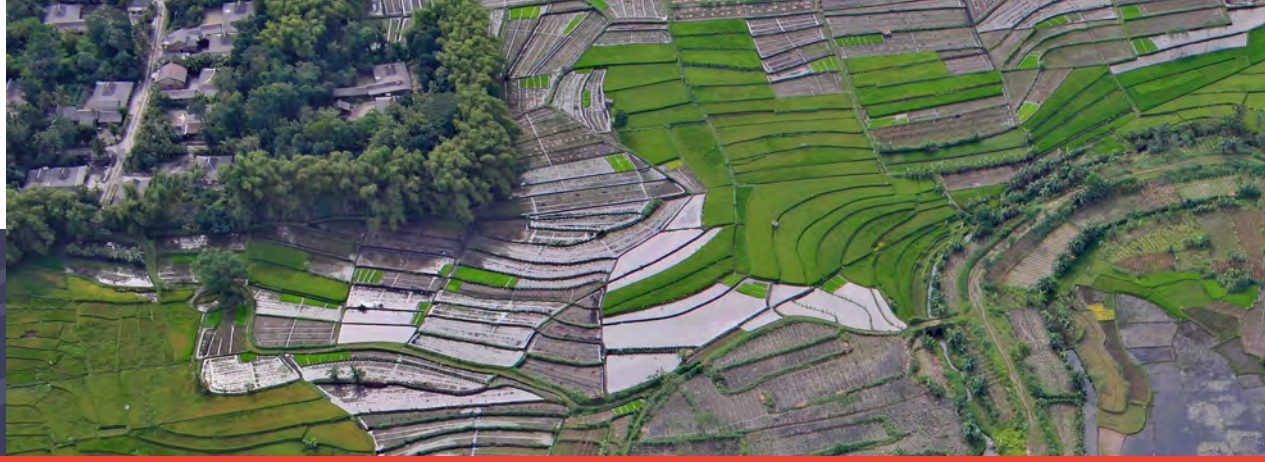

Maturity Matrices

for Institutional Benchmarking of Dam Safety in Indonesia

KEMENTERIAN PEKERJAAN UMUM DAN PERUMAHAN RAKYAT

Australian Government
Department of Foreign Affairs and Trade

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Foreword

Indonesia has more than 200 dams, with 192 dams owned by the Ministry of Public Works and Housing (MPWH). These are registered as single purpose or multi-purpose dams for irrigation, water supply, hydropower, and flood control. There are also 32 dams owned by state-owned companies and the private sector, such as those under PT. PLN (Persero)[1], PT Pembangkitan Jawa Bali (PJB)[2], BP Batam[3], PT Indonesia Power[4], among others.

Indonesian's River Basin Organizations are responsible for water resources management, including the construction, operation and maintenance of water resources infrastructure. Due to the number and importance of the country's dams, the dam safety aspects and their functions should be under good management. This is in line with Article 2 of MPWH decree No. 27/PRT/M/2015 on the management of dam safety, which is based on dam safety conceptions, namely structural safety, surveillance, and emergency preparedness. In this regard, the role of Dam Safety Unit (DSU) is crucial to ensuring proper dam management.

The Ministry of Public Works and Housing together with the World Bank introduced the concept of Maturity Matrices for institutional benchmarking of dam safety in Indonesia as a tool to assess and evaluatethe implementation of dam safety activities within and among the Dam Safety Units. The ten components assist the DSU to develop program planning, identify program activities, allocate resources, and plan maintenance and physical rehabilitation based on the targets established for each DSU.

Along with the implementation of the second phase of the Dam Operational Improvement and Safety Program (DOISP), which is aimed to increase dam safety and dam function in water supply owned by the MPWH, the Directorate General of Water Resources urges the dam managers to measure dam safety as well as develop comprehensive plans for the maintenance and physical rehabilitation using the Maturity Matrices to build sustainable dam management in Indonesia.

Jakarta, November 2018

Dr. Ir. Hari Suprayogi, M. Eng.
Direktur Jenderal Sumber Day Air
Kementerian Pekerjaan Umum dan Perumahan Rakyat

[1] Indonesian State Electricity Company
[2] PT Pembangkitan Jawa-Bali produces and supplies electricity in East Java and Bali, and operates as a subsidiary of PT PLN (Persero).
[3] Batam Indonesia Free Zone Authority
[4] Indonesia Power is one of the subsidiaries of PT PLN (Persero)

Foreword

As the largest archipelago in the world, Indonesia faces a number of challenges when it comes to ensuring water security. Growth in water withdrawals compared to the available supply, coupled with the island geography and lack of storage, is predicted to lead to high levels of water stress by 2040. Part of the Government's strategy to address these challenges involves investing in the development of hydraulic infrastructure to increase storage capacity and improve security at the nexus of water, food, and energy. This is part of a broader strategy to promote economic prosperity and poverty reduction measures by storing water for productive purposes.

Ensuring the safety of dams and downstream communities is increasingly important. The challenges of rapid population growth and urbanization, along with increasing climate variability and rainfall intensification, and an aging infrastructure all contribute to accentuating the related hazards. The poorest bear the heaviest burden. That's because they are typically the most vulnerable to the impacts of drought, floods, and landslides; they also pursue livelihoods that depend on climate-sensitive sectors.

In response to these factors, the World Bank supports a number of initiatives aimed at helping client countries to addressing such hazards and improve the overall operational, maintenance and management of hydraulic infrastructure.

The World Bank has a long history of support to the Government of Indonesia in their efforts to improve dam safety. The development of Maturity Matrices together with the Ministry of Public Works and Housing (MPWH) represents an important contribution to these ongoing efforts. Maturity Matrices are a key part of this. They provide an objective method for assessing the effectiveness of the operation, maintenance, surveillance and emergency preparedness programs. They are developed through a highly participative consultative process of development and are embedded within the legal and institutional framework for dam safety in the country. In addition to providing a tool to assist with self-assessment of the dam safety program, the Maturity Matrices help to identify and communicate both components and activities within the dam safety program, as well as inform the allocation of resources and their prioritization. This will provide an important tool to support implementation of the Dam Operational and Improvement Safety Program (DOISP) Phase II in strengthening the national dam safety institutions, restoring functionality, operational performance, and economic productivity of large dams across Indonesia.

The World Bank extends its appreciation to the Government of Indonesia, especially the Ministry of Public Works and Housing and those related stakeholders who have actively contributed to the development of the Maturity Matrices. We hope that this tool will be used by dam operators and managers under the MPWH and extended to application in the private sectors as a joint effort to apply the dam safety principles and promote a process of continuous improvement.

Jennifer J. Sara
Senior Director
Global Practice, Water

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The development of Maturity Matrices for Institutional Benchmarking of Dam Safety in Indonesia is part of a broader program of World Bank support to the water resources and irrigation sector in Indonesia. The World Bank team and its consultants are grateful for the contributions and consultations from those involved from the Ministry of Finance, the Ministry of Planning and the Ministry of Public Works and Housing. While acknowledging these contributions, the findings, interpretations, and conclusions expressed herein do not necessarily represent the views of these individuals or their organisations.

The World Bank team was led by Marcus Wishart (Senior Water Resources Specialist and Task Team Leader) and included Martin Albrecht (Water Resources Management Specialist), Agus Jatiwiryono (Dam Specialist), Ilham Abla (Irrigation Specialist), Deviariandy Setiawan (Senior Water and Sanitation Specialist), David Ginting (Water Resource Specialist), Isabel Duarte (Program Assistant) and Nina Herawati (Program Assistant). The work was implemented under the leadership of Sudipto Sarkar (Practice Manager) of the World Bank with valuable guidance provided by Rodrigo Chaves (Country Director for Indonesia).

The Maturity Matrices for Benchmarking Dam Safety Institutions in Indonesia are based on work developed by Damwatch Engineering Ltd of New Zealand under the leadership of Peter Amos (Managing Director and Principal Engineer), Nigel Connell (Water Resource Engineer), and Viculp Lal (Senior Structural Engineer) with guidance and review from Murray Gillon (Principal Consultant) and Neil Blaikie (private consultant). Research into the legal framework for dam safety was provided by John Pisaniello (Associate Research Professor of Engineering Law) and Joanne Tingey-Holyoak (Senior Lecturer and Researcher) from the University of South Australia as part of the Global Assessment of Legal and Institutional Frameworks for Dam Safety.

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Executive Summary

Indonesia has a large and growing portfolio of large dams distributed across the island archipelago. This infrastructure is important in supporting the Government's vision of security at the nexus of water, food, and energy and contributing to economic prosperity and poverty reduction measures by storing water for productive purposes.

The development of Maturity Matrices for Institutional Benchmarking of Dam Safety in Indonesia is intended to provide a method for assessing the effectiveness of the operation, maintenance, surveillance and emergency preparedness programs adopted by dam authorities.

The Maturity Matrices can serve a wide range of functions and are intended to be used as a tool to help in identifying and prioritise areas for improvement in the dam safety program, compare the performance of the dam safety program over time, contrast the effectiveness of different programs across different dam management units, and inform the prioritisation of resources for dam operation, maintenance and safety improvement.

Maturity Matrices are a powerful tool to evaluate how well developed a process or program is performing. They are typically based on a system used to demonstrate the state of practice in an organisation for performing an activity. The matrix shows advancing maturity from a rudimentary or elementary level of practice through stages to advanced, expert or good industry practice.

Maturity Matrices have been developed for dam owners and operators to assess the effectiveness of a dam safety program against in-country standards and guidelines, or, good industry practice as considered most appropriate. The primary benefit from using dam safety-related Maturity Matrices is the improved understanding of the effectiveness or maturity of the dam safety program across the whole range of dam safety activities. This understanding of performance across a range of different metrics for dam safety allows for owners and operators to monitor performance over time. It also allows national regulatory bodies to assess performance across different operators and owners.

The Maturity Matrices also provide a useful means to communicate the effectiveness of a dam safety program to wider audiences. As part of continuous improvement initiatives, the matrices allow areas requiring improvement to be identified and prioritised for targeted investment and resourcing. This can also be applied over time or across a portfolio to identify systemic issues and target interventions and remedies accordingly.

The Maturity Matrices developed herein have been developed with due recognition of the Indonesian context. The foundations are provided by the national legal and regulatory framework with the specific elements identified and further elaborated through a series of workshops and expert consultations. The Maturity Matrices are focused on the operations of the Dam Management Units within the Balais, or basin organisations, and targeted to the dam safety standards and guidelines in Indonesia, or best industry practice as considered most appropriate in-country.

Acronyms

BBWSs	Balai Besar Wilayah Sungai(s)
BSN	National Standardization Agency of Indonesia
BWSs	Balai Wilayah Sungai(s)
DGWR	Directorate General for Water Resources
DMU	Dam Management Unit
DOISP	Dam Operational Improvement and Safety Project
DSC	Dam Safety Commission
DSU	Dam Safety Unit
EAP	Emergency Action Plan
FEMA	Federal Emergency Management Agency
Ha	Hectares
ICOLD	International Committee on Large Dams
INACOLD	Indonesian National Committee on Large Dams (Komite Nasional Indonesia untuk Bendungan Besar - KNI-BB)
MPWH	Ministry of Public Works and Housing
MW	Mega Watt
PFMA	Potential failure modes analysis
PJTs	State-Owned River Agency (Perusahaan Umum Jasa Tirta)

Contents


ILONTE

1.0 Introduction

Dam Portfolio and Trends

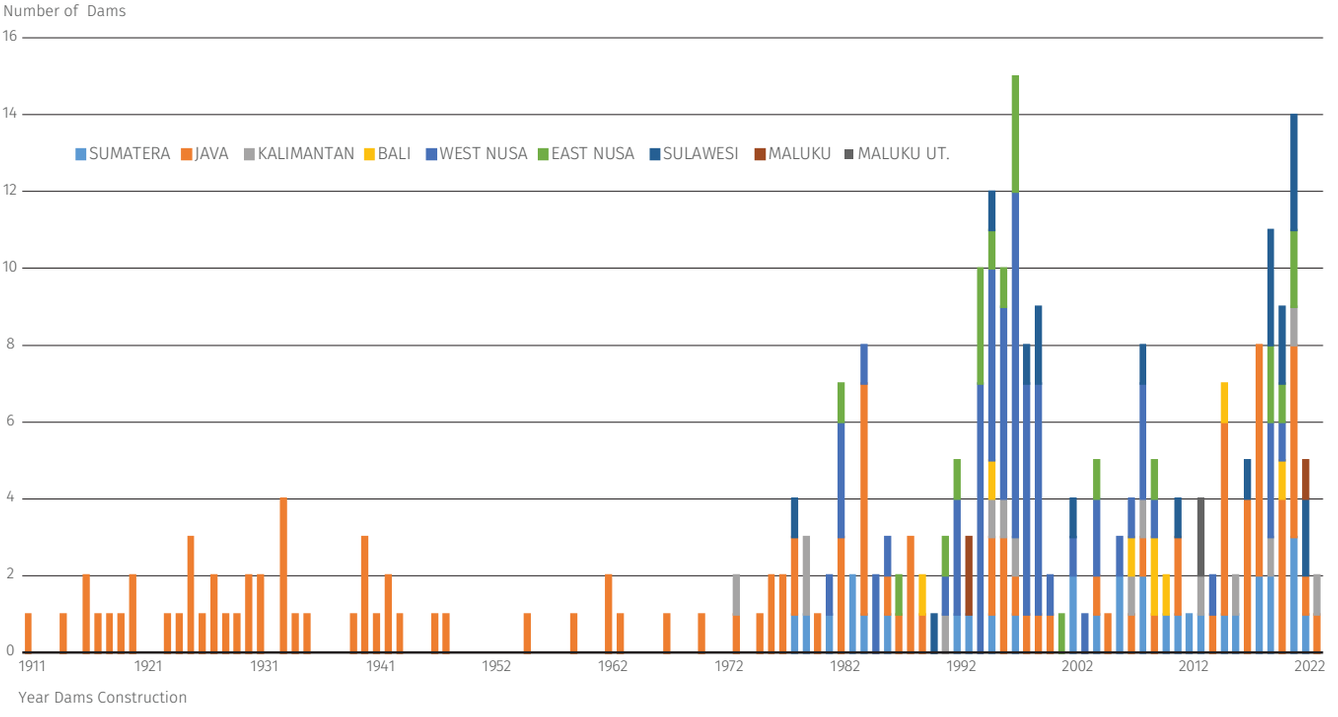
Indonesia has a long history of dam development, with an extensive network of more than 2,200 dams. Of these, 213 are classified as large under Ministerial Regulation Number 27/PRT/M/2015. There are 164 dams registered as being for single purpose use with another 49 registered as multi-purpose reservoirs (Table 1). The majority of these (183 as of 2016) are owned by the Ministry of Public Works and Housing (MPWH) and used primarily to provide bulk water for irrigation. In the absence of water services charges for many sectors, including irrigation, revenues from hydropower and domestic and industrial water supply provide important revenue streams to finance the costs associated with operation and maintenance (O&M) of public assets. In addition to irrigation, hydropower, and water supply, many dams also provide flood protection benefits for downstream communities and assets through regulating flows.

There are also 30 registered dams owned by various corporations. This includes 18 single purpose hydroelectric dams with a total reservoir capacity of 5.5 billion cubic meters and an installed capacity of 5,545 MW. Three of these are under Badan Pengusahaan Asahan, four under Vale and another 11 under the national power utility. There are another 25 hydropower facilities installed on multi-purpose facilities to give 43 dams in total used in

Indonesian Large Dams (Purpose and Numbers) Table 1

	Purpose of Dam	Number
Multi-Purpose	Irrigation + Water Supply	23
	Irrigation + Hydropower	13
	Irrigation + Hydropower + Water Supply	13
	Hydropower + Water Supply	0
Single Purpose	Irrigation only	110
	Hydropower only	18
	Water Supply only	6
	Tailing or other	30
Multi + Single Purpose	Irrigation total	159
	Hydropower total	43
	Water Supply total	41

Completion Date of Dams in Indonesia Figure 1



the generation of hydropower. In addition, there are six dedicated water supply dams (five dams under BP Batam and one under Krakatau Tirta Industri), complimented by another 35 multi-purpose dams that were developed primarily for irrigation purposes but also provide water for domestic supplies.

The majority of dams owned and operated by the MPWH are more than 20 years old (70 percent), with roughly 20 percent built prior to independence in 1945. There was a period of very low investment in dams from independence through until the times of political upheaval were over in the 1970s. From the 1980s this was followed by three decades of development, with more than 70 dams completed in the 1990s. This period in the 1990s represented a doubling of efforts from the decade before and after, and accounts for more than half of the current portfolio. These thirty years saw more than twice the number of dams constructed than in the seven decades before (Figure 1).

The development of dams in Indonesia relates to geography (Table 2). More than 40 percent of the dams in Indonesia are located in Java, which accounts for nearly 60 percent of the population, with most used to support some 750,000 hectares of irrigated agriculture. This represents 11 percent of the total national irrigated area. This portfolio includes 70 large dams providing the island with the highest absolute water storage volume, at around 8.6 billion cubic meters. With several of the dams built during colonial times before Indonesia's independence in 1945, Java's dams are also the oldest.

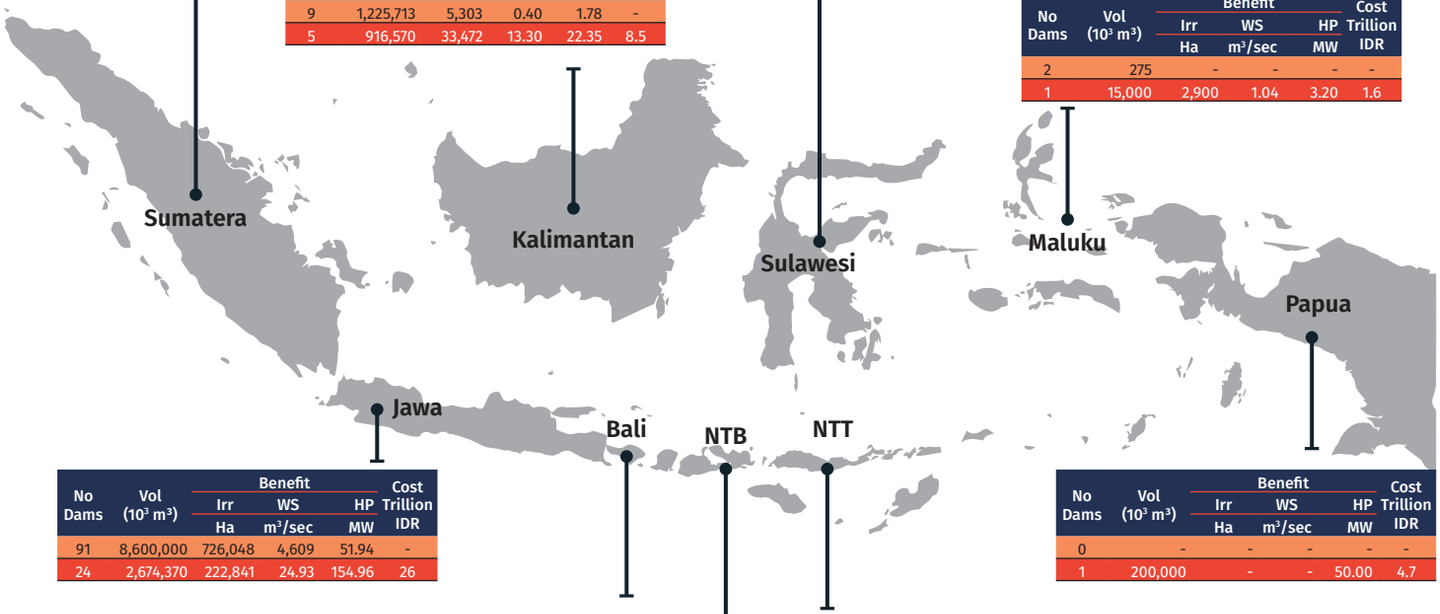
In order to realize the broader vision of water security, food security and energy security, the Government has initiated an ambitious program of new dam construction between 2014 and 2019. This includes 65 new dams, the majority of which are located in Java (24), followed by Sumatra (11), Sulawesi (9), East Nusa Tenggara (7), Kalimantan (5), West Nusa Tenggara (4), Bali (3) and Maluku (1) and Papua (1) (Figure 2). Overall costs are estimated at more than 70 Trillion Rupiah (around USD 5 billion) in total, with a total storage volume of 6.5 billion cubic meters, and an estimated 460,382 Ha of irrigated land to be served.

