-14:30	Maintenance /Operation -1B	Maintenance /Operation -2B	Maintenance /Operation -3B	Maintenance /Operation -4B
14:30-16;00	Research project	Research project	Research project	Research project
16:00-17:00				Closing ceremony

## CHAPTER 5 UPGRADE OF EQUIPMENT AND FACILITIES

### 5.1 Target Equipment and Facilities

As explained in Chapter 2 (p.2-20), the need for hydraulic model experiment to verify the functions of designed rivers and Sabo structures is increasing in response to the frequent sediment disasters in Indonesia. Prior to hydraulic model experiments to verify the function of a structure, it is necessary to create a model that reflects the structure and the topography of the river channel. Since it takes time to make a model, in order to increase the number of experiment cycles, it is necessary to create conditions that allow the creation of models and experiments at multiple locations at the same time. The indoor hydraulic model experiment building of Balai Teknik Sabo is equipped with water supply and electrical systems, allowing experiments to be conducted without being affected by weather conditions within a usable floor area of 525 m<sup>2</sup>. On the other hand, the outdoor hydraulic model experiment field has a total area of 1,050 m<sup>2</sup>, but since it is supplied by only a single water supply line from the indoor hydraulic model experiment building, only 150 m<sup>2</sup> of the field is currently in use. Balai Teknik Sabo is the only institution in Indonesia equipped with a hydraulic model experiment facility for Sabo structures, making the improvement of the outdoor hydraulic model experiment field an urgent issue.

As mentioned in Section 2.5, the equipment in the concrete testing laboratory and soil testing laboratory is in operational condition, and its management and maintenance will continue under Indonesian authorities. Non-operational X-band radar is under consideration for repair using the national budget. Among the various equipment and facilities, the highest priority for upgrades is the outdoor hydraulic model experiment field.

### 5.2 Current Status of the Outdoor Hydraulic Model Experiment Field

#### 5.2.1 Facility Layout and Overview

As of August 2024, the facility layout of the outdoor hydraulic model experiment field is shown in Figure 5-1.

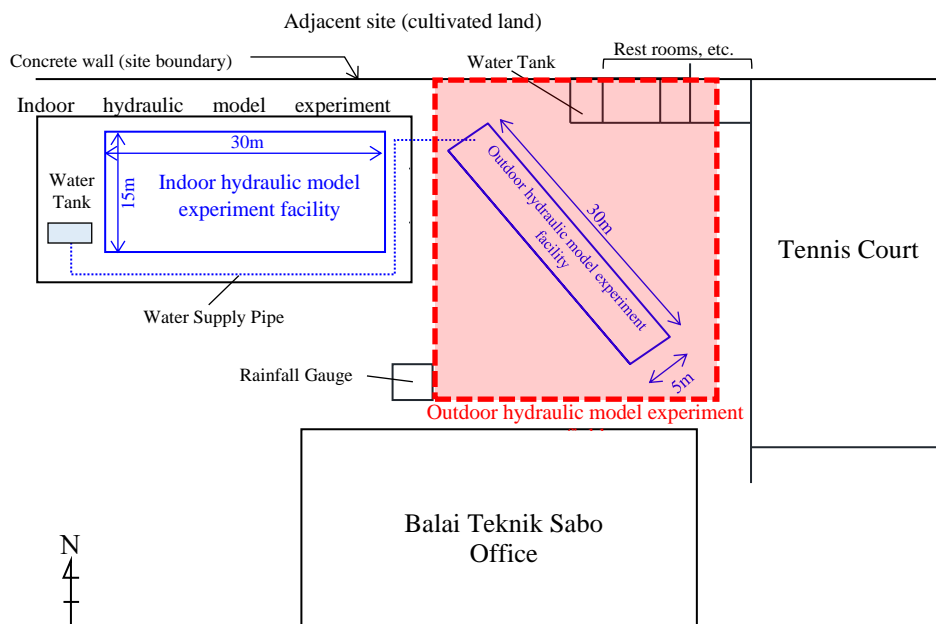


Figure 5-1 Current layout of facilities around the outdoor hydraulic model experiment field

### 5.2.2 Current situation and issues

As of August 2024, the challenges faced by the outdoor hydraulic model experiment field are as follows:

1. The outdoor hydraulic model experiment facility is small, and larger-scale experiments are prioritized in the indoor hydraulic model experiment building, which has greater capacity.
2. The water used for experiments in the outdoor facility is supplied from the indoor hydraulic model experiment building. As a result, when the indoor facility is in use, the outdoor facility cannot be utilized.
3. The outdoor hydraulic model experiment facility is installed diagonally on the land, making it difficult to efficiently use the remaining unused land within the area.