Distribution of Dams in Indonesia Table 2

ISLAND	NUMBER OF REGISTERED DAMS			TOTAL VOLUME	BENEFIT		
					Irrigation	Hydropower	Supply
	Total	Large	Small	(10^3 m^3)	(ha)	(mw)	(m3/sec)
Sumatera	20	20	0	2,865,254	118,467	988	7.97
Java	91	70	21	8,631,765	726,049	4,609	51.94
Kalimantan	9	7	2	1,225,713	5,304	0.4	1.78
Bali	5	5	0	27,158	5,230	1.5	0.53
West Nusa Tenggara	62	51	11	270,149	51,229	0.5	0.47
East Nusa Tenggara	15	9	6	33,525	4,926	-	-
Sulawesi	9	9	0	506,055	36,384	515	2.50
Maluku	1	1	0	275	-	-	-
Maluku Utara	1	1	0	-	-	-	-
TOTAL	**213**	**173**	**40**	**13,559,895**	**947,589**	**6,115**	**65.20**

Distribution of Existing and Planned Dams in Indonesia

Figure 2



No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
20	2,850,000	118,467	988	7.97	-
11	985,000	88,002	9.59	108.34	11

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
9	1,225,713	5,303	0.40	1.78	-
5	916,570	33,472	13.30	22.35	8.5

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
9	506,055	36,384	515	2.5	-
9	1,380,620	75,217	9.20	35.68	10

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
2	275	-	-	-	-
1	15,000	2,900	1.04	3.20	1.6

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
91	8,600,000	726,048	4,609	51.94	-
24	2,674,370	222,841	24.93	154.96	26

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
0	-	-	-	-	-
1	200,000	-	-	50.00	4.7

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
5	27,158	5,230	1.5	0.53	-
3	29,600	7,586	3.74	3.86	2

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
15	33,525	4,926	-	-	-
7	216,590	14,696	1.44	3.90	5.6

No Dams	Vol (10^3 m^3)	Benefit			Cost Trillion IDR
		Irr	WS	HP	
		Ha	m^3/sec	MW	
62	270,148	51,229	0.48	0.47	-
4	99,920	12,134	0.75	10.30	2

Dam Safety Management

Dam safety management and dam safety assurance in Indonesia is the responsibility of the dam owner. This is in accordance with Article 77 of Ministerial Regulation Number 27/ PRT/M/2015 and based on three fundamental principles:

1. structural safety;
2. surveillance; and,
3. emergency preparedness.

This approach reflects international practice. Structural safety is addressed initially in dam design. Operational dam safety requires a surveillance program with checks and assessments of on-going safety and preparation for emergencies should they arise (Figure 3).

Operation of the dam, as well as the reservoir, is intended to optimize the utilization of water and water resources, and maintain the safety of the dam, and consists of:

1. dam operation;
2. dam maintenance; and
3. monitoring of the dam condition.

Dam operation is performed by controlling the water discharge to meet the water needs of downstream users, including the environment, along with flood operation, to control the water level in reservoir and flood control to mitigate downstream flooding, and measures to quickly discharge the reservoir water during a state of emergency or extraordinary situation. In the event of emergency or exceptional circumstances, the operation of the dam as well as the reservoir is prioritized for the purpose of dam and environmental safety.

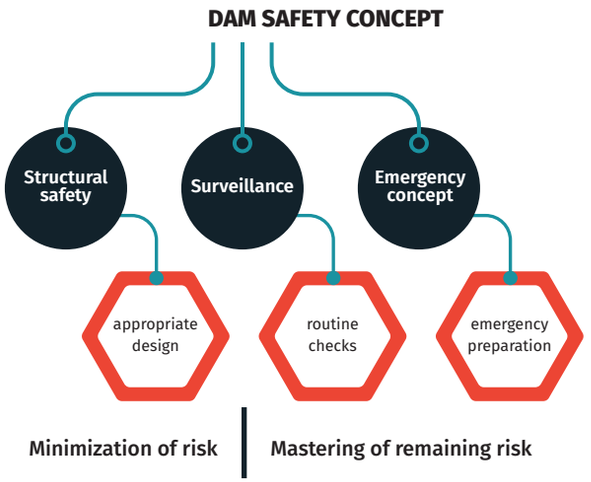
Dam maintenance, as well as maintenance of the reservoir, consists of:

1. preventative maintenance aimed at preventing damage and quality deterioration of the dam construction and any complementary building and to extend its life cycle;
2. extraordinary maintenance that includes repair work, retrofitting or modification works and rehabilitation based on specific needs outside the scheduled maintenance, aimed at repairing any damage caused by deterioration of its integrity, after flooding, earthquakes, control equipment failure, other failure (structural, hydraulic, seepage, operation, etc.), due to vandalism, etc.
3. reservoir maintenance which is also provided for under the Regulation and is aimed at maintaining the reservoir function according to its age serviceability, the quantity and quality of water in the reservoir and in order to maintain the safety of the dam.

Dam monitoring is conducted with the aim of identifying symptoms of any problems occurring in the dam to enable early action to be taken by the dam management unit in a quick and precise manner. The Dam Management Units must submit periodic reports with information on the condition of the dam as well as the reservoir to the relevant agencies.

Emergency preparedness is the third element of the dam safety framework. Dam safety is unique in that it represents an extreme situation characteristic of a low probability event with a high consequence or hazard. Given the high population densities in many areas the legislative provisions are important in providing operational tools to reduce the likelihood of dam failure and manage the potential impacts associated in the event of a dam failure. During preparation, the downstream communities that would be affected by any potential dam failure and the provincial and local authorities responsible for early warning, evacuation and post-flood assistance, are required to be consulted.

Dam Safety Concept in Indonesia Figure 3



Maturity Matrices for Benchmarking Dam Safety

Maturity Matrices are based on a system used to demonstrate the state of practice in an organisation for performing an activity. The matrix shows advancing maturity from a rudimentary or elementary level of practice through stages to advanced, expert or good industry practice.

Maturity Matrices are a powerful tool to evaluate how well developed a process or program is performing. Maturity Matrices have been developed for owners to assess the effectiveness of a dam safety program against in-country standards and guidelines, or, best industry practice as considered most appropriate.

The primary benefit from using dam safety-related Maturity Matrices is the improved understanding of the effectiveness or maturity of the dam safety program across the whole range of dam safety activities. This understanding of performance across a range of different metrics for dam safety allows for owners and operators to monitor performance over time, it also allows national regulatory bodies to assess performance across different operators and owners.

The Maturity Matrices are a valuable means to communicate the effectiveness of a dam safety program to wider audiences. As part of continuous improvement initiatives, the matrices allow areas requiring improvement to be identified and prioritised for targeted investment and resourcing. This can also be applied over time or across a portfolio to identify systemic issues and target interventions and remedies accordingly.

Maturity Matrices to assess the effectiveness of dam safety programs are already in use by hydropower dam owners in North America and Europe. These are not directly applicable to the Indonesian context given differences in the approach to dam safety management. The Matrices developed herein are therefore significantly different, being focused on the operations of the Dam Management Units and targeted to the dam safety standards and guidelines in Indonesia, or good industry practice as considered most appropriate in-country.

The objective for developing Maturity Matrices specific to the Indonesian context was to provide a method for assessing the effectiveness of the operation, maintenance, surveillance and emergency preparedness programs adopted by dam authorities. The outcome of this assessment is intended to be used to provide a tool that will help in identifying and prioritise areas for improvement in the dam safety program, compare the performance of the dam safety program over time, contrast the effectiveness of different programs across different dam management units, and inform the prioritisation of resources for dam operation, maintenance and safety improvement.

2.0

The Institutional Framework for Dam Safety Assurance

Management of the dam, and dam safety assurance, as well as the reservoir is the responsibility of the dam owner according to Article 77 of the Ministerial Regulation Number 27/ PRT/M/2015.

Government Oversight and Regulator

Indonesia is a unitary republic divided into five layers of government: central, provinces, districts (*kabupaten*) and municipalities (*kota*), sub-districts (*kecamatan*), and villages (*kelurahan/desa*). The archipelago is administratively divided into 33 provinces[1], which include two special regions and the special area of the capital city of Jakarta. These are further sub-divided into smaller entities of districts (413), municipalities (98), sub-districts (9,982), villages (80,414) and neighbourhoods.

The wide range of decentralization programs and reforms that came into effect in 2001 replaced the previous system of centralized government and development planning. These reforms gave greater authority, political power, and financial resources directly to sub-national spheres of government. The powers transferred include those of executing a wide range of responsibilities in the areas of health, primary and middle-level education, public works, environment, communication, transport, agriculture, manufacturing, and other economic sectors. Prior to this reform program, sub-national governments had mainly functioned as implementing agencies of national policies and programs.

Ministry of Public Works and Housing

The MWPH is responsible for formulating and implementing policies for water resources management; road management; the provision of housing; the development of residential areas; housing finance; arrangements for buildings, water supply systems, waste water management systems and environmental drainage, as well as waste management and construction services. The Ministry is also tasked with implementation of human resource development in the area of public works and public housing, in addition to the strategic integration of public works infrastructure development. The Water Law gives the MPWH the responsibility to manage and develop the water resources including the licensing of water infrastructure and dam safety. The management structure of MPWH is shown in Figure 4.

Within the MPWH, the Directorate General of Water Resources (see Figure 5) is responsible for the following as defined in "Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat nomor 15/PRT/M/2015 tanggal 21 April 2015":

1. Formulation of policies in the field of conservation of water resources, water resources utilization and control of water damage on surface water sources, and utilization of groundwater in accordance with the provisions of the legislation
2. Implementation of policies in the field of integrated and sustainable water resources management in accordance with laws and regulations
3. Preparation of norms, standards, procedures, and criteria in the field of water resources management
4. Provision of technical guidance and supervision in the field of water resources management
5. Evaluation and reporting in the field of water resources management
6. Administration of the DGWR
7. Implementation of other functions provided by the Minister of Public Works and Housing

River Basin Organisations - Balais

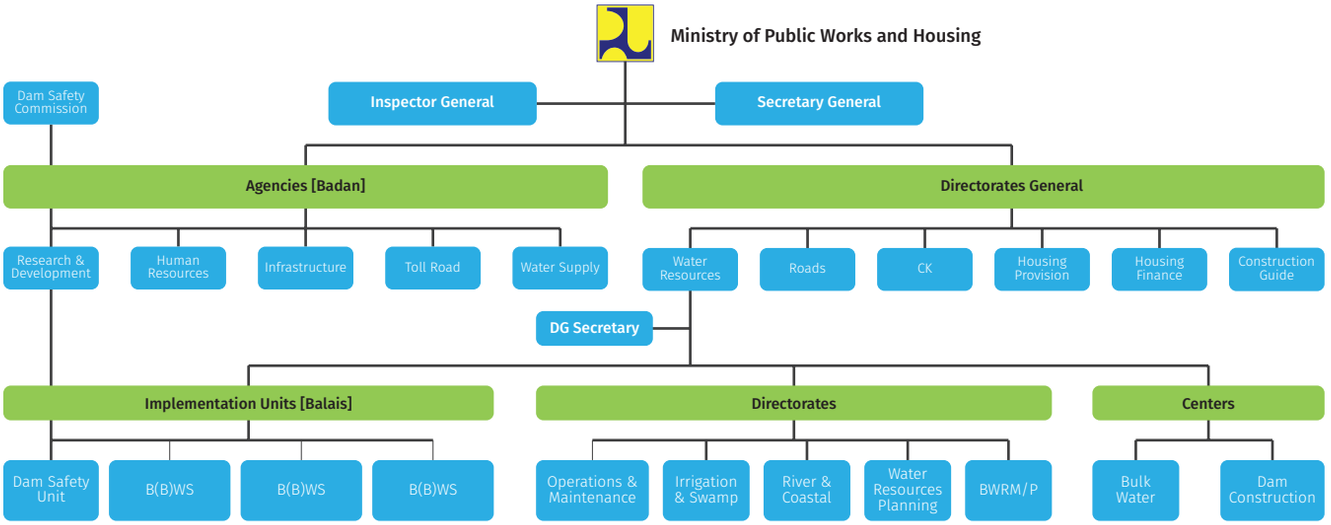
Given the unique characteristics of the country's topography and climate, a system of "river basin management" has been established in Indonesia that combines a number of independent river basins into larger administrative "river territories" or Wilayah Sungai(s). Introduction of the Water Law in 2004 introduced a national system of river basin management carried out by public river basin organizations referred to as either Balai Besar Wilayah Sungai(s) (BBWSs) or Balai Wilayah Sungai(s) (BWSs). These Balai fill both regulatory and management functions, as well as undertaking construction, operation, and maintenance of river infrastructure and irrigation systems larger than 3,000 hectares. Provincial water agencies also provide water resource and river basin management in provincial

[1] Badan Penyelenggara Jaminan Sosial-Kesehatan (Social Security Agency for Health Insurance) The two special regions are Nanggroe Aceh Darussalam at the northern tip of Sumatra and Yogyakarta in Central Java, along with the special capital city district of Jakarta (DKI) and the 30 Provinces: (1) Bali; (2) Banten; (3) Bangka-Belitung; (4) Bengkulu; (5) Gorontalo; (6) Jambi; (7) Jawa Barat; (8) Jawa Tengah; (9) Jawa Timur; (10) Kalimantan Barat; (11) Kalimantan Selatan; (12) Kalimantan Tengah; (13) Kalimantan Timur; (14) Kalimantan Utara; (15) Lampung; (16) Maluku; (17) Maluku Utara; (18) Nusa Tenggara Barat; (19) Nusa Tenggara Timur; (20) Papua; (21) Papua Barat; (22) Riau; (23) Riau Kepulauan; (24) Sulawesi Selatan; (25) Sulawesi Tengah; (26) Sulawesi Tenggara; (27) Sulawesi Utara; (28) Sumatra Barat; (29) Sumatra Selatan ; (30) Sumatra Utara.

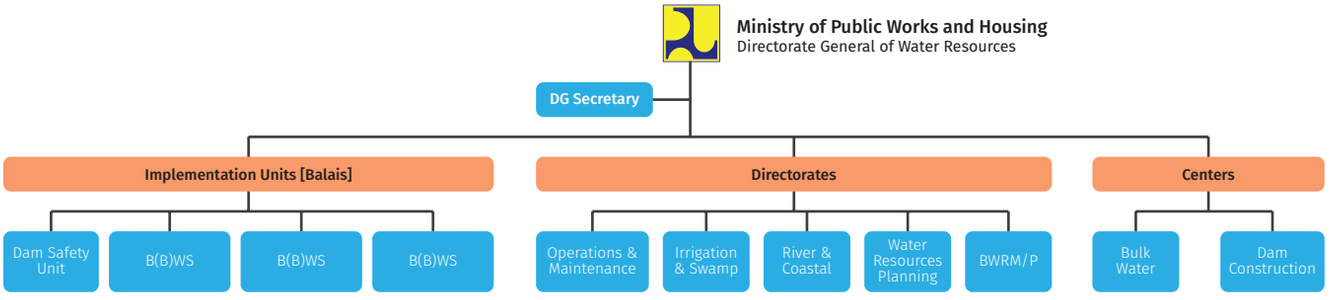
basins and basins of national river territories, in coordination with the national river basin agencies.

There are 131 such territories are under central, provincial, or district control. The central government, under the overall direction and management of the DGWR, controls the more significant river basins, which total 63 river territories. These are managed by 33 river basin organizations, including the BBWSs and lower level BWSs, as well as the two state-owned river agencies (*Perusahaan Umum Jasa Tirta*, PJT I/II). Fifty-three WSs are under provincial control and 15 are under district control, although basin management at the district level is largely inactive. The provinces have their own water resources management agencies (*dinas*), that manage river basins under their control.

Ministry of Public Works and Housing Management Structure Figure 4



MPWH Directorate General of Water Resources Management Structure Figure 5



The dinas may be involved in some management activities in national river territories in coordination with related B(B)WSs.

The roles and responsibilities of the B(B)WSs include water resources management, planning, construction, operation and maintenance in the context of the conservation of water resources, water resources development, utilization of water resources and control of water resources in the river basin. This includes the following functions:

1. Preparation of water resource management plans for the basin;
2. Planning and implementation of protected area management of water resources in the basin;
3. Water resources management, including the conservation, development, utilization, and control of water resources in the basin;
4. Preparation of technical recommendations in the granting of licenses for the provision, allocation, use, and exploitation of water resources in the basin;
5. O&M of water resources infrastructure in the basin;
6. Management of hydrological systems;
7. Organization of data and information on water resources;
8. Facilitation of coordination team of water resources management in the basin;
9. Empowerment of communities in the management of water resources;
10. Implementation of the Central River Region administration.

Dam Management Units

In the case that the central government is the dam owner, the Minister appoints the technical implementation unit responsible for water resource management or one of the two state-owned river agencies to be the dam manager. The dam manager is assisted in carrying out the management of the dam, as well as the reservoir, by a Dam Management Unit.

Under these provisions, the B(B)WSs are the designated technical implementation units along with two state-owned river agencies (Perusahaan Umum Jasa Tirta , PJT I/II). B(B)WS and BWS dams rely on Government funding for maintenance and operation, while PJTs manage their assets for commercial return. The head of the Dam Management Unit is required to meet the following requirements:

1. Hold a certificate of expertise in the field of dam management issued by competent authorities in accordance to relevant provisions of law.
2. Have the competence in the management of the dam as well as the reservoir.

The requirements and procedures for the establishment of the Dam Management Unit are carried out in accordance with guidelines established by the Minister. To date, 39 guidelines and manuals have been adopted.

Operation and maintenance of the dam, as well as the reservoir, consists of:

1. dam operation and maintenance, intended to optimize the utilization of water and water resources and maintain the dam safety;
2. dam maintenance; and
3. monitoring of the dam condition.

MPWH require operation of the dam to be performed by controlling the water discharge to meet the needs of downstream users, including the environment, along with flood operation, to control the water level in the reservoir and flood control to mitigate downstream flooding, along with measures to quickly discharge the reservoir water during a state of emergency or extraordinary situation. In the event of emergency or exceptional circumstances, the operation of the dam as well as the reservoir is prioritized for the purpose of dam and environmental safety.

The DMU must submit periodic reports with information on the condition of the dam as well as the reservoir to the relevant agencies. The information on the dam as well as the reservoir conditions includes:

1. Structural and operational behaviour;
2. The readings of instruments and their interpretation, the results of the inspection, and safety evaluations;
3. Modification or rehabilitation;
4. Events related to dam safety;
5. The condition reservoir including water allocation.

The DMU must provide an information system for each dam, as well as the reservoir, that can be accessed by the public. This should include regular updating on the collection, processing, and provision of data and information on the dam as well as the reservoir.

Dam Construction Centre

The DGWR and the B(B)WSs are supported by the Dam Construction Center (*Pusat Bendungan*) whose role and responsibilities are outlined in the *Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat nomor* 15/PRT/M/2015 tanggal 21 April 2015. These include the following:

1. Preparation and implementation of guidance norms, standards, procedures, and criteria for dams, lakes, water, and ponds, as well as the physical conservation of water resources;
2. Readiness assessment and execution of activities in dams, lakes, water, and ponds, as well as the physical conservation of water resources;
3. Planning arrangements for dams, lakes, water, and ponds, as well as the physical conservation of water resources;
4. Human resource development relating to the management of dams, lakes, water, and ponds, as well as the physical conservation of water resources;
5. Implementation of administrative affairs of the centre.

Dam Safety Commission

A Dam Safety Commission has been in place since 2007 and was re-established under Ministerial Decree No. 03/KPTS/M/2016 to assist the MPWH in:

1. providing recommendations regarding dam safety to the Minister during each phase of dam development, such as design, construction, operation, rehabilitation, and dam closure;
2. evaluating the activities of the Dam Management Unit in order to make recommendations to the Minister; and
3. preparing an accountability report to the Minister.

Under the former Government Regulations the Dam Safety Commission was the regulator for dam safety assurance, including different ministries/agencies who own the dam. However, the prevailing regulations are only binding on those dams under the MPWH. This notwithstanding, other agencies continue to adhere to the provisions of the current Ministerial regulations.

The Dam Safety Commission is responsible for:

1. conducting assessments of dam safety;
2. providing recommendations regarding dam safety; and
3. conducting dam inspections.

In carrying out these functions, the Dam Safety Commission has a legal mandate to exercise the following functions:

1. Give recommendations to the Minister before granting any design approval, initial charge permits, operation permits, approval of design for dam modification or rehabilitation, and permit on dam disposal;
2. Provide recommendations to the Minister in charge of governmental affairs in the environmental area before granting initial placement of mining waste and the operation permit for the dam intended for mining waste storage;
3. Provide technical advice and guidance;
4. Evaluation of the results of activities undertaken by the technical implementing unit field of dam safety;
5. Organize inspection of the dam.

The DSC membership comprises representatives of government and state-owned companies such as the owner of the dam, professional association, and another government agency related to dams as appointed by the minister (Figure 6). The Chairman of the DSC is the Director General of Water Resources.

Dam Safety Unit

The Dam Safety Commission is supported by the Dam Safety Unit (DSU) under the DGWR in the MWPH who are responsible for providing technical and administrative support to the Commission. The roles and responsibilities of the DSU are outlined in *Peraturan Menteri* PU No. 25 / PRT / M / 2006. The specific responsibilities include the following:

1. Data collection and processing for every dam;
2. Assessment of dam construction and management;
3. Dam inspection;
4. Providing technical advice on dam construction;
5. Dissemination and guidance on dam safety;
6. Drafting regulations, guidelines, technical instructions on dam safety;
7. Monitoring the implementation of dam construction safety aspects;
8. Inventories and registration of dam as well as its hazard classification;
9. Dam archive management.

Panel of Experts

The regulations also provide for the appointment of a Panel of Experts comprising technical experts upon the recommendation of the Dam Safety Commission and Dam Safety Unit. This is intended to support the dam owner and is recommended under the legislation in cases involving either:

1. new technology in dam design and construction,
2. dams greater than 75m in height and storing least 100 million cubic meters, or
3. a high hazard dam.

Indonesian National Committee on Large Dams

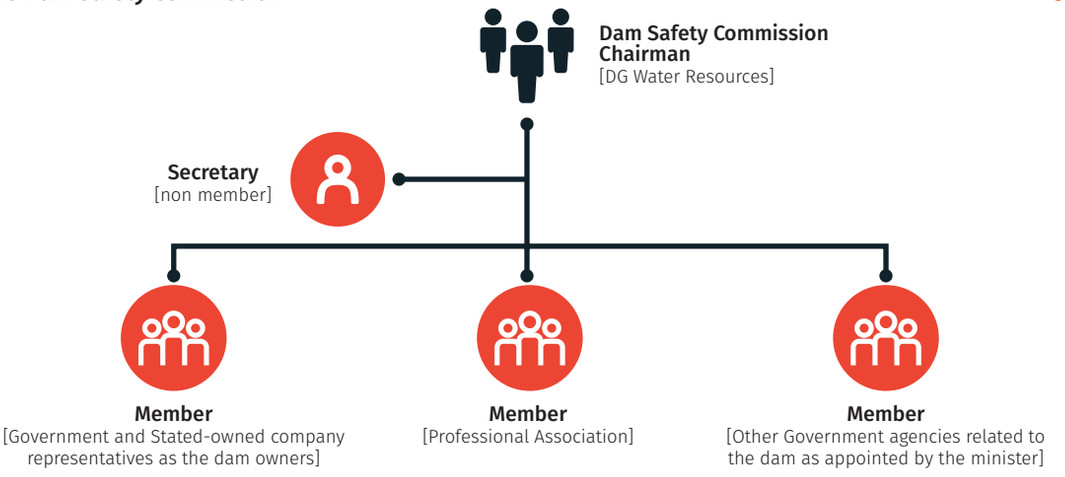
The Indonesian National Committee on Large Dams (INACOLD: *Komite Nasional Indonesia untuk Bendungan Besar* - KNI-BB) is a professional organization that serves on the Dam Safety Commission and has an active role in the development, operation and maintenance of large dams in Indonesia through the activities of the organization and its members. INACOLD has been an active member of the International Commission on Large Dams (ICOLD) since 1967, and maintains relationships with other regional and international institutions.

In line with its goal, the INACOLD/KNI-BB aims to develop and maintain large dams to create a more effective and efficient means of the development and management of water resources for the wealth of the community. This is achieved through:

1. Development and management in the planning, implementation, and operation and maintenance of large dams;
2. improving the quality of expertise and responsibility of Indonesia's Technical Experts on dams in the field of large dams; and
3. actively participating in the improvement of wealth for the Indonesian people through the development and management of large dams through water resources management.

The Structure of the Dam Safety Commission

Figure 6



3.0 The Legal Framework for Dam Safety Assurance

The legal basis for dam development, operation and maintenance, and safety is based on a civil law system, intermixed with customary law and the Roman Dutch law, and comes in different forms. The official legal hierarchy is enumerated under Law No. 10 Year 2004 on the Formulation of Laws and Regulations and includes the following:

1. The 1945 Constitution (*Undang-Undang Dasar* 1945 or UUD'45)
2. Law (*Undang-Undang* or UU) and Government Regulation in Lieu of Law (*Peraturan Pemerintah Pengganti Undang-Undang* or Perpu)
3. Government Regulation (*Peraturan Pemerintah* or PP)
4. Presidential Regulation (*Peraturan Presiden* or Perpres)
5. Regional Regulation (*Peraturan Daerah* or Perda)

Dam regulation has evolved through three distinct periods and is currently governed through Regulation of the Minister, Public Works and Housing, No. 27/PRT/M/2015 specifically on dams. The Ministerial Regulation was enacted in response to the repeal by judicial review in 2014 of the Water Resources Law No.7 of 2004.

Prior to 2004, dam safety was regulated under the Water Resources Law No. 11/1974 and Ministerial Regulation No. 72/1998 on Dam Safety. The regulation replaced the country's first, non-mandatory Dam Safety Guidelines (SNI No.1731-1989-F) issued in 1989 by the National Standardization Agency of Indonesia ("BSN"). During this period, Indonesia moved toward a more integrated approach to water resources management. This was codified through the Water Resources Law No.7 of 2004.

Between 2004 and 2015, the primary enabling legislation was provided through the Water Resources Law No.7 of 2004, with specific provisions required through the Spatial Planning Law No. 26 of 2009 and the Environment Law No. 32 of 2009. Specific provisions were stipulated through Ministerial Regulation No. 72/1998 on Dam Safety, a Ministerial Decree on the Dam Safety Commission and Government Regulation No. 37/2010 on Dams, approval of which was expedited following the failure of the Situ Gintung dam that occurred on March 27, 2009.

After 2015, following repeal of the Water Resources Law No.7 of 2004, Indonesia reverted back to operating under Water Law No. 11 of 1974 and Ministerial Regulation No 72/PRT/1997

on Dam Safety. This regulation was subsequently repealed and replaced by Ministerial Regulation No. 27/2015 on Dams and Ministerial Decree No. 03/KPTS/M/2016 on Dam Safety Commission.

The overarching provisions cover all dam types and all types of ownership. The criteria used to define a dam for the purpose of registration under Ministerial Regulation Number 27/ PRT/M/2015 is based on the ICOLD definition and includes the following:

1. Dam with height of 15 metres or more measured from the lowest point in the foundation;
2. Dam with height of 10 metres up to 15 metres measured from the lowest point in the foundation with the following provisions:
   - the dam crest length shall be at least 500 metres;
   - the capacity of the reservoir at least 500,000 cubic metres; or
   - the maximum flood discharge must be at least 1,000 cubic metres per second.
3. Any dam with particular level of difficulty to the foundation or dam designed using new technology and/or dam that have a high hazard class.

The High Hazard Class is determined based on the criteria provided in the "Guidelines for Determining Dam Hazard Classification (1998)", as well as the "Technical Guidance for Dam Hazard Classification (2011)". The dam safety hazard level is classified into 4 categories based on the ICOLD Bulletin 167:

1. Low Danger Level;
2. Medium Danger Level;
3. High Danger Level; and
4. Very High Danger Level.

The division of hazard levels is based on the number of potential fatalities exposed to the risk of the dam collapsing (Table 4). This is based on the assumption that each household consists of one family and that each family includes five people that live in one house. The risk is defined by the dam height, volume, downstream population, and management status using the Modified ICOLD (also used in the World Bank financed Dam Operational Improvement and Safety Project (DOISP)), the Anderson Method (as a check) and the FEMA Guidelines. Special criteria have also been included in the 2015 Ministerial Regulation (Chapter V) for "high dams" over 75 meters requiring the appointment of an International Panel of Experts.

Under Ministerial Regulation No.27 of 2015 Article 77(1) the dam owner is primarily responsible for dam management and safety. However, the previous provisions relating to liability and responsibility for dam failure included in Chapter IV.4 of Regulation 37 of 2010 has now been removed from the new Ministerial Regulation 27 of 2015. It is possible that the regulator could also be held responsible for dam safety since the Dam Safety Commission takes quite a hands-on assessment role (rather than just a compliance-audit role) and provides technical support to the MPWH in performing its duties as an "independent dam safety supervisor".

The main tenants of the dam safety approach described earlier are defined under Article 2(4):

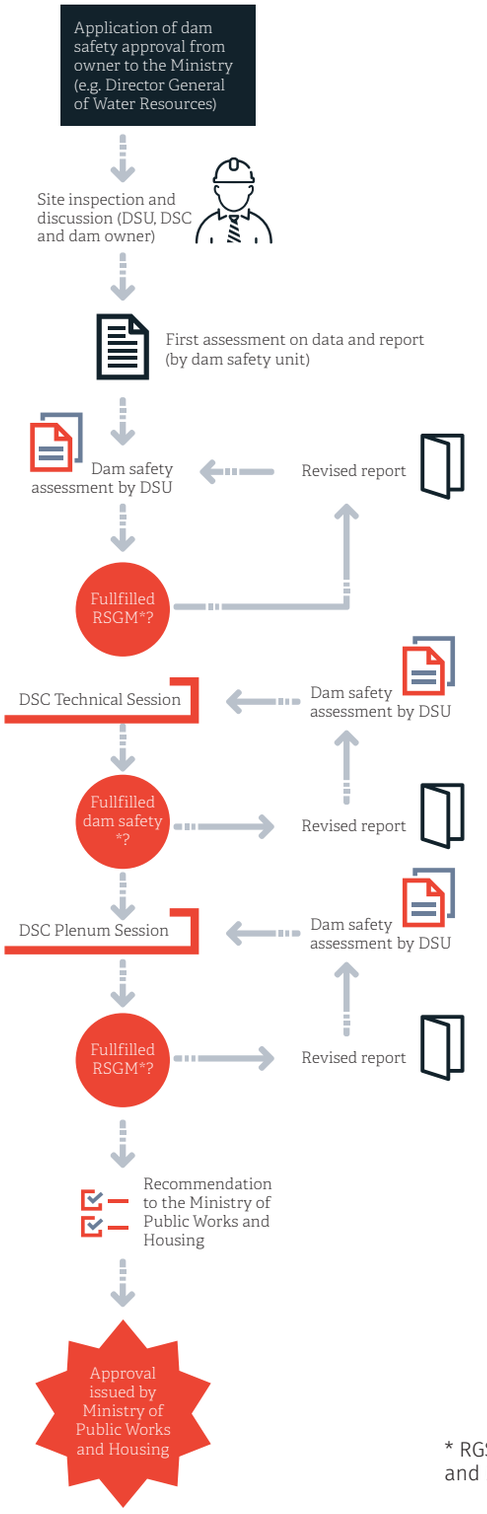
1. structural safety to avoid any structural failure, hydraulic failure, as well as against seepage failure;
2. operation, maintenance and monitoring; and
3. readiness for emergency preparedness.

Dam safety licencing is required in every phase of dam development. The licencing process involves a number of regulatory agencies and the dam owners (Figure 7).

Dam Hazard Level Table 3

Number of Households (Cumulative)	Distance from the Dam (in Km)				
	0 – 5	0 - 10	0 - 20	0 - 30	>30
0	1	1	1	1	1
1 – 20	3	3	2	2	2
21 – 200	4	4	4	3	3
> 200	4	4	4	4	4

Dam Safety Licensing Process Figure 7



* RGSM = Regulations, Guidelines, Standards and Manuals related to dam safety.

Dam inspections and safety reviews are required for the development of the dam, during construction and operation and maintenance. The inspection of the dam includes

1. data collection for:
   - consideration of the study, preparation of technical advice and dam inventory;
   - monitoring the implementation of the dam construction safety aspects; and
   - clarification of the report on the implementation of development and report management of the dam.
2. Inspections include reporting on:
   - site location,
   - monitoring the implementation of the construction,
   - implementation of reservoir impoundment,
   - major inspection,
   - extraordinary inspection,
   - special inspection, and
   - inspection upon request of the dam builder, manager or owner.

Failure to follow-up on any of the recommended actions results in suspension of the operational permit.

The dam owner, dam manager and Dam Management Unit, as well as the technical implementation units, are required to keep and maintain documents relating to the original construction as well as management of the dam and reservoir. This should include the following documents which are supposed to be submitted to the local agency in charge of the local government archive by the dam owner:

1. planning;
2. environmental management;
3. land acquisition;
4. construction including the dam's as-built drawing;
5. operating and maintenance instructions, monitoring the behaviour of the dam, history of the dam operation, as well as the emergency action plan; and
6. report on the implementation of environmental management and monitoring.

Periodic reports are required to be submitted to the relevant agencies by the DMU, including structural and operational information on the behaviour of the dam and the reservoir conditions; readings from instruments and their interpretation, the results of the inspection, and safety evaluations; modification or rehabilitation; events related to dam safety and extraordinary incidents; and the condition of reservoir, including water allocation. The DMU must also provide an information system on the dam as well as the reservoir that can be accessed by the public. This should specify: the collection, processing, and provision of data and information on the dam as well as the reservoir; and be regularly updated.

The legislative provisions for emergency preparedness relating to dam safety are intended to ensure that the dam manager is prepared for the worst conditions in the event of a catastrophic failure. The draft emergency action plan should contain specific actions relating to dam safety as well as community rescue actions and environmental safety and should be based on potential failure modes analysis of the dam. To meet the emergency preparedness level, the DMU must have:

1. emergency action plans;
2. equipment and material to act accordingly in an emergency;
3. updated emergency action plans in accordance with current conditions;
4. preparation for stand-by emergency personnel;
5. socialization to potentially affected community on the potential dam failure; and
6. socialization to provincial and local government of districts/cities whose territory may be affected by the potential dam failure.

Emergency Action Plans have been developed for about 80 dams, of which 56 have been financed under DOISP. These are based on the Hazard Classification Guidelines prepared under the original Dam Safety Project and approved by the Indonesian Dam Safety Committee in 1999, along with the Emergency Action Plan (EAP) Guidelines prepared under DOISP. In the draft of the emergency action plan, the dam builder can obtain technical input from the water resource management in the river basin and input from affected communities against any potential dam failure.

In the case that one river basin has more than one dam, the emergency action plan for each dam should be made into one unified emergency action plan. When a dam is built in a river basin that already has a dam, preparation of the emergency action plan for that dam being built must also involve the dam management unit that already exists in addition to involving local technical agencies and local communities. The emergency action plan for the existing dam should be adjusted to be integrated into one unified emergency action plan together with emergency action plan for other dams in the basin. If in one river basin more than one dam is built at the same time, the emergency action plans shall be prepared in a coordinated manner so that all the emergency action plans shall be made into one unified emergency action plan.

The dam safety precautions are provided by:

1. notifying the relevant parties to the dam;
2. operating hydro-electro mechanical equipment of the dam; and
3. taking necessary steps to prevent the collapse of the dam, with community rescue actions conducted in accordance to prevailing regulations.

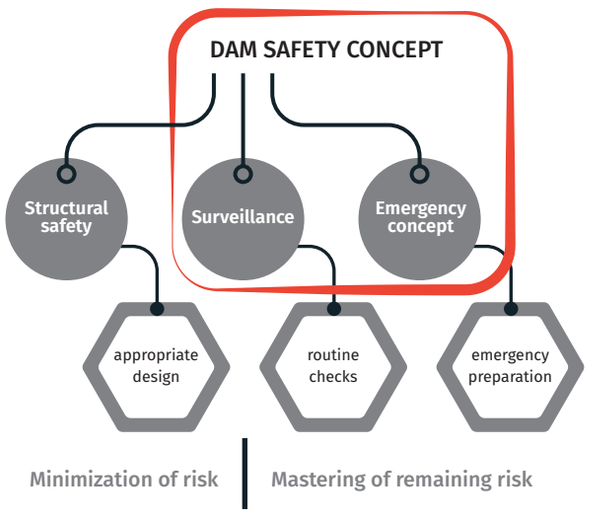
4.0
Developing Maturity Matrices for Dam Safety in Indonesia

Principles and Process

The development of Maturity Matrices for institutional benchmarking of dam safety in Indonesia is primarily concerned with the surveillance and emergency preparedness principles of dam safety management (as shown in Figure 8). A dam safety program is made up of a number of components, ranging from dam safety practice in the field to support functions and governance required to provide assurance of dam safety. Maturity Matrices are intended to reflect the most important components of a dam safety program and it is important to keep in mind that Maturity Matrices evaluate dam safety programs and not individual dam types or systems (e.g. earth fill versus concrete or local operation versus remote operation).

The Maturity Matrix is a simple two axis chart with 'Maturity Level' on the horizontal axis and 'Components' describing the main activities under the dam safety program on the vertical axis (as shown on Figure 9). The Maturity Matrices are high level and selective in the detail used to assess dam safety program maturity. They are outcomes based and should not be considered an expert system. Components align with the terminology of the International Commission on Large Dams (ICOLD) and are common groupings of dam safety activities around the world. The Master Matrix contains summary descriptions of each maturity level for every component of the dam safety program.

Coverage of the Maturity Matrices within the Indonesian Dam Safety Concept Figure 8



Development of Maturity Matrices appropriate for Indonesia followed an iterative and consultative process. This included an initial review and conceptualization of the Maturity Matrices based on a detailed review of the legal hierarchy, specific dam safety regulations and technical guidelines , the institutional responsibilities, followed by expert review and verification.

The Maturity Matrices were refined and validated through working sessions with officials from the MPWH, dam managers from the Balais, and consultations with key stakeholders. The Maturity Matrices and the method of evaluation were presented, self-assessments by dam safety representatives of Balais were carried out and the Maturity Matrices subsequently adjusted to address feedback.

In Indonesia, Balais have responsibilities beyond dam safety that extend into catchment management, water resource management, along with bulk water distribution operation and maintenance. Where appropriate the Maturity Matrices were adjusted to included these management activities. This was particularly important to align the Maturity Matrices with the criteria used by the MPWH in the annual performance assessment of the Balai for dam safety.

The Maturity Matrices were subject to a final round of facilitated self-evaluation by representatives from the Balai's. The criteria were codified into the maturity scoring and programmed into a Scoring Workbook. This was applied as part of the annual dam safety assessment carried out by the MPWH.

Master Matrix Structure (Note: these descriptions are not used for assessing maturity level) Figure 9

Master Matrix	Maturity Level				
Dam Safety Program Component	Level 1	Level 2	Level 3	Level 4	Level 5
1 Governance					
2 Information Management					
3 Dam Safety Training and Education					
4 Surveillance		[summary description]			
5 Spillway and Outlet equipment					
6 Reservoir Operations					
7 Dam and Spillway Maintenance					
8 Audits and Reviews					
9 Managing Dam Safety Issues					
10 Emergency Preparedness					

Note: these descriptions are not used for assessing maturity level

Workshopping the Development of Maturity Matrices with representatives from the Dam Management Units (May 2017)

Maturity Levels and Differentiators

Five maturity levels were defined and adopted with even steps between successive levels. The descriptions and typical characteristics for each of the proposed maturity levels were defined and refined through the consultative process with representatives from the MPWH and participating Balais (Table 4).

The general characteristics that indicate the progression of maturity across the matrices are referred to as differentiators. These are characteristics of the dam safety program that differentiate between the different maturity levels (Figure 10). The adopted differentiators are used to formulate the line item descriptions of each maturity level in the component matrices.

Recognising the wide range of assets owned by Balais, the appropriate level of maturity for a DMU portfolio of dams is dependent on:

1. The national importance of dams in the portfolio, e.g. a dam providing water or power to a significant population that is vital to the national economy;
2. Portfolio of dams without one of national importance and including one or more dams as regulated by the Minister of Public Works and Housing Regulation No. 27/PRT/M/2015; and
3. Portfolio of dams smaller than those regulated by the Regulation from the Minister of Public Works and Housing.

Guided by the legal and regulatory framework for dam safety in Indonesia, the appropriate level of maturity for different Balai can be differentiated (as shown in Table 5). The targeted Maturity Level for each DMU should be defined as appropriate to the characteristics of the portfolio of dams under the Balai.