**Figure 5-2 Panoramic view of outdoor hydraulic model experiment facility**

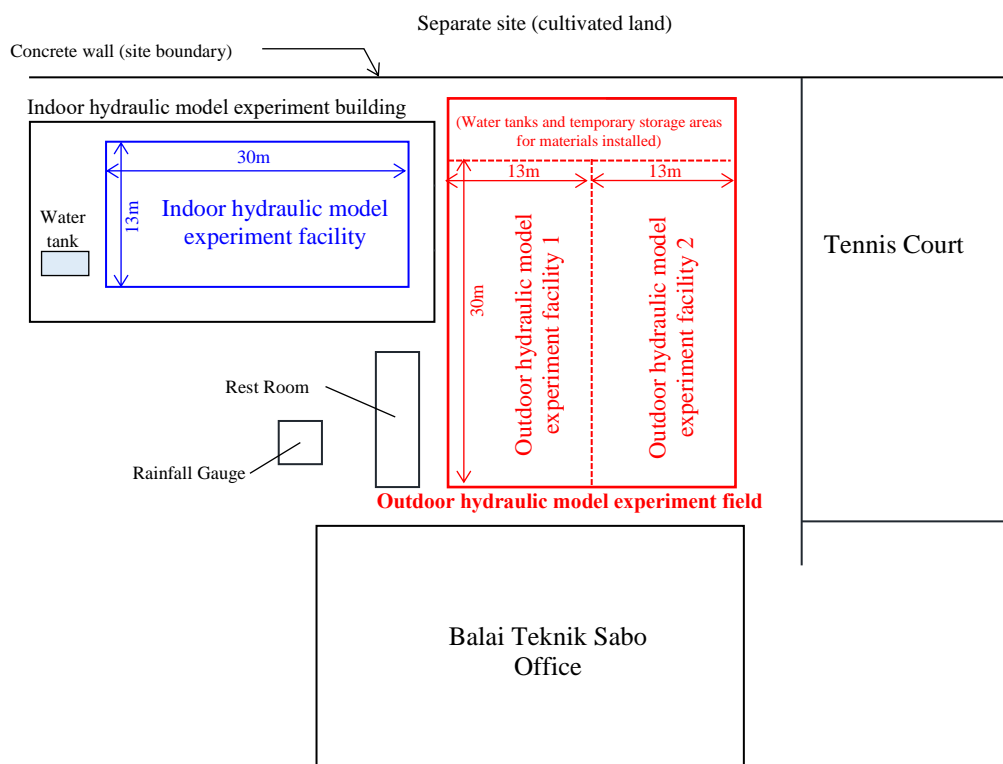
### 5.3 Improvement Suggestions

Based on the identified challenges, a plan for improving the existing outdoor hydraulic model experiment field was considered. In preparing the improvement plan, the following information was confirmed through hearings from Balai Teknik Sabo:

- 1) North Side Tank and Staff Restroom: These facilities can be relocated.
- 2) East Side Tennis Court: It is difficult to relocate the tennis court.
- 3) North Side Land (Cultivated Area): The land is separated by a concrete wall, making it difficult to expand the field towards the north.
- 4) Rainfall Monitoring Facility on the South Side: This facility can be moved.

Taking into account the feasibility of relocating or moving the surrounding facilities, and from the perspective of maximizing land use, an improvement plan for the layout of the outdoor hydraulic model experiment field is shown in Figure 5-3. The improvement guidelines are as follows:

- 1) The waterway will be oriented vertically, rather than at an angle to the field, allowing the maximum possible use of the area to the east of the indoor hydraulic model experiment building.
- 2) To accommodate a higher number of hydraulic model experiment, the number of outdoor hydraulic experiment facilities will be increased to two. Each of these will be the same size as the existing indoor hydraulic model experiment facility.
- 3) **Independent Water Supply:** The indoor and outdoor hydraulic model experiment facilities will have independent water supplies, allowing simultaneous experiment in both areas.



**Figure 5-3 Proposal for improving the outdoor hydraulic model experiment facility**

The improvements made to the outdoor hydraulic model experiment field in Table 5-1 were compared before and after the improvements and summarized in the table below.

**Table 5-1 Improvements to the outdoor hydraulic model experiment field**

Item	Before Improvement	After Improvement
Field Location	East side of indoor hydraulic model experiment	No change
Facility Orientation	Northwest to Southeast direction	North to South direction
Dimensions	1 waterway of 5 m × 30 m	2 waterway of 15 m × 30 m each
Water Supply	Shared water supply with indoor hydraulic model experiment facility	<ul style="list-style-type: none"> <li>• Dedicated water tank and supply line for the outdoor facility</li> <li>• Water tank placed on the north side waterways</li> </ul>
Movable Surrounding Facilities	<ol style="list-style-type: none"> <li>1) Water tank (north side)</li> <li>2) Staff rest room (north side)</li> <li>3) Rainfall observation facility (west side)</li> </ol>	<ol style="list-style-type: none"> <li>1) Relocated to north</li> <li>2) Moved to a location that does not interfere with other facilities</li> <li>3) Relocation minimized</li> </ol>
Non-movable surrounding facilities	<ul style="list-style-type: none"> <li>• Concrete wall at the north boundary</li> <li>• Tennis court</li> </ul>	No change
Other changes	<ul style="list-style-type: none"> <li>• Many unused areas, space not fully utilized</li> </ul>	<ul style="list-style-type: none"> <li>• Optimized layout to maximize the use of available space</li> <li>• Water tank and material storage space secured on the north side waterways</li> </ul>

#### 5.4 Construction Costs for Improvement and Operation & Maintenance Costs

The estimated construction costs for improving the outdoor hydraulic model experiment field have been summarized in Table 5-2. After the improvement is completed, the operation and maintenance costs will need to be secured by Indonesian side to ensure continued functionality.

**Table 5-2 Estimated construction costs for improving the outdoor hydraulic model experiment field**

No.	Item	Quantity	Amount (Rp.)	Remarks
1	Facility demolition and disposal	1,000 m <sup>2</sup>	50,000,000	Demolition of buildings and existing facilities, disposal of concrete and other debris
2	Land leveling	1,000 m <sup>2</sup>	50,000,000	Land leveling (gravel laying, boundary block installation, drainage, and power line installation)
3	Hydraulic model foundation	429 m <sup>3</sup>	100,000,000	Foundation: h=0.5m, 13.0 m × 33.0 m × 2 places; Concrete wall: h=0.5m × b=0.15m × l=13.8m; Fill dirt (good quality) V=450m <sup>3</sup>
4	Concrete water tank (water supply side)	1 unit	100,000,000	Water tank: H=1.5m × B=1.5m × L=10m, with 3.0m height legs
5	Concrete water tank (drainage side)	1 unit	60,000,000	Water tank: H=1.5m × B=1.5m × L=15m
6	Main piping works	2 sets	100,000,000	Steel pipes Φ20cm L=8m per section, with bends, valves, and other accessories
7	Water pump system	2 units	300,000,000	Includes pump bodies, distribution panels, fuel tanks, and control panels
8	Field development	1,000 m <sup>2</sup>	70,000,000	Pathways, field paving, and ramp installation
9	Material storage area	1 set	20,000,000	Block wall and storage area
10	Staff rest rooms	60 m <sup>2</sup>	150,000,000	4 m × 15 m (3 rooms: 4 m × 5 m each); includes electrical and air conditioning facilities
11	Relocation of existing observation facilities	1 set	50,000,000	Includes rain gauge and others
<b>Total</b>			<b>1,050,000,000</b>	<b>Excluding VAT</b>