Applying the same level of maturity to each Balais is counterproductive considering that some Balai do not have the same risk profile or resources of other Balais. The maturity level should be tailoured to the specific context and conditions. This should give due consideration to the number and type of dams, including consideration of height, reservoir size, type, etc., the size of the population and value of assets downstream, the resources available to the Balai and others as relevant.

For large portfolios with a wide range of dam sizes, grouping such a large portfolio of dams into sub-groups as described in Table 5 was assessed as prudent. Each group of the portfolio was assessed using the Matrix assessment and the target Maturity for each sub-group in accordance with Table 5.

Maturity Level Descriptions and Typical Characteristics Table 4

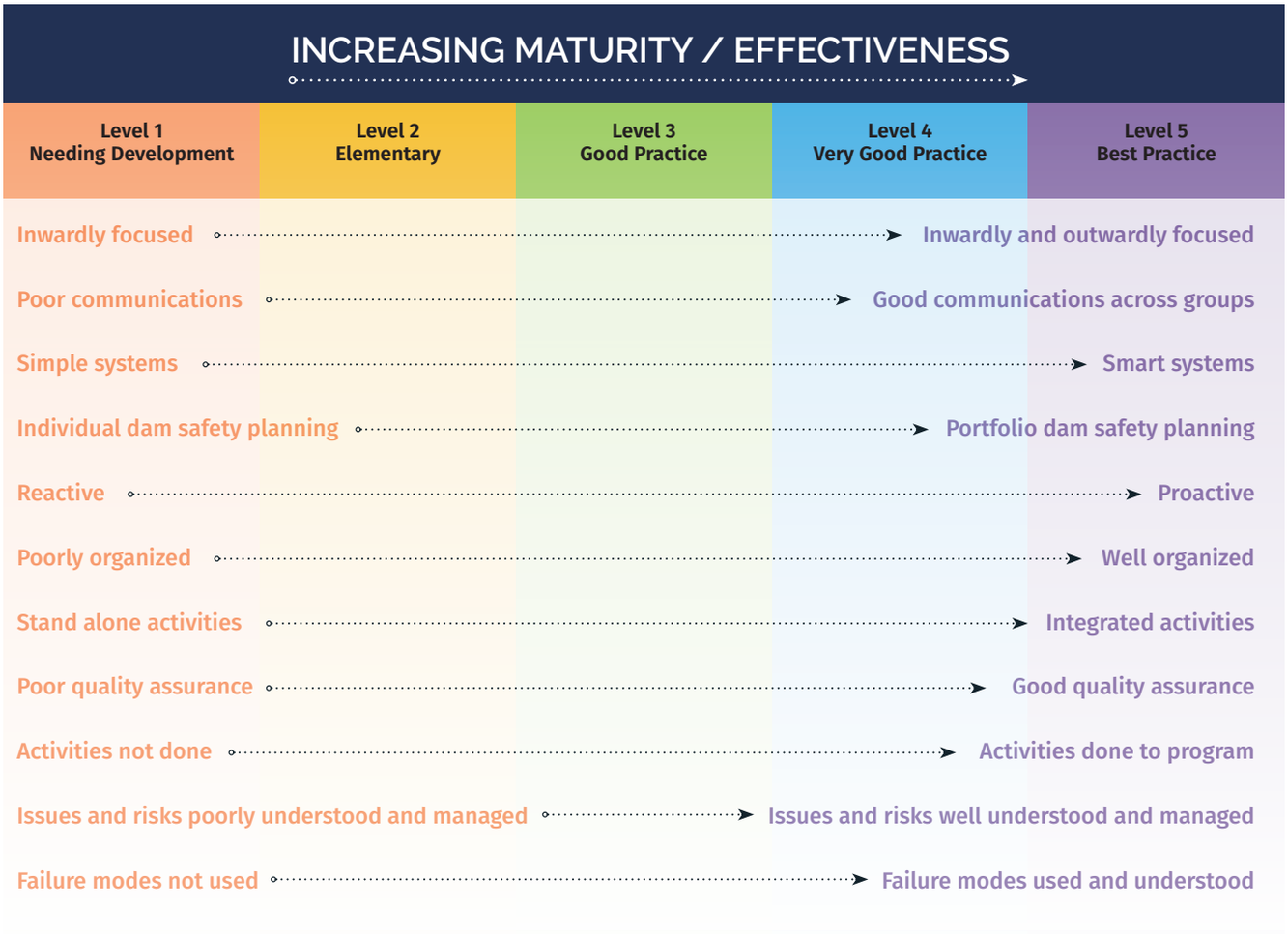
	Maturity Level				
	Level 1 Needing Development	**Level 2 Elementary**	**Level 3 Good Practice**	**Level 4 Very Good Practice**	**Level 5 Best Practice**
Maturity Level Description	Lacks conformance to applicable guidelines, standards and best practice	Conforms to applicable guidelines, standards and best practice in some areas	Generally conforms to applicable guidelines, standards and best practice	High degree of conformance with applicable guidelines, standards and best practice with good understanding	High degree of understanding and conformance with applicable guidelines, standards and best practice. No significant opportunities for improvement

Illustrative Target Levels of Maturity Table 5

	DMU Portfolio	Example Target Maturity Level
1	One or more dam of National Importance	4 or 5 Very Good or Best Practice
2	One or more dam as regulated by the Minister of Public Works and Housing Regulation No. 27/PRT/M/2015	3 Good Practice
3	Only dams smaller than those regulated by the Minister of Public Works and Housing Regulation No. 27/PRT/M/2015	2 Elementary

Maturity Levels and Differentiators (The general characteristics indicating progression of maturity across the matrices are referred to as differentiators)

Figure 10



Component Matrices

Component matrices list the activities that are needed for carrying out each component of the dam safety program. The activities are listed on the vertical axis. The horizontal axis represents the maturity level. Each column represents an increasing level of maturity in the component (which is sub-divided into activities). A matrix shows advancing maturity from a rudimentary or elementary level of practice through stages to advanced or best practice.

The dam safety program 'Components' and their 'Activities' were defined through the consultative process and are listed in Table 6.

Each 'Component' in turn has its own matrix. Those 'component' matrices again have the maturity levels on the horizontal axis with the activities for that component listed on the vertical axis.

For example, Figure 11 shows the Governance Matrix with its activities of Regulation, Delegated Roles and Responsibilities, Internal and External Communication and Resourcing.

The maturity level evaluations are carried out using the component matrices.

Dam Operation and Safety Program Components and Activities Table 6

Component	Activity
1 Governance	Regulation
	Delegated Roles & Responsibilities
	Internal & External Communication
	Resourcing
2 Information Management	Standards, Policies, Plans and Procedures
	Physical Infrastructure
	Operational
	Studies, Reviews and Reports
3 Dam Safety Training and Education	Dam Safety
	Flow Control Equipment
	Reservoir Operation
	Incident and Emergency Preparedness
4 Surveillance	Surveillance Program
	Inspections
	Instrumentation and Data Management
	Dam Safety Assessment
5 Spillway and Outlet Equipment	Spillway and Outlet Equipment Program
	Inspections and Maintenance
	Testing
	System Performance Assessment
6 Reservoir Operations	Operation Protocols
	Relationships with External Stakeholders
	Debris Management
7 Dam and Spillway Maintenance	Dam, Reservoir and Access maintenance
	Spillway and Outlet Structure maintenance
8 Audits and Reviews	Dam Safety Program Audits
	Dam Safety Program Reviews
	Dam Safety Reviews
	Flow Control Equipment Reviews
9 Managing Dam Safety Issues	Issue Management System
	Managing Non-conformances
	Managing Physical Infrastructure Issues
	Managing Dam Safety Deficiencies
10 Emergency Preparedness	Hazard and Consequence Identification
	Owner Emergency Preparedness Plans (EPPs)
	Relationships with Community and External Agencies
	Tests and Exercises

At the intersection of an Activity (or Component) and a maturity level is a collection of line items. There are generally 2 to 4 line items per activity (labelled (a) to (c) in Figure 12). The line items describe the characteristics that match a particular maturity level for that activity (Refer to Figure 12 which shows the governance component matrix).

These line items contain descriptions that are consistent and develop across the maturity levels. This allows the user to identify the current status and to identify the requirements for achieving a higher maturity rating.

Consider the following Example:

A line item in the Component 1: Governance Maturity Matrix "Regulation" activity progresses from Maturity Level 1 to Maturity Level 5 as follows:

- Level 1 is "(b) Relevant policy and regulations **not met**"
- Level 2 is "(b) Relevant policies and regulations **generally met**"
- Level 3 is "(b) Relevant policies and regulations **met**"
- Level 4 is "(b) Relevant policies and regulations **met and sometimes exceeded**"
- Level 5 is "(b) Relevant policy and regulations **met and generally exceeded**"

An example of the component level Governance Matrix and its Activities used to carry out the maturity level evaluations. Figure 11

Governance Component matrix Activity	Maturity Level				
	Level 1 Needing Development	Level 2 Elementary	Level 3 Good Practice	Level 4 Very Good Practice	Level 5 Best Practice
Alignment with Regulation					
Delegated Roles & Responsibilities					
Internal & External Communication					
Resourcing					

Component matrix line items (e.g. Governance) Figure 12

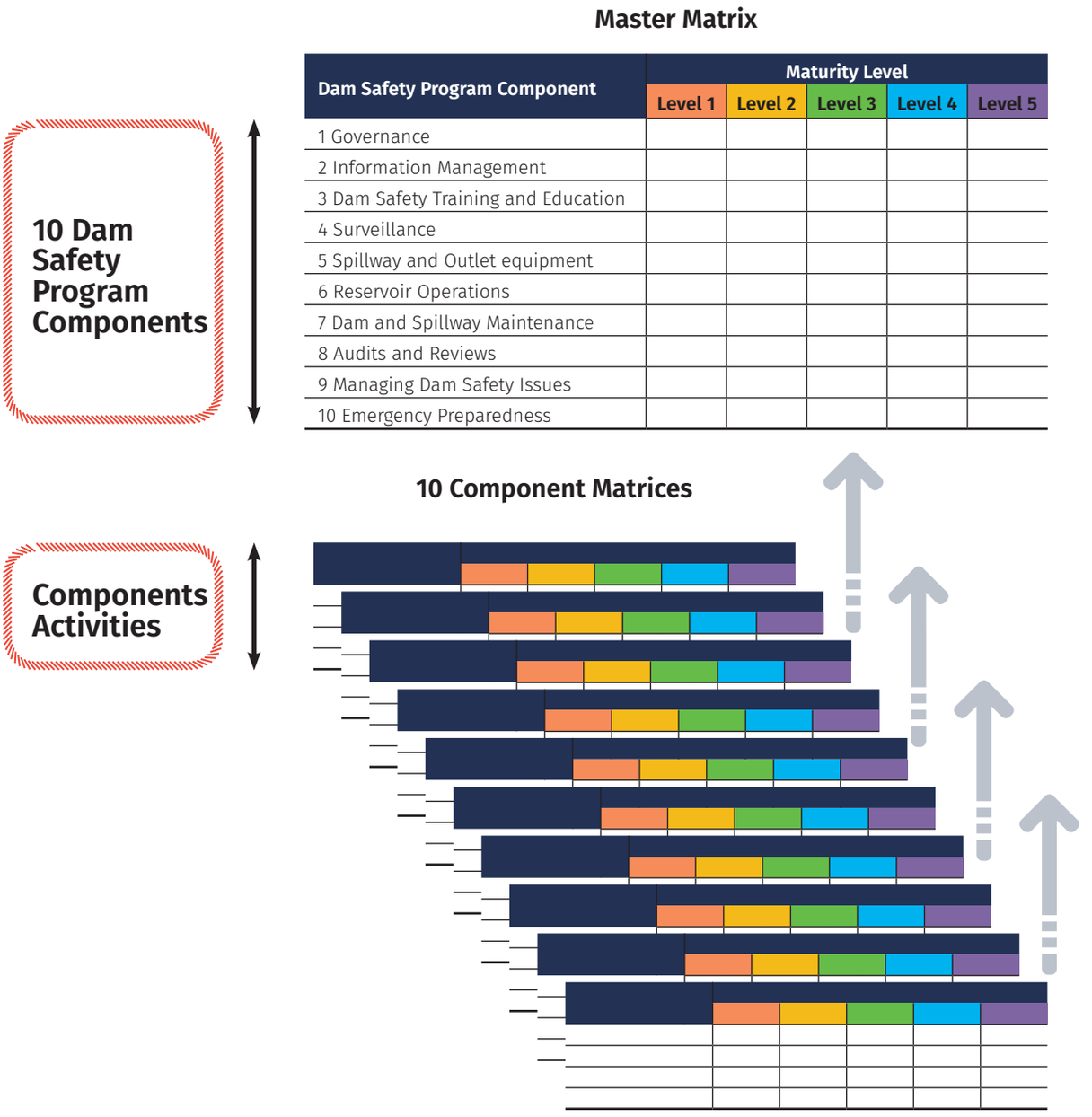
Governance Component matrix Activity	Maturity Level				
	Level 1 Needing Development	Level 2 Elementary	Level 3 Good Practice	Level 4 Very Good Practice	Level 5 Best Practice
Alignment with Regulation	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Delegated Roles & Responsibilities	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Internal & External Communication	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Resourcing	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
	(c) [line item]	(c) [line item]	(c) [line item]	(c) [line item]	(c) [line item]

Relationship Between Master Matrix and Component Matrices

The relationship between the Master Matrix and the Component Matrices is shown in Figure 13. The ten component matrices, when scored, roll up into the Master Matrix which displays a summary of the maturity level achieved by the Dam Management Unit being evaluated.

Relationship Between Master Matrix and Component-Matrices

Figure 13



5.0
Application of the Maturity Matrices in Indonesia

Methods of Evaluation

The evaluation of dam safety program maturity is best conducted as an audit or a series of review workshops where the maturity levels and descriptors are tested and checked against documentation and established practice.

A facilitator is necessary to direct the process and the workshops. This person could be internal to the organization and part of the dam safety program, internal but external to the dam safety program, or a dam safety engineer or expert external to the organization that is familiar with the purpose and function of the Maturity Matrices.

The internal dam safety facilitator would have a deep understanding of the dam safety program, but may be too close to the program to make objective assessments and may find some of the necessary questions confronting.

An internal facilitator who is external to the dam safety program may be objective but may not understand dam safety drivers and the industry practice on which the maturity levels are based.

The external independent facilitator understands the industry practice that underpins the maturity levels but may not understand the context specific dam safety drivers. This person would provide objectivity and industry benchmarking examples to assist with maturity evaluation.

The choice of whether to use a dam safety engineer or expert may depend on the complexity of the dam portfolio and dam safety program. The engineer or expert may also assist in developing program maturity advancement strategies. The external/independent facilitator's objectivity will add credibility to the maturity matrix evaluations and advancement programs.

Steps of the Procedure

The following steps direct the user through the process of evaluating their dam safety program activities, and finally, to document and demonstrate their current dam safety program maturity status. The final documentation exercise is programmed into the Scoring Workbook described below. However, it is important that the user understands the process explained below which is automated in the Scoring Workbook.

Step One. Start with the Governance component matrix and systematically identify the line items for each Governance activity that best represent the characteristics (or maturity level) of the user's dam safety program. The achieved maturity level for an activity is that highest level where all line items are selected.

The presentation of the component maturity results is achieved by colouring the selected sub-element maturity level line items. This provides a snapshot of the maturity level of a whole surveillance component.

Assigning the Matrix level for each activity sub-item is the crucial activity and the thoroughness with which this is done determines the standard attained for the benchmarking evaluation. An example for the Governance Component Matrix is demonstrated below (Figure 14).

The worked example for the Governance Component Matrix demonstrates the following:

1. All 'Governance Activities' have achieved an 'Elementary' maturity level (coloured yellow)
2. The 'Governance Program' can therefore be considered to have achieved an 'Elementary' maturity level (Maturity Level 2)
3. The 'Internal & External Communication' activity have achieved 'Good Practice' (Maturity Level 3) and 'Very Good Practice' (Maturity Level 4) maturity levels
4. The 'Regulation' activities have achieved 'Good Practice' (Maturity Level 3)
5. It is noteworthy that one line item in both the 'Regulation' and 'Resourcing' activities achieved a level of maturity higher than the maturity level assigned to the activity. This is because all line items contribute to the maturity level achieved by each activity
6. From this example it can be concluded that there is further development required in the 'Delegated Roles and Responsibilities' and 'Resourcing' activities to advance the whole Governance 'Component' to at least a 'Good Practice' (Maturity Level 3)
7. The achievement of the 'Very Good Practice' maturity level for 'Internal and external communication' is recognized but it does not change the fact that the Governance 'Component' as a whole has only achieved an 'Elementary' Maturity Level 2.

This step has been programmed into an Excel workbook (The Scoring Workbook). This is described in more detail below and in Annex 1.

Governance Component-Matrix Example Evaluation Presentation Figure 14

Governance Component matrix Activity	Maturity Level				
	Level 1 Needing Development	Level 2 Elementary	Level 3 Good Practice	Level 4 Very Good Practice	Level 5 Best Practice
Alignment with Regulation	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Delegated Roles & Responsibilities	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Internal & External Communication	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
Resourcing	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]	(a) [line item]
	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]	(b) [line item]
	(c) [line item]	(c) [line item]	(c) [line item]	(c) [line item]	(c) [line item]

Step Two. Repeat step one for each dam safety program 'Component Matrix'.

Step Three. Roll the component matrix evaluation from Steps One and Two into the Master Maturity Matrix. This step is illustrated for the 'Governance' example above (Figure 14) with a simplified direct scale down, or rolled up example shown below (Figure 15).

Step Four. Complete the 'Master Matrix'. Figure 16 provides an example displaying the first three 'Components' to indicate how it would appear and function.

From the worked example for the three components above (Figure 16) it can be concluded that:

1. The 'Governance' and 'Dam Safety Training and Education' components have achieved an 'Elementary' maturity level, while recognizing some of their activity line items (or sub-activities) are rated in more advanced maturity levels.
2. The 'Information Management' component has achieved a 'Good Practice' maturity level while recognizing that two of its sub-activities have rated at 'Very Good Practice' maturity level.
3. When rolling up the score from the ten Component Matrices to the Master Matrix, only activities with all sub-activities fulfilling the matrix level roll up to the Master Matrix. In the example shown in Figure 16 only Activity 2 Information Management rolls up at maturity level 3.

Governance Roll-Up into Master Matrix (1 element shown) Figure 15

Dam Safety Program Component	Maturity Level				
	Level 1 Needing Development	Level 2 Elementary	Level 3 Good Practice	Level 4 Very Good Practice	Level 5 Best Practice
Governance					

Master Maturity Matrix Example Presentation (3 Components shown) Figure 16

Dam Safety Program Component	Maturity Level				
	Level 1 Needing Development	Level 2 Elementary	Level 3 Good Practice	Level 4 Very Good Practice	Level 5 Best Practice
Governance					
Information Management					
Dam Safety Training and Education					

COMPLETE FOR ALL DAM SAFETY PROGRAM COMPONENTS

The Scoring Workbook

An evaluation of the whole dam safety program is achieved once all the elements of the dam safety program (refer Master Matrix) are assessed and the results depicted on the Master Maturity Matrix.

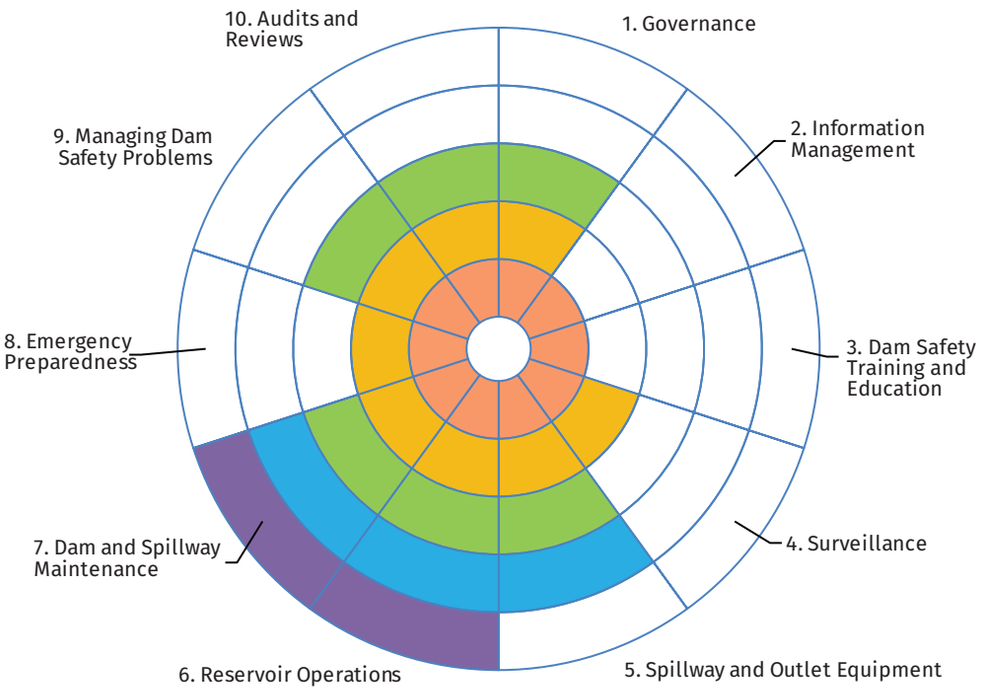
The completed Master Matrix provides a visual representation of the maturity level of the dam safety program managed by the DMU which is being assessed. Other forms of visual representation are presented in the Excel Scoring Workbook, User Manual and radial plots from the self assessments are presented in Appendix 2 herein.

The Scoring Workbook is based in Excel to ensure that it can be widely applied and requires little specialised training. The workbook automates the recording and presentation of the maturity scores for each of the ten component matrices above (Figure 13) and then transfer these to generate the Master Matrix record (equivalent to Figure 9).

The Excel Scoring Workbook can also generate circumplex plots of the Master and Component Matrices. Instructions and explanation of the Excel Scoring Workbook are included in Annex 1. These alternative plots are presented in Appendix 2 and can be used by DMUs as considered appropriate for presentation and communication of the maturity of their dam safety program.

Illustrative example of the circumplex plots generated by the Excel Scoring Workbook to visualize the results of the assessment of dam safety programs within individual Balai.

Figure 17



Workshop Preparation and Participation

The success of the self assessment depends on inclusion of all key personnel who are critical to achieving the goals of the dam safety program. The personnel may vary with each element (or sub-element), however, the appropriate operational, engineering, managing, and wider organization support roles that contribute to the dam safety program should participate in the evaluation.

Other key stakeholders (e.g. executive managers or external parties) may also be consulted in the planning and, if necessary, included in the evaluation. This will ensure their requirements are considered and that the outcomes will be in a form that will be understood and lead to effective program advancement approvals.

If external facilitators are used it is recommended that they be engaged in the early planning stages to utilize their expertise in the evaluation processes and workshop structure. Early participation will maximise the evaluation efficiency and the value of the outcomes.

6.0

Applying the Outcomes to Improve Dam Safety

Once the maturity evaluation is complete for the dam safety program, the DMU may choose to set higher maturity goals for specific elements and sub-elements and then identify the gap between these goals and the current maturity status. Maturity level goal setting may also be completed prior to an evaluation. The line item descriptors above the evaluated levels can be used as a guide to develop activities and plans to reach the desired levels.

Improving the maturity level for any particular activity requires identifying the constraint on maturity improvement and then addressing the constraint (summarised in Table 7). The DMU may then consider how program maturity advancements are best prioritized and staged to achieve the most appropriate path to improvement for their organizational goals. These can be used to inform the establishment of an improvement program in order to define specific targets, identify activities, determine resource requirements and agree on an implementation plan. This should be accompanied by a continuous evaluation program to enable course correction as needed.

Setting target Maturity Levels should be done with recognition of the specific context and conditions. Applying the same level of maturity to each Balai can be counterproductive considering that some Balais do not have the same profile or resources as other Balais. The maturity level should therefore be tailoured and give due consideration to the number and type of dams, including consideration of height, reservoir size, type, etc., the size of the population and value of assets downstream, the resources available to the Balai and other factors as relevant.

The MPWH uses benchmarking among the national dam safety institutions (the Balais) to create a positive tension and motivation within these institutions for executing their dam safety management responsibilities. This is instilled through a Dam Safety Competition run by the MPWH on an annual basis. The competitive nature of the Dam Safety Competition creates an environment for improvement at all levels within these organisations. This in turn fuels an appetite for knowledge, a need to know, which responds favourably to training in dam safety management.

The Dam Safety Competition is a voluntary assessment in which individual Balais with dam safety responsibilities choose to compete. The Balais that compete in the competition manage a variety of dam portfolios (Table 8) and the competition is divided into three categories of dam dependant on reservoir volume (Table 9). Balais can choose to compete in one or more competition categories.

The competition has two components. The first is a workshop where representatives from the competing Balai come together to present their respective department activities. These presentations are judged by a panel made up of six retired senior managers appointed by MPWH. Each presenter is questioned on their presentation by the panel and provided an opportunity to respond. The second is a series of site inspections by the panel to the offices and dam sites of each of the competing Balais. This provides an onsite review and verification of the presentations made by the representatives from the participating Balai and so the second component counts for 80 percent of the total score achieved by each Balai in the Dam Safety Competition.

Illustrative Maturity Identification and Improvement Table 7

Constraint	Improvement	Notes
Human resource	Hire	Due to lack of staff
Human resource competence	Training	Hire trainer perhaps from Balai with competence
Understanding failure modes	Training in Potential Failure Modes Analysis	Continuous training and awareness for all institutions involved in dam safety
Lack of facilities	Invest in facilities	Project financing available
Monitoring Systems	Integrated system within balai and central levels	Continued investments in data collection systems and monitoring platforms

It is important to note that the focus of the dam safety competition has been dam specific, although more than one dam may be represented in the competition. In comparison, the Maturity Matrices evaluate the performance of the organization in managing the safety of the portfolio of dams under its jurisdiction.

The Maturity Matrices for dam safety were introduced into the competition along with the use of the Excel Scoring Workbook. Representatives from the each of the competing Balai undertook a self-assessment of their respective dam portfolio management programs using the dam safety maturity matrix Excel Scoring Workbook as part of the Competition. Results of this self-assessment are included in Appendix 2 herein. The panel was introduced to the tool and guided through the steps required to provide a facilitated self assessment. This serves the basis for integrating the provisions into the competition and for the panel to act as facilitators in the field based workshops for evaluating the performance under the Maturity Matrices.

Review of the results from the facilitated self-assessments (Appendix 2) shows the following:

1. Almost all Balai self-assessments provided scores at Level 1 and 2 for a number of components; i.e. are at elementary level or need development.
2. Some Balais score better where they are well resourced.
3. Balais scoring at higher maturity levels could assist Balais needing development.
4. Many Balais noted weaknesses in meeting training needs.
5. Many Balais expressed challenges with communication through their organisation
6. There is need for Emergency Preparedness Planning within almost all Balais;
7. Some Balais assessed themselves at the highest level (Level 5 = Best Practice) for some components. Independent assessment of the Balai will help to confirm if such a high score is reasonable.

Balai Portfolio Dam Numbers and Competition Categories Table 8

Balai	Total No of Dams	Competition Category		
		Reservoir volume < 2 Mm3	Reservoir volume 2-20 Mm3	Reservoir volume >20 Mm3
Bali Penida	5	2	3	---
Bengawan Solo	33	13	15	5 2
Brantas	17	5	5	7 3
Ciliwung – Cisadane	1	1	---	---
Cimanuk Cisanggarung	7	2	2	3
Citarum	5	3	1	1 1
Kalimantan III	7	4	3	---
Mesuji Sekampung	3	---	---	3
Nusa Tenggara I	62	47	9	6
Nusa Tenggara II	14	11	3	---
Pemali Juana	17	4	9	4
Pompengan Jeneberang	4	---	1	3
Serayu Opak	3	---	---	3
Sumatera I	5	3	2	---
Total	**183**	**95**	**53**	**35**

1) 1 dam managed by PJT 2
2) 1 dam managed by PJT 1
3) 7 dams managed by PJT 1

Dam Management Units Competing in 2017 Dam Safety Competition Table 9

No.	DMU	Name of Dam	Comment
Category I (Volume > 20 million m3)			
1	BBWS Serayu Opak	Sempor	2 of 3 dams managed
2	BBWS Serayu Opak	Sermo	
3	BBWS Pemali Juana	Jati Barang	1 of 4
4	BBWS Bengawan Solo	Pondok	1 of 4
5	BBWS Pompengan Jeneberang	Kalola	All > 20 Mm3 managed
6	BBWS Pompengan Jeneberang	Ponre-ponre	
7	BBWS Pompengan Jeneberang	Bili-bili	
8	BBWS Cimanuk Cisanggarung	Darma	2 of 3 dams > 20 Mm3
9	BBWS Cimanuk Cisanggarung	Malahayu	
10	BWS Nusa Tenggara I	Pengga	1 of 6
11	BBWS Mesuji Sekampung	Way Jepara	2 of 3 dams > 20 Mm3
12	BBWS Mesuji Sekampung	Way Rarem	
Category II (Volume 2-20 million m3)			
1	BBWS Pemali Juana	Penjalin	1 of 9
2	BBWS Bengawan Solo	Gonggang	1 of 15
3	BBWS Pompengan Jeneberang	Salomekko	1 of 1
4	BBWS Cimanuk Cisanggarung	Setu Patok	1 of 2
5	BWS Nusa Tenggara I	Tiu Kulit	3 of 9 dams managed
6	BWS Nusa Tenggara I	Sumi	
7	BWS Nusa Tenggara I	Pelaperado	
8	BWS Nusa Tenggara II	Tilong	1 of 3
9	BWS Kalimantan III	Samboja	2 of 3 dams managed
10	BWS Kalimantan III	Manggar	
Category III (Volume < 20 million m3)			
1	BBWS Pemali Juana	Panohan	1 of 4
2	BBWS Brantas	Sampean Baru	1 of 5
3	BWS Nusa Tenggara I	Surabaya	1 of 47
4	BBWS Bengawan Solo	Parangjoho	1 of 13
5	BBWS Ciliwung Cisadane	Gintung	1 of 1
6	BBWS Cimanuk Cisanggarung	Bolang	1 of 2
7	BWS Bali Penida	Benel	1 of 2

7.0
Conclusions and Recommendations

The development of Maturity Matrices for benchmarking dam safety in Indonesia provides an objective method for assessing the effectiveness of the operation, maintenance, surveillance and emergency preparedness programs under implementation by the Dam Management Units in the Balais. The consultative process for development of the matrices results in a tool that is embedded within the legal and institutional framework for dam safety in Indonesia. In addition to providing a tool to assist with self-assessment of the dam safety program, the Maturity Matrices help to identify and communicate both components and activities within the dam safety program.

The Maturity Matrices will further help in identifying and prioritising areas for improvement in the dam safety program. Application of the maturity assessment across the individual Balai provides a relative measure to contrast the effectiveness of dam safety programs across the different dam management units. With continued application, the Maturity Matrices will similarly allow for comparison of the performance of the individual dam safety programs within a Balai over time. This will help in identifying appropriate interventions, inform the allocation of resources, and their prioritisation for dam operation, maintenance and safety improvement.

Comparison of the different Balai's should be done carefully and in recognition of the similarities and differences in dam portfolios. The Balai are organised and resourced based on the size, purpose and complexity of their portfolio of dams. A Balai with a large number of dams essential for drinking water and

having high potential impact if they fail should not be compared to a Balai responsible for a small number of irrigation dams in isolated locations.

All improvements in the dam safety management programs of the Balais rely on budget allocations. In the absence of irrigation service fees the revenue streams are limited and the dam safety programs rely on transfers from government. The results of the maturity assessment can assist in communication of the budget needs as well as help to inform prioritization within a fixed resource environment to ensure that resources are allocated where they are most needed.

The level of understanding of dam performance mechanisms and connecting these mechanisms with interpretation of surveillance data varies between Balais. The Balais are currently required to send surveillance data to the central Dam Safety Unit for assessment and archiving. This results in lack of rigorous dam performance assessment based on surveillance data within Balais. There is a need to improve the feedback loops so that the outcomes of the surveillance data assessment are sent back to the respective Balai for action. This will help re-enforce the circle of improvement and adaptation. The Maturity Measures provide a measure to benchmark the evolution of performance.

Currently the assessment of surveillance data carried out by the Balais is driven by trends in individual surveillance readings without an overall understanding of the engineering involved in the safe performance of the dam. Accordingly, while there is ostensibly compliance with the dam safety legal framework, there is a lack of institutional understanding of dam performance. This risk would be reduced by improved communication but also by building dam safety understanding in Balai. Improved communication of surveillance data assessment results by the central Dam Safety Unit is necessary for understanding by both Balais and the senior management of MPWH Directorate General Water Resources and potentially higher in the MPWH management.

The Maturity Matrices provide a mechanism to systematically identify those challenge areas within the Balai. Dedicated training and capacity building programs can be aligned to address those systematic issues that manifest across the national portfolio and all Balais. In other areas where some Balais are performing well, peer-to-peer learning can be implemented to leverage expertise within the existing structures. Sourcing trainers from a Balai scoring high level of maturity to train personnel in Balais scoring low level of maturity in a certain dam safety program component or activity could be trialled where competence is a constraint on maturity level.

Potential Failure Modes Analysis (PFMA) is a useful exercise that can be used to guide and inform dam safety personnel on where to focus dam safety observations and inspections, where to strategically perform an investigation or install instruments to monitor dam performance. The process and results of the PFMA can also help to identify and prioritize O&M deficiencies, identify the need for improved operational processes, and targeted training needs.

The systematic application of PFMA can be used to inform the development of the Maturity Matrices. A PFMA is an informal identification and examination of “potential” failure modes for an existing dam by a team of persons based on a review of all existing data and information, input from field and operational personnel, site inspections, completed engineering analyses, identification of potential failure modes, failure causes and failure development and an understanding of the consequences of failure.

Carrying out a PFMA for dams within the portfolio of each Balai can help enhance the understanding and insights into the risk exposure and target surveillance to identified failure modes. This is accomplished by including and going beyond the traditional means for assessing the safety of a dam by intentionally seeking input from the diverse team of individuals who have information about the performance and operation of the dam. PFMA can subsequently be used to develop an appropriate program to enhance and focus the visual

surveillance and instrumented monitoring program, as well as the dam safety inspection process, identify shortcomings or oversights in data, information or analyses necessary to evaluate dam safety and a potential failure mode and help to identify the most effective dam safety risk reduction measures. While few, if any, Balai currently apply PFMA on a systematic basis, this approach could significantly improve effectiveness of surveillance, understanding of potential dam failure mechanisms and in turn improve initial understanding of surveillance data by the Balais, prior to sending the surveillance data to the central Dam Safety Unit. Integrating the development of staff from the Balais, the Dam Safety Unit and the Dam Safety Commission in the application of PFMA with the implementation of the Maturity Matrices would provide strong positive re-enforcement through adaptation of the dam safety program in response to specific issues.

Variability in the results of the self-assessments carried out by the Balai indicates that consistency has yet to be achieved. An independent assessment would validate the self-assessment capacity and provide calibration. The panel used to evaluate the Dam Safety Competition, and the competition itself, provides an important opportunity to continue to refine the application of these Maturity Matrices. This will also help to calibrate the self assessments nationally to provide a relative barometer of performance. An independent facilitator is recommended for future use of the Maturity Matrices.

The Maturity Matrices have not been applied to assess the dam safety support functions being provided by the MPWH. For example the central Dam Safety Unit supporting the Dam Safety Commission undertakes data analysis from monitoring instruments as a centralised service. This is a key activity within the overall dam safety framework but is not assessed within the current use of the Maturity Matrices for benchmarking dam safety programs within the Balai.

The Maturity Matrices could be expanded to assess dam safety in portfolios beyond the Balai under the supervision of the MPWH. This could include the Dam Management Units, or their equivalents, among the hydropower operators and private dam owners with some modifications. The same benefits should be achieved and consistency across all dam portfolios in Indonesia.

Employing a consistent approach across the national portfolio of large dams could provide an important regulatory reporting tool. This could be used to report against agreed metrics as part of the annual and comprehensive safety reviews of all of dams in Indonesia. These could be formalised through an annual national dam safety report.

The Government is implementing the second phase of the Dam Operational Improvement and Safety Project (DOISP). This is aimed at: (i) increasing the safety and the functionality with respect to bulk water supply of large MPWH-owned dams/ reservoirs, and (ii) strengthening the safety and operational management policies, regulations and administrative capacity. Specific outcome indicators include strengthening national dam safety institutions, as well as restoring the safety, operational performance, and economic life of a number of large dams and reducing the impact of sedimentation. Within this context, the Maturity Matrices provide a robust, tested and easy to apply method of benchmarking the performance of institutions involved in dam safety. The project provides an opportunity to sustain further development, application and refinement of the Maturity Matrices through a systematic bi-annual approach that is embedded within a financially supported framework for implementation.

Appendixes

Appendix 1: The Excel Scoring Workbook

The Excel Scoring Workbook consists of thirteen worksheets: Instructions, Master matrix, ten Activity Matrices and a summary worksheet.

The instructions, which are included in the Excel Scoring Workbook, are repeated below.

The procedure from outset of a new benchmarking assessment is to:

1. Install the Excel Scoring Workbook on a computer that has Excel installed;
2. Open the Excel Scoring Workbook;
3. Reset the entire workbook with the button on the Instruction worksheet;
4. Start with Component 1 Governance matrix worksheet scoring each activity line item (using the score button in the appropriate Maturity Matrix column) and also enter justification for each score chosen;
5. Repeat for each of the 10 worksheets consecutively, 1 Governance through 10 emergency Prep.

The Master Matrix and Summary Worksheets are automatically completed by the Excel Scoring Workbook program as scoring proceeds.

The results can be printed or captured electronically for record purposes. Figure C1 shows the Governance Matrix with the scoring buttons included and those (judged appropriate) scored.

Component 1 Governance Maturity Matrix

Figure C1

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 1: Governance Maturity Matrix **Scoring Form**

Governance is defined as the organizational commitment to, and resourcing and oversight of, the effective delivery of a dam safety program and management of dam safety risk.

Activity	Maturity Level					Remarks
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5. Best Practice	
1-A. Policy and Regulation [Regulations and Policy regarding dam safety.]	(a) Little or no understanding of relevant policies and regulations.	(a) Some understanding of relevant policies and regulations.	(a) Relevant policies and regulations generally understood.	(a) Relevant Policies and regulations well understood.	(a) Relevant Policies and regulations well understood, with good relationship with the Dam Safety Commission	
	1	2	3	4		
	(b) Relevant policy and regulations not met.	(b) Relevant policies and regulations generally met.	(b) Relevant policy and regulations met.	(b) Relevant policies and regulations met and sometimes exceeded.	(b) Relevant policy and regulations met and generally exceeded.	
	1	2	3			
1-B. Roles & Responsibilities [Roles and Responsibilities as they relate to the Dam Safety Program]	(a) Little or no definition and understanding of roles and responsibilities.	(a) Roles and responsibilities are poorly defined and understood.	(a) Roles and responsibilities are generally defined and understood.	(a) Roles and responsibilities are well defined and understood locally.	(a) Roles and responsibilities are well defined and understood throughout the Dam Management Unit (DMU) and Ministry.	
	1	2	3	4		
	(b) Personnel not enabled to perform roles and responsibilities.	(b) Personnel poorly enabled to perform roles and responsibilities.	(b) Personnel enabled to perform roles and responsibilities.	(b) Personnel enabled and encouraged to perform roles and responsibilities.	(b) Personnel enabled and strongly encouraged to perform roles and responsibilities and improve dam safety outcomes.	
	1	2	3			
1-C. Internal & External Communication [Internal communications within the DMU, Ministry of Public Works and Housing. External communication with the community]	(a) Poor communication within and between the DMU and Ministry.	(a) Communication confined to formal lines of communication within the DMU and between DMU and Ministry.	(a) Two-way formal and informal communication happens between all levels within the DMU and Ministry.	(a) Effective two-way formal and informal communication between all levels within the DMU and Ministry.	(a) Effective and regular two-way formal and informal communication between all levels within the DMU and Ministry.	
	1	2	3	4		
	(b) Little or no external communication between the DMU and key stakeholders.	(b) Only informal external communication happens between the DMU and key stakeholders.	(b) Two-way external communicatio happens between the DMU and key stakeholders.	(b) Effective two-way external communication exists between the DMU and key stakeholders.	(b) Effective and regular two-way external communication happens between the DMU and key stakeholders.	
	1	2	3	4		
1-D. Resourcing [Provision of appropriate human, financial and equipment resources for delivery of the Dam Safety Program]	(a) Financial and equipment resources fall well short to achieve basic outcomes of dam safety program	(a) Financial and equipment resources insufficient to achieve all basic outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve basic outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve a high level of outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve a high level of efficient outcomes of dam safety program and to implement improvement opportunities	
	1	2	3	4		
	(b) Human resources fall well short to achieve basic outcomes of dam safety program	(b) Human resources insufficient to achieve all basic outcomes of dam safety program	(b) Human resources sufficient to achieve basic outcomes of dam safety program	(b) Human resources sufficient to achieve a high level of outcomes of dam safety program	(b) Human resources sufficient to achieve a high level of efficient outcomes of dam safety program and to implement improvement opportunities	
	1	2	3			
	(c) Little or no succession planning.	(c) Succession planning and implementation is inadequate.	(c) Succession planning and implementation generally in place.	(c) Succession planning fully in place and implemented	(c) Succession planning fully in place to improve dam safety outcomes and implemented	
	1	2	3			

In Figure C1 the roll up maturity is determined by the highest maturity achieved over each activity. This is represented by the Red dashed line in Figure C1. The Maser Matrix is generated by the Excel Scoring Workbook program similar to Figure C2.

Figure C2 Shows the Governance component of the Master matrix. To complete the assessment the other 9 component matrices (Component Matrices 2 to 10) need to be scored (similar to Component 1 shown in Figure C1).

Master Matrix Governance Component

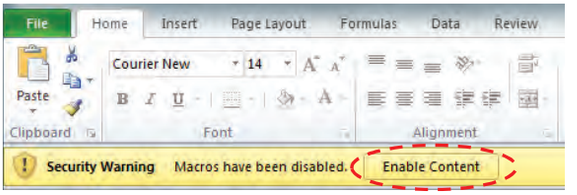
Figure C2

Activity		Maturity Level				
		1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
1-A	(b)	1	2			
1-B	(b)	1	2	3		
1-C	(b)	1	2	3		
1-D	(c)	1				

The instructions worksheet of the Excel Scoring Workbook.

INSTRUCTIONS

1) a) Enable Macros if you are prompted to do so upon opening the Workbook (see image below)



b) SAVE this Workbook to a folder

2) RESET Entire Workbook if it contains previous responses (save a copy, if required)
Do this by clicking the "RESET ENTIRE WORKBOOK" button - see image below:

Image only → RESET ENTIRE WORKBOOK

3) a) Proceed to the Worksheet Tab titled "1. Governance".
This is the maturity matrix titled "Component 1: Governance Maturity Matrix"

b) RESET the Worksheet if it contains previous responses
Do this by clicking the "RESET SCORING FORM" button - see image below:

Image only → RESET SCORING FORM

c) For each line item, select a response by clicking on a radio button in the row

○ ○ ○ ○ ○

d) For each selection, insert text in the Remarks column to justify your response to the questions below:
Question 1: What elevates your maturity level selection from the maturity level one level lower?
Question 2: What prevents your maturity level selection from moving one level higher?

Insert text →

Remarks

e) Proceed to the next line item and so on, until you have completed the Worksheet
If you change your mind, you can reset the form again by clicking the RESET button.
Note that clicking the RESET button will delete ALL responses in the Worksheet
Responses to individual line items can be changed by selecting the appropriate button

4) Once finished, proceed to the next Tab
Finish selecting responses on each Tab until you have completed all forms
The "Master Matrix" highlights will be generated automatically once all forms are complete

5) Your responses are plotted on the Tab titled "Summary".
Take a PRINT of this 'Summary' Worksheet for your record.

6) Polar plots are generated in the sheet titled "Polar_Plots"
Do this by clicking the "Plot All Charts" button - see image below:
Take a PRINT of this 'polar_plots' Worksheet for your record.

Image only → Plot All Charts

7) You can RESET this entire Workbook by clicking the button below:
(you will be prompted for confirmation)

Actual Button !! → RESET ENTIRE WORKBOOK

Appendix 2: Results of the Maturity Matrices

	Batam Participant List	Semarang Participant List
1.	BBWS Bengawan Solo	BBWS Bengawan Solo
2.	BBWS Brantas	BBWS Brantas
3.	BBWS Ciliwung-Cisadane	BBWS Ciliwung-Cisadane
4.	BBWS Cimanuk-Cisanggarung	BBWS Cimanuk-Cisanggarung
5.	BBWS Citarum	Did Not Participate
6.	BBWS Mesuji-Sekampung	BBWS Mesuji-Sekampung
7.	BBWS Pemali-Juana	BBWS Pemali-Juana
8.	BBWS Pompengan-Jeneberang	BBWS Pompengan-Jeneberang
9.	BBWS Serayu Opak	BBWS Serayu Opak
10.	BWS Bali-Penida	BWS Bali-Penida
11.	BWS Kalimantan-III	BWS Kalimantan-III
12.	BWS Nusa Tenggara-I	BWS Nusa Tenggara-I
13.	BWS Nusa Tenggara-II	BWS Nusa Tenggara-II
14.	BWS Sumatera-I	Did Not Participate
15.	BWS Sumatra-IV	Did Not Participate

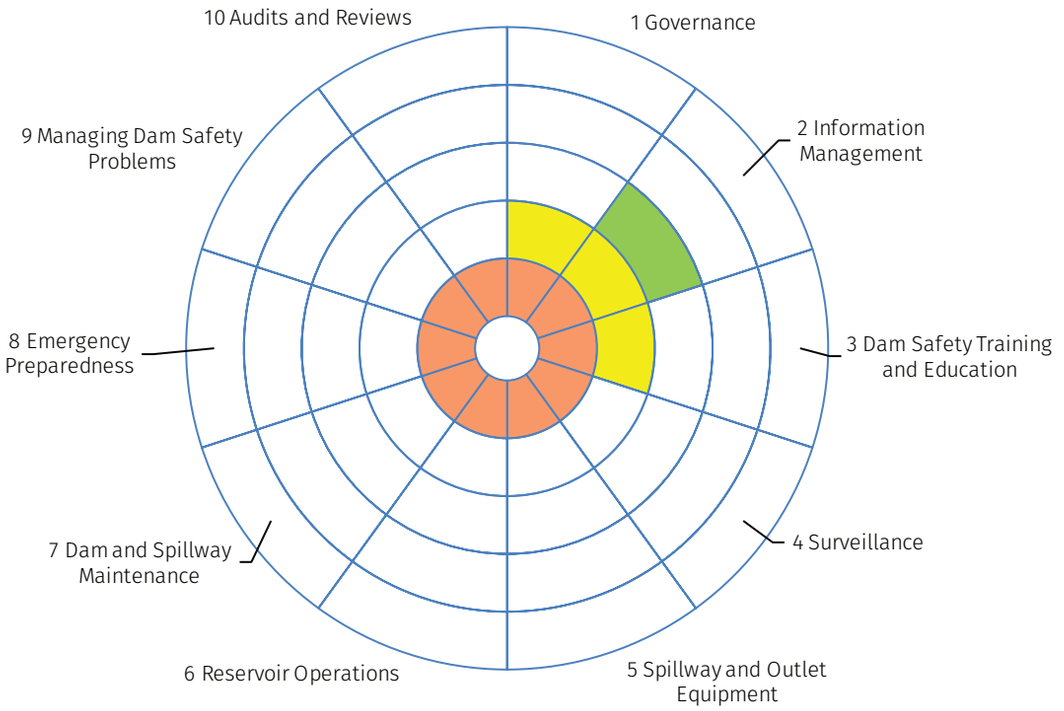
Maturity Level Legend

1. Needing Development
2. Elementary
3. Good Practice
4. Very Good Practice
5. Best Practice

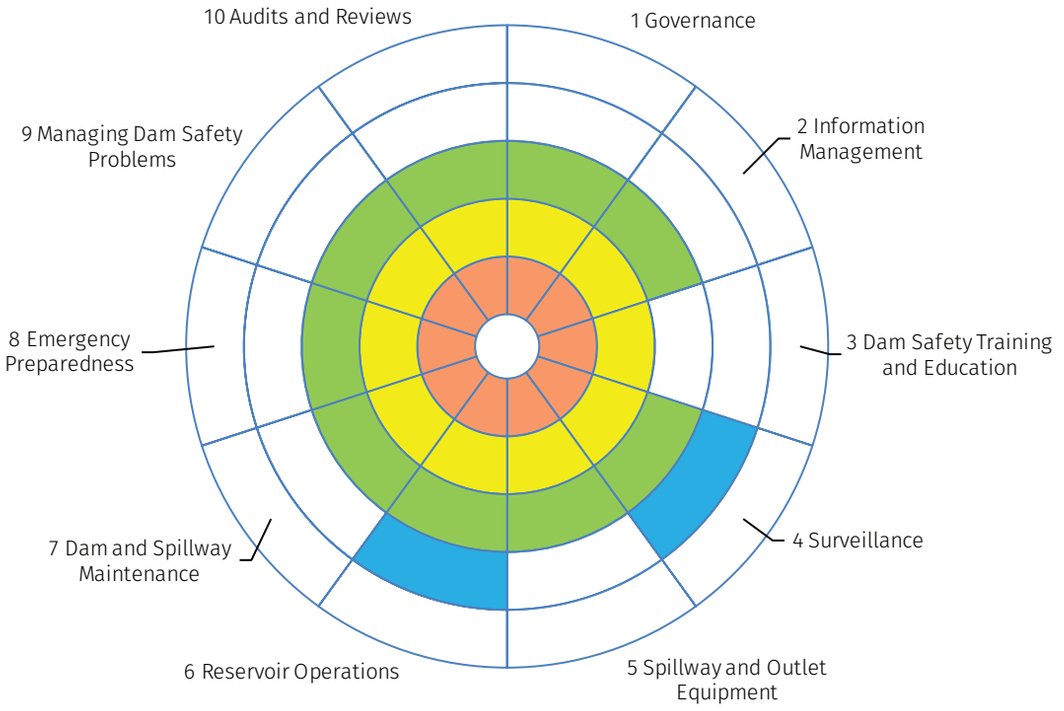
Appendix 2A: Component Overview (Master Matrix) for Balais

BBWS Bengawan Solo

Workshop 2 (May 2017)

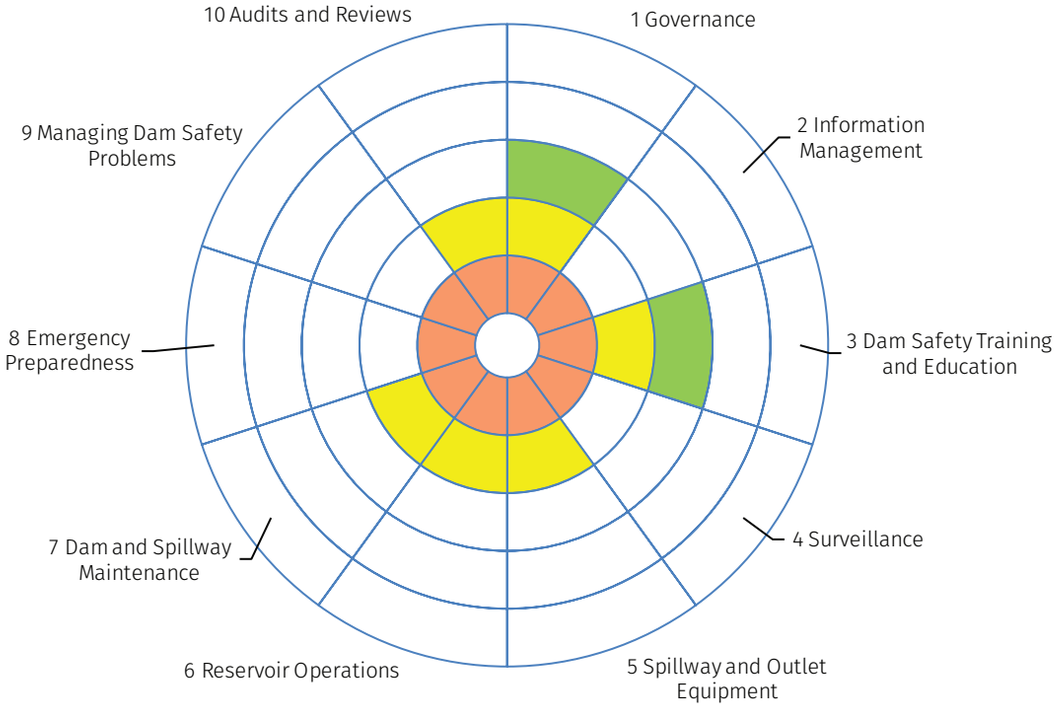


Workshop 3 (July 2017)

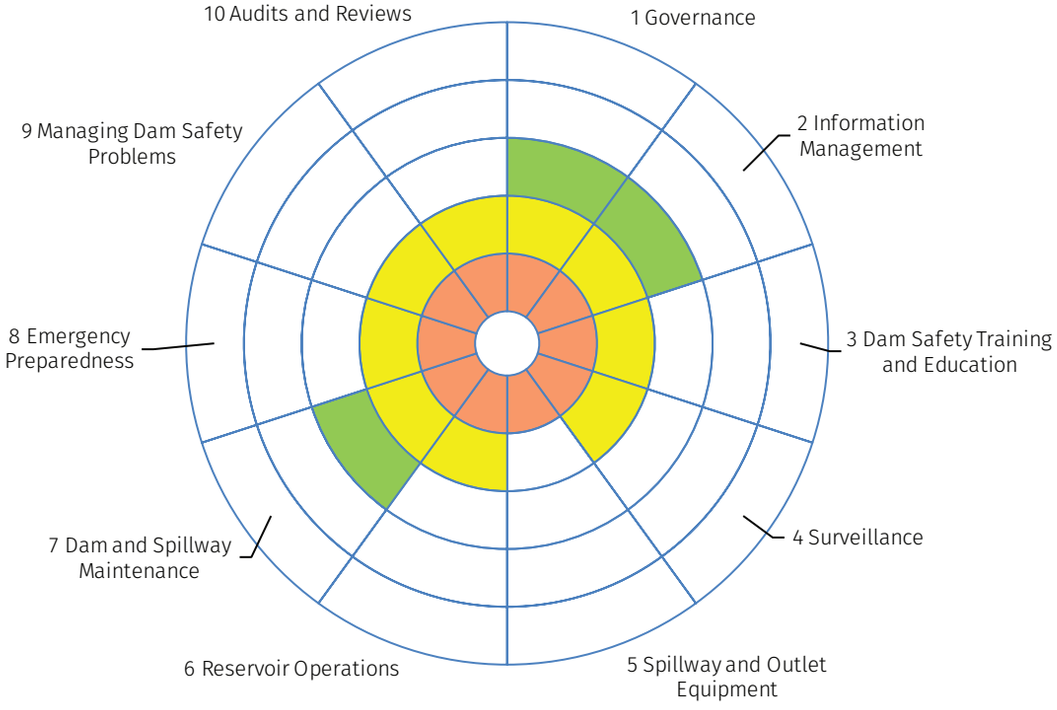


BBWS Brantas

Workshop 2 (May 2017)

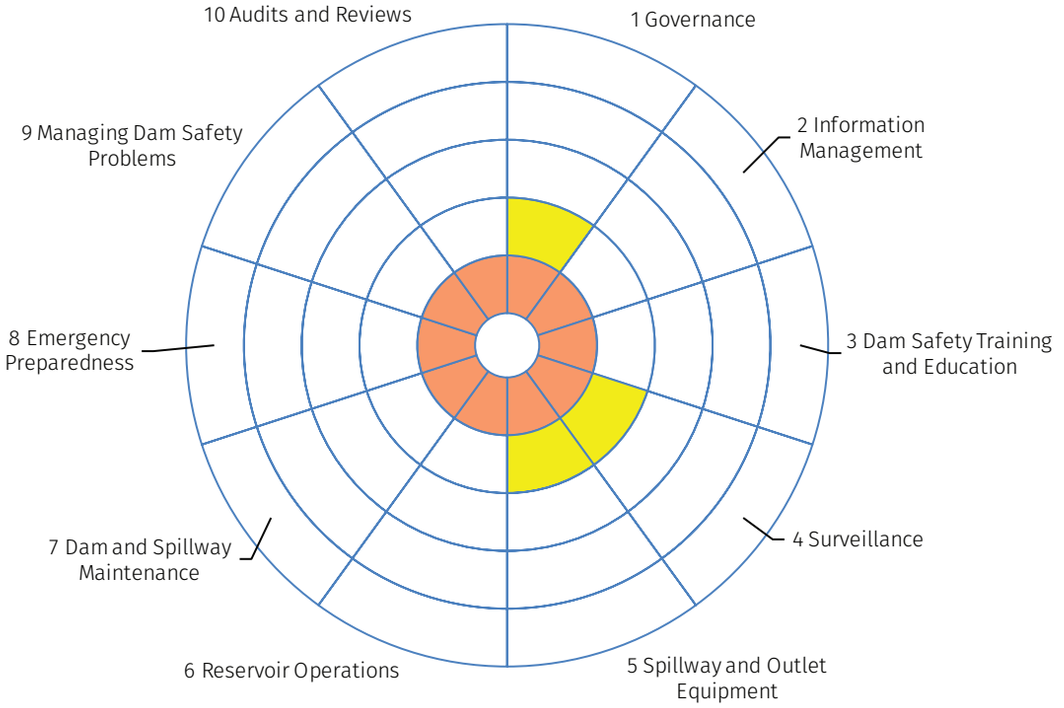


Workshop 3 (July 2017)

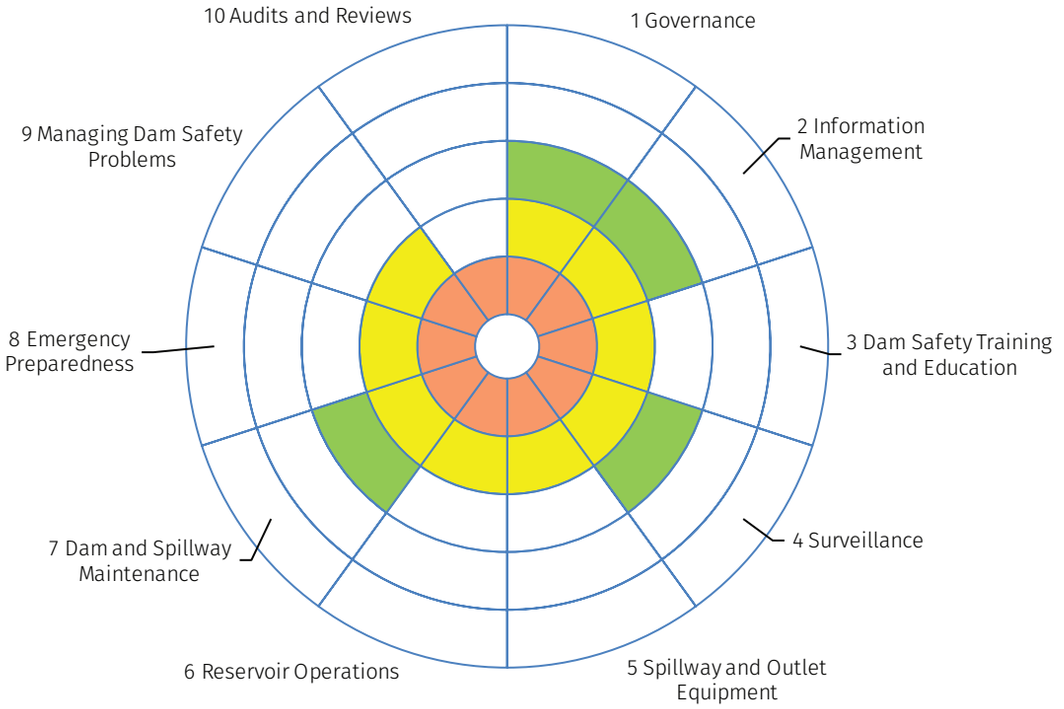


BBWS Ciliwung-Cisadane

Workshop 2 (May 2017)

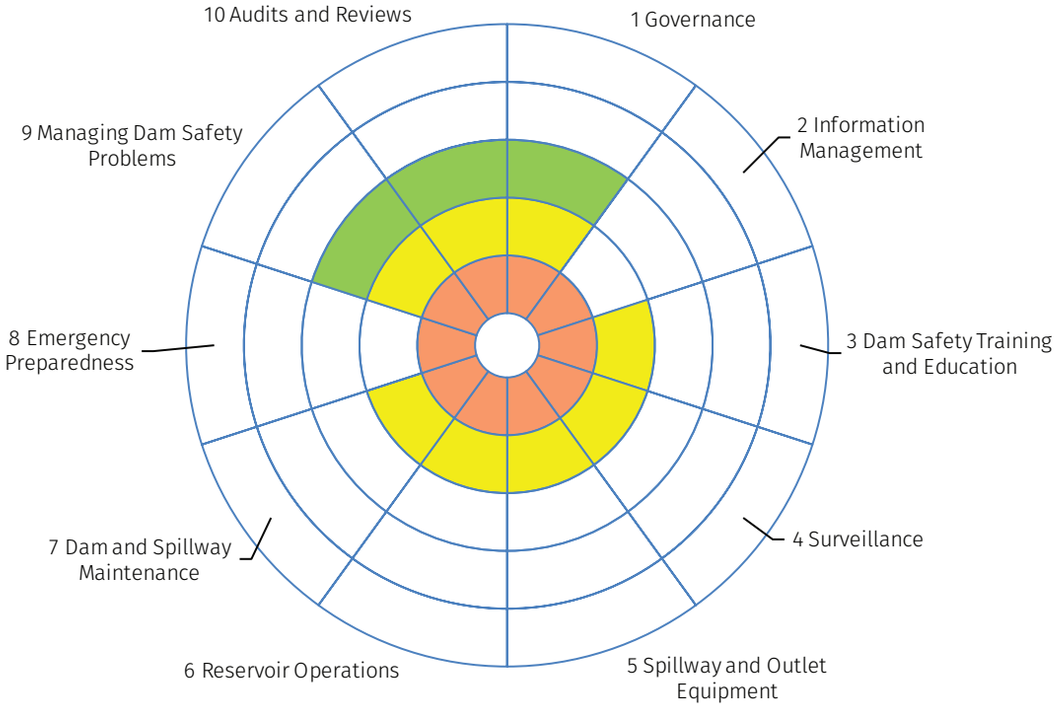


Workshop 3 (July 2017)



BBWS Cimanuk-Cisanggarung

Workshop 2 (May 2017)



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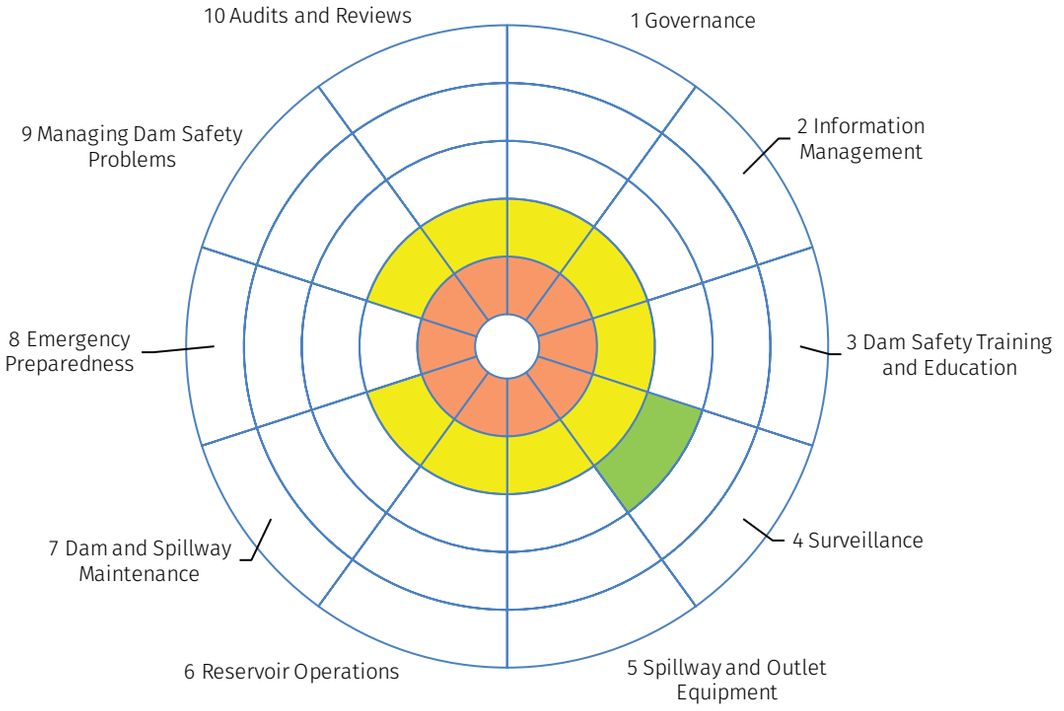
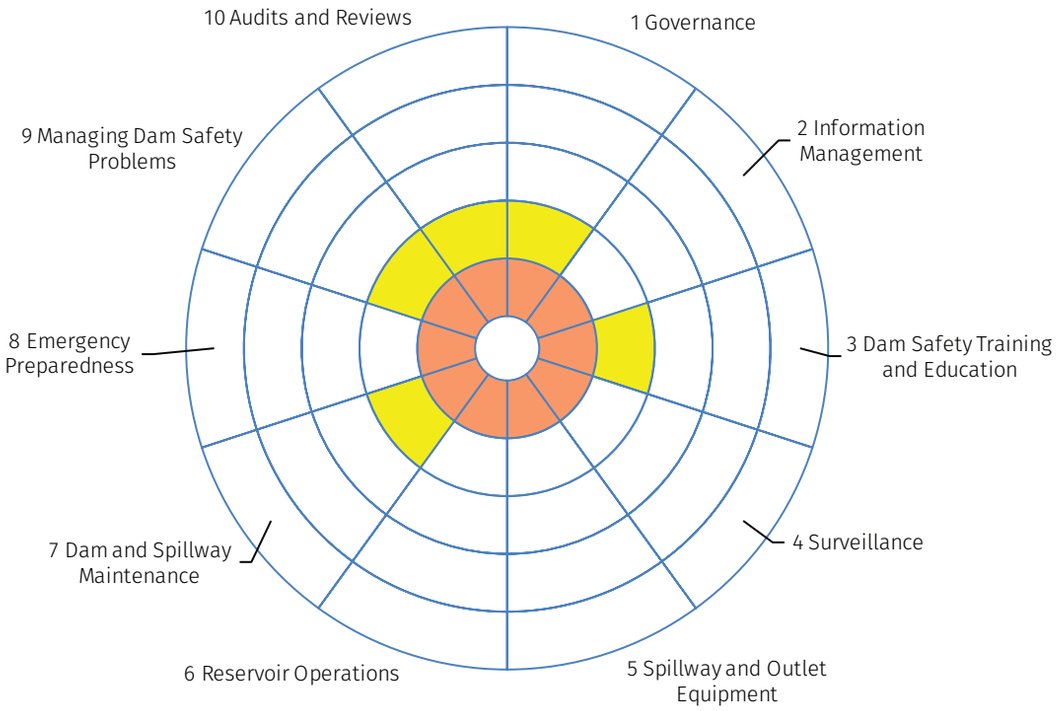


BBWS Citarum

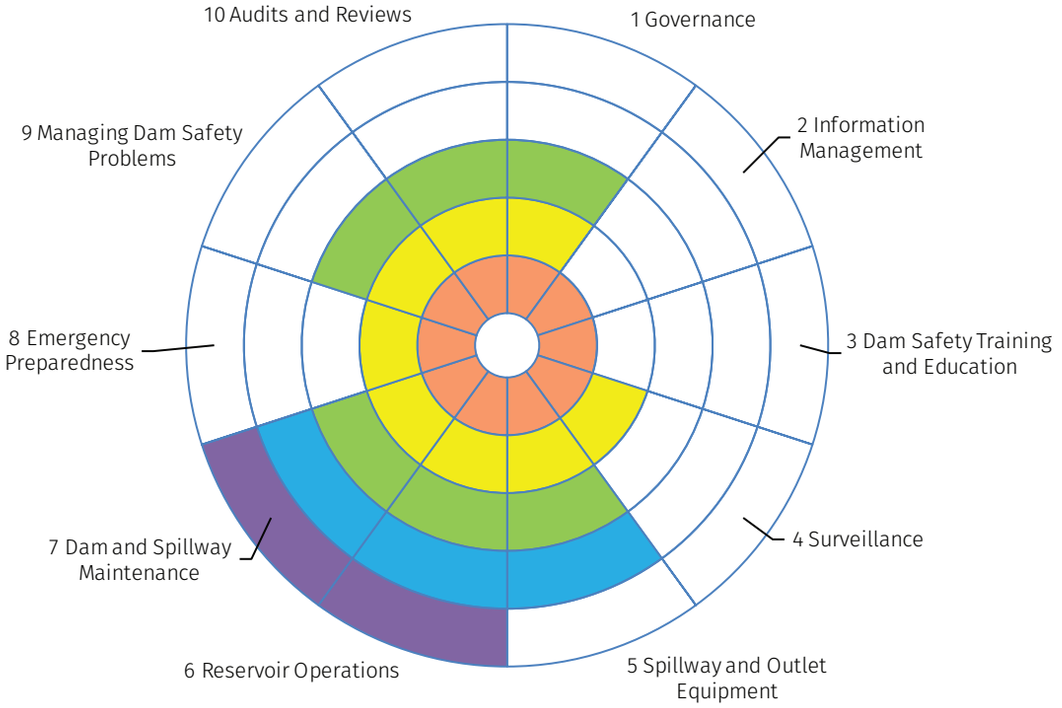
Workshop 2 (May 2017)



Workshop 3 (July 2017)
Not Present

BBWS Mesuji-Sekampung

Workshop 2 (May 2017)



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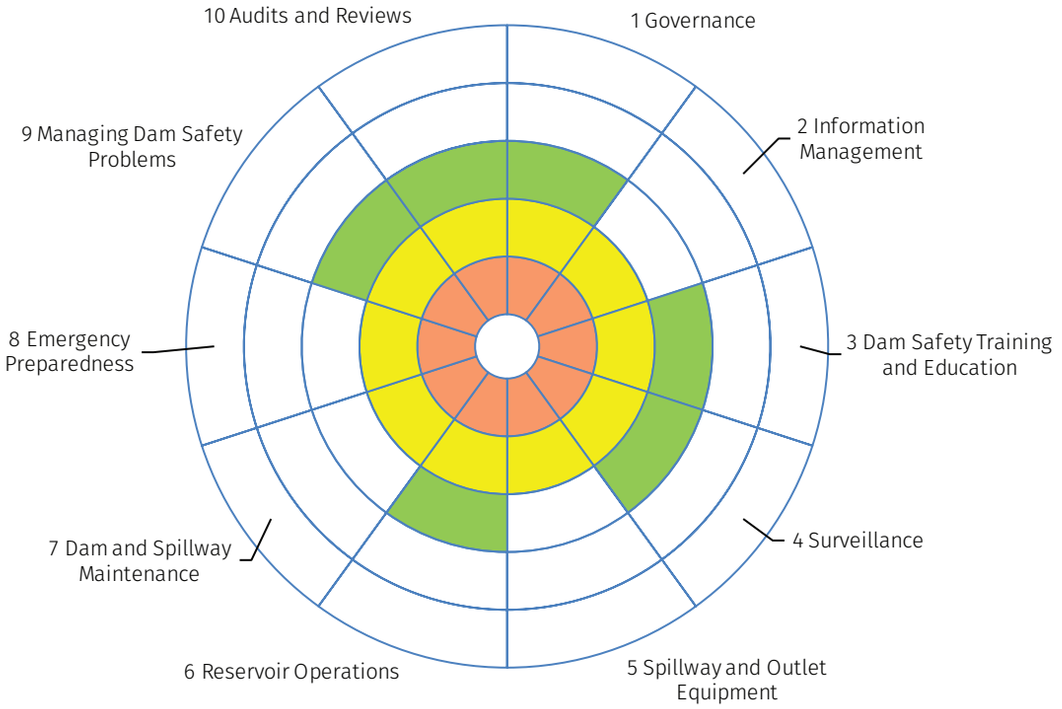
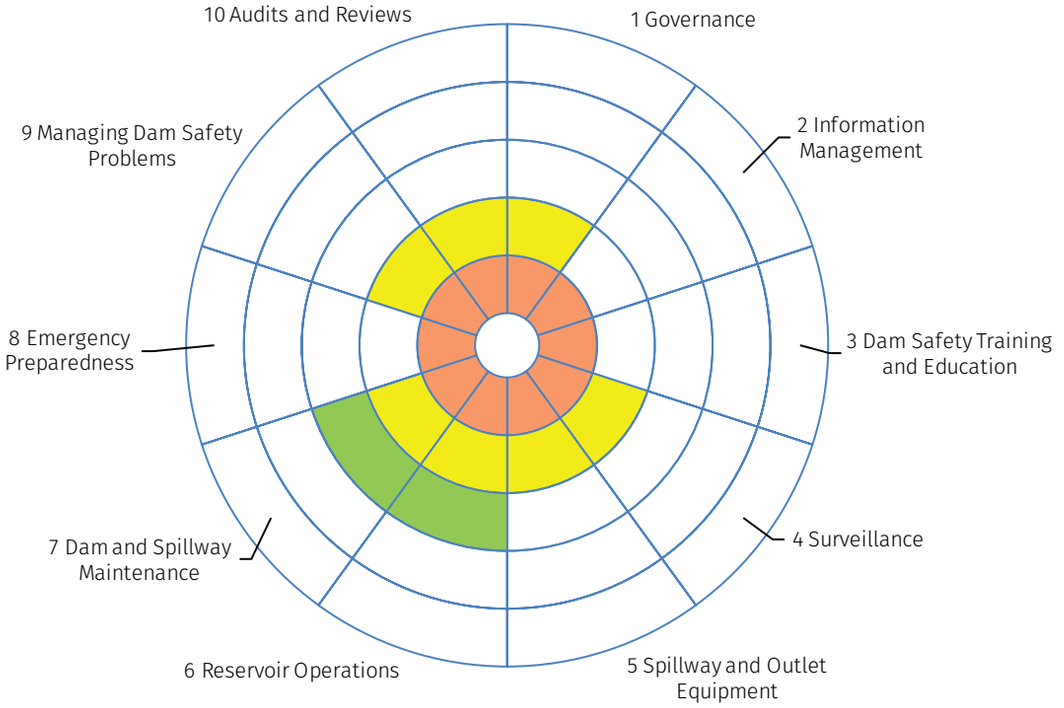
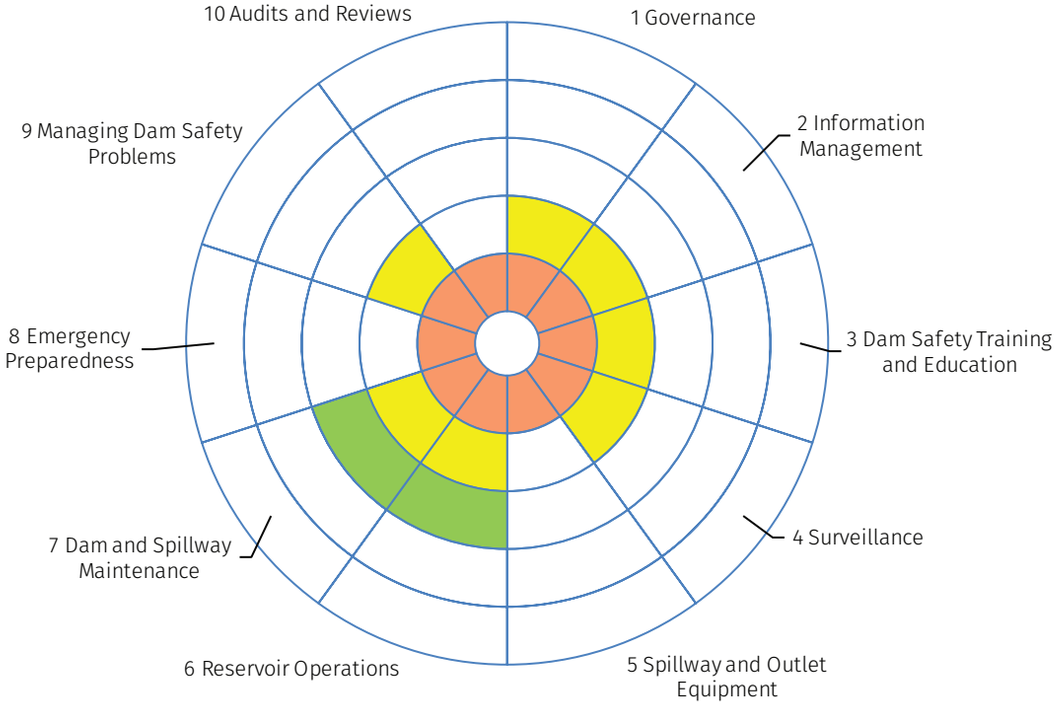


BBWS Pemali-Juana

Workshop 2 (May 2017)

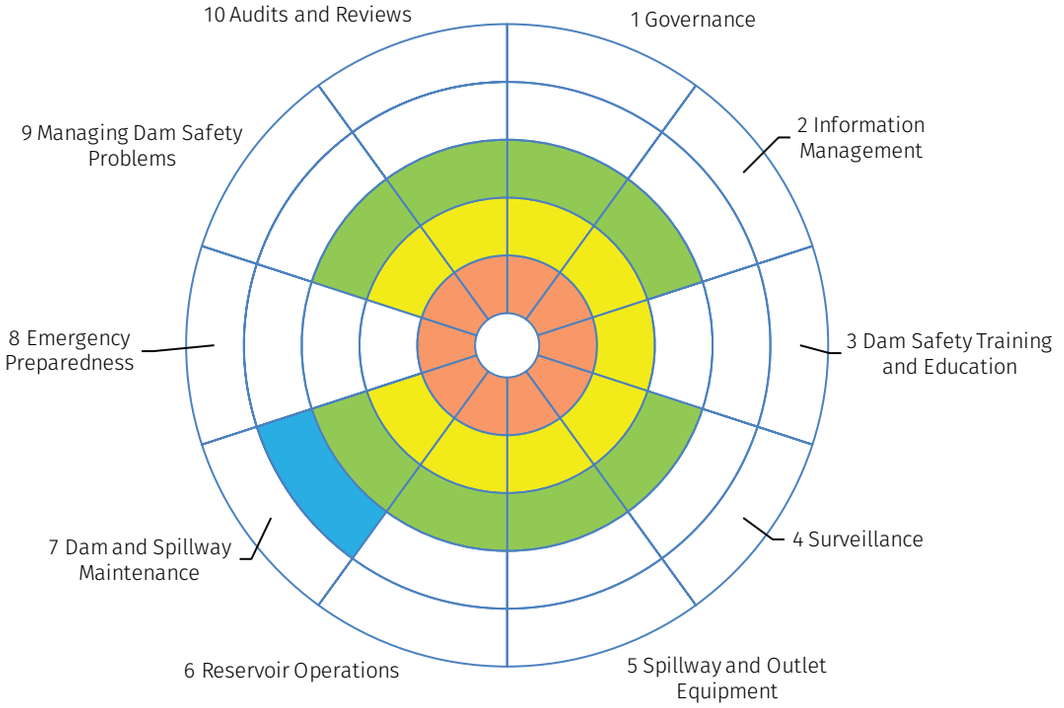


Workshop 3 (July 2017)



BBWS Pompengan-Jeneberang

Workshop 2 (May 2017)



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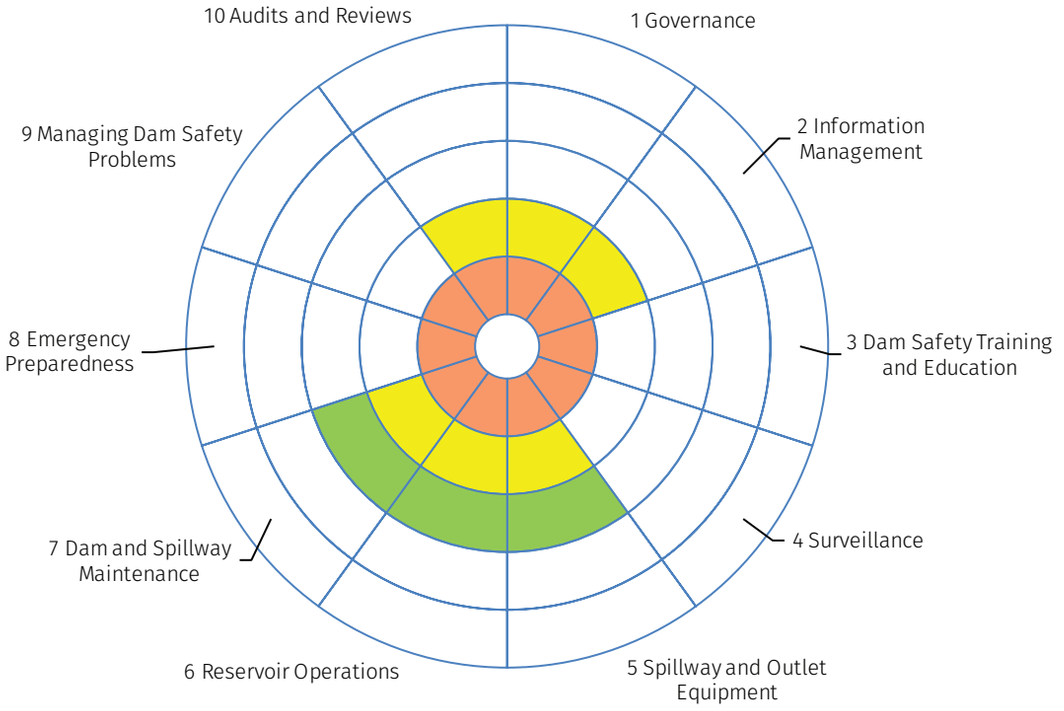
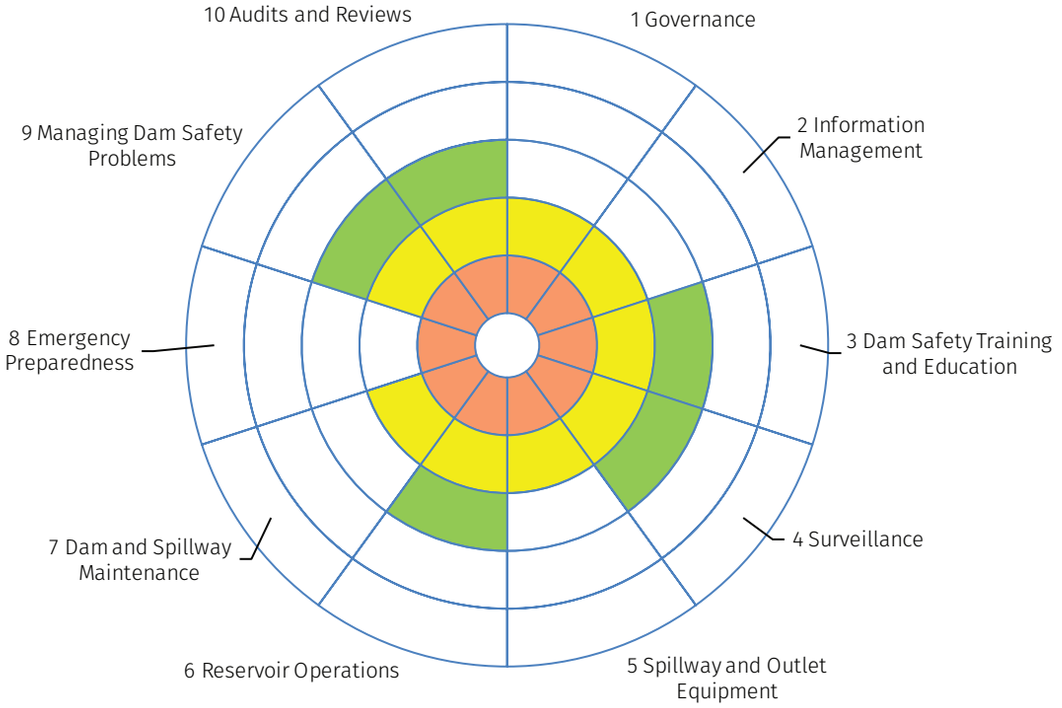
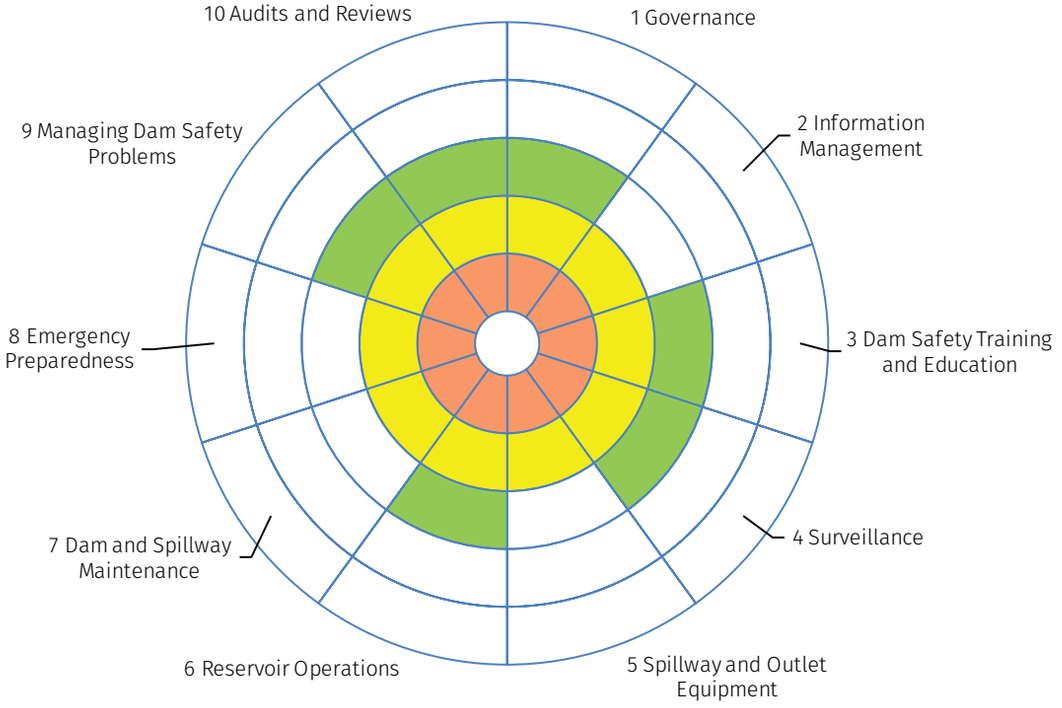


BBWS Serayu Opak

Workshop 2 (May 2017)

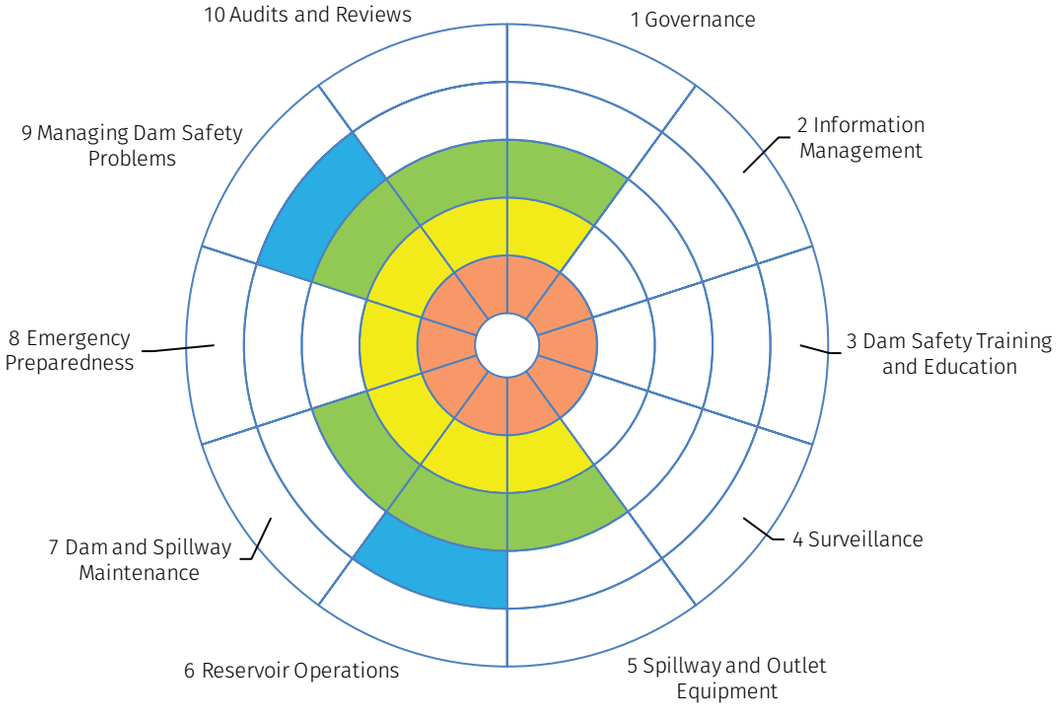


Workshop 3 (July 2017)



BWS Bali-Penida

Workshop 2 (May 2017)



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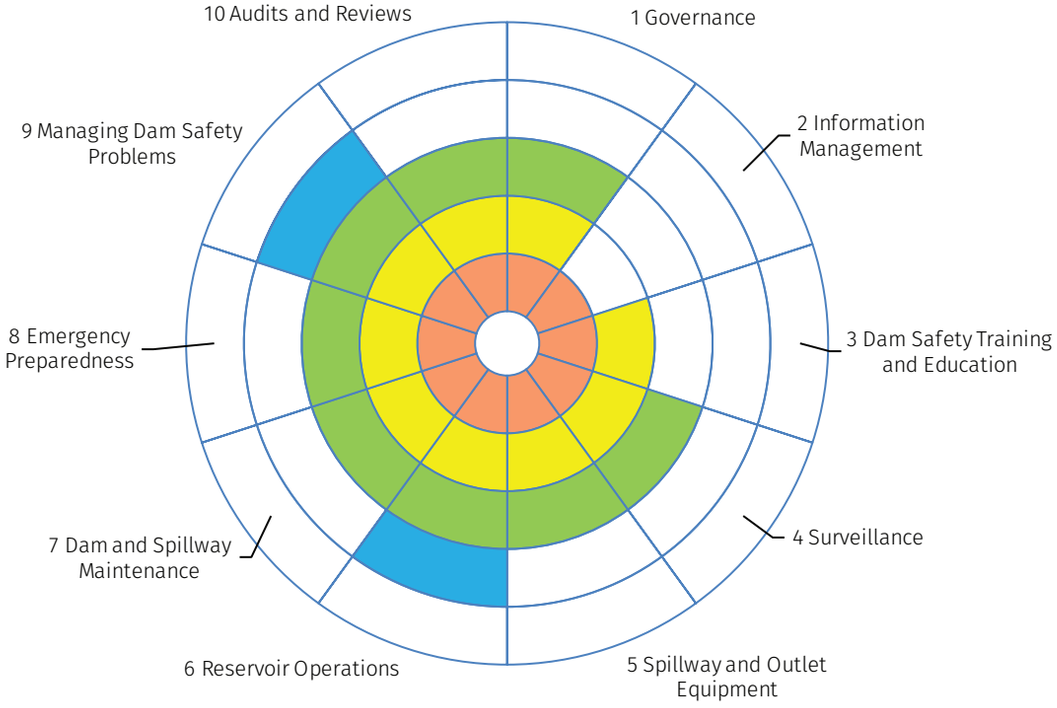
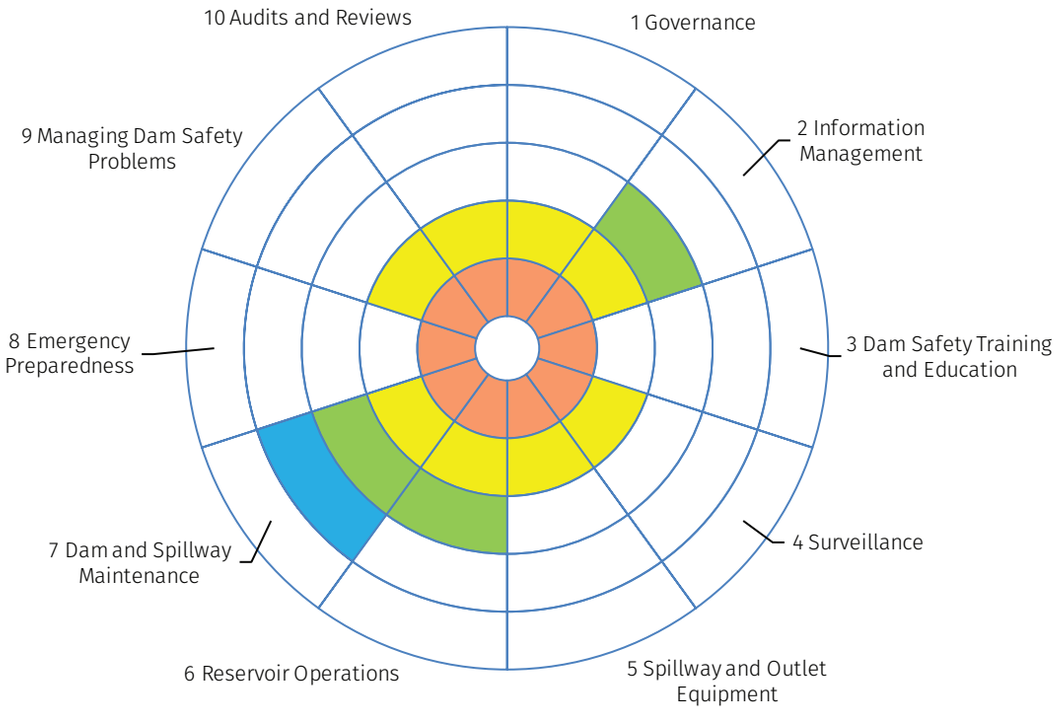


BWS Kalimantan-III

Workshop 2 (May 2017)



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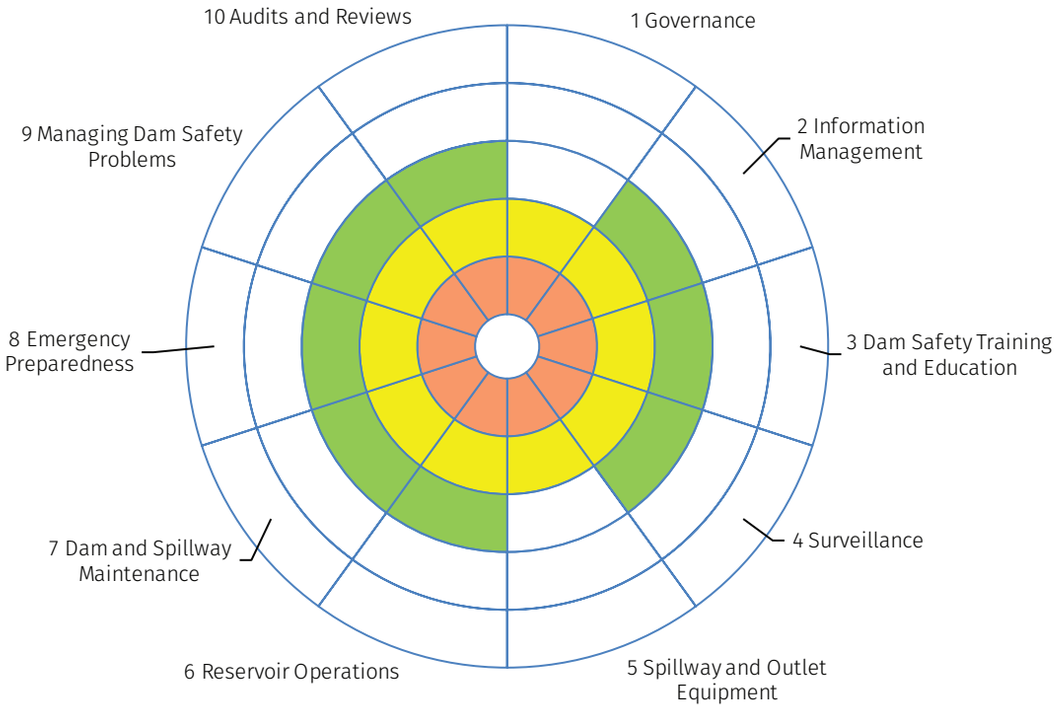
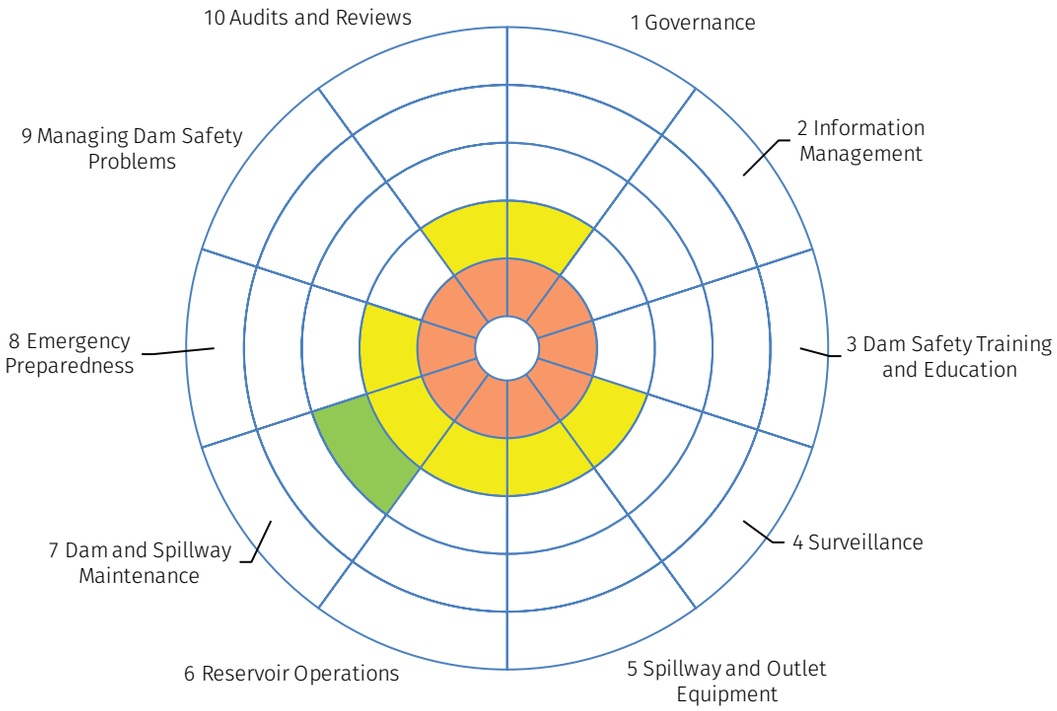


BWS Nusa Tenggara-I

Workshop 2 (May 2017)



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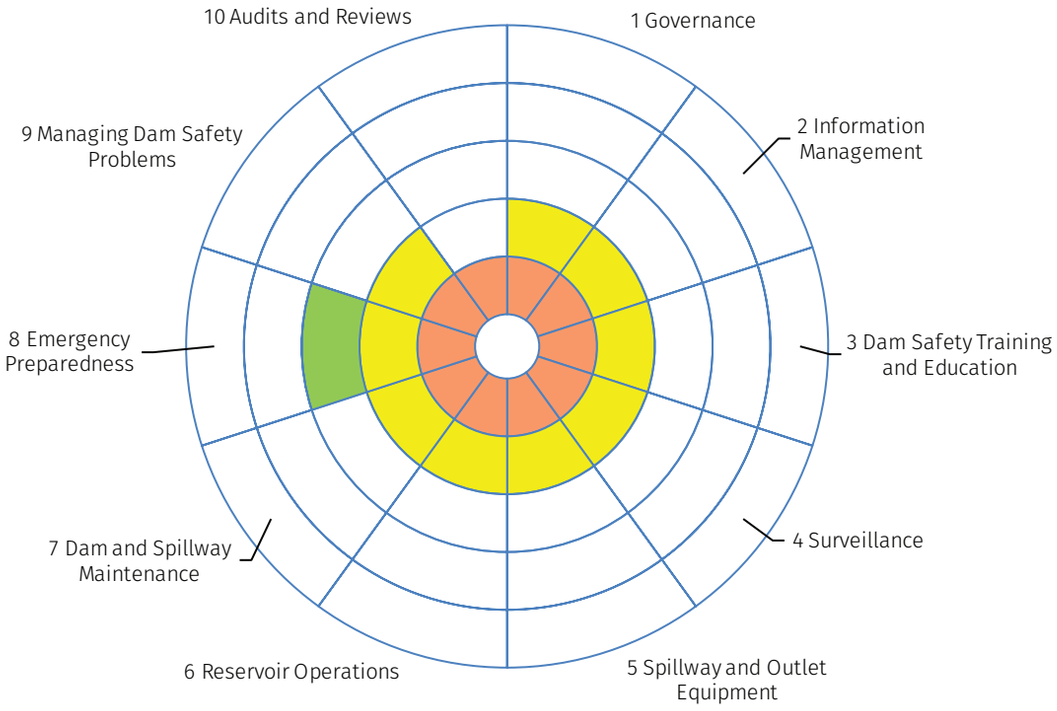

BWS Nusa Tenggara-II

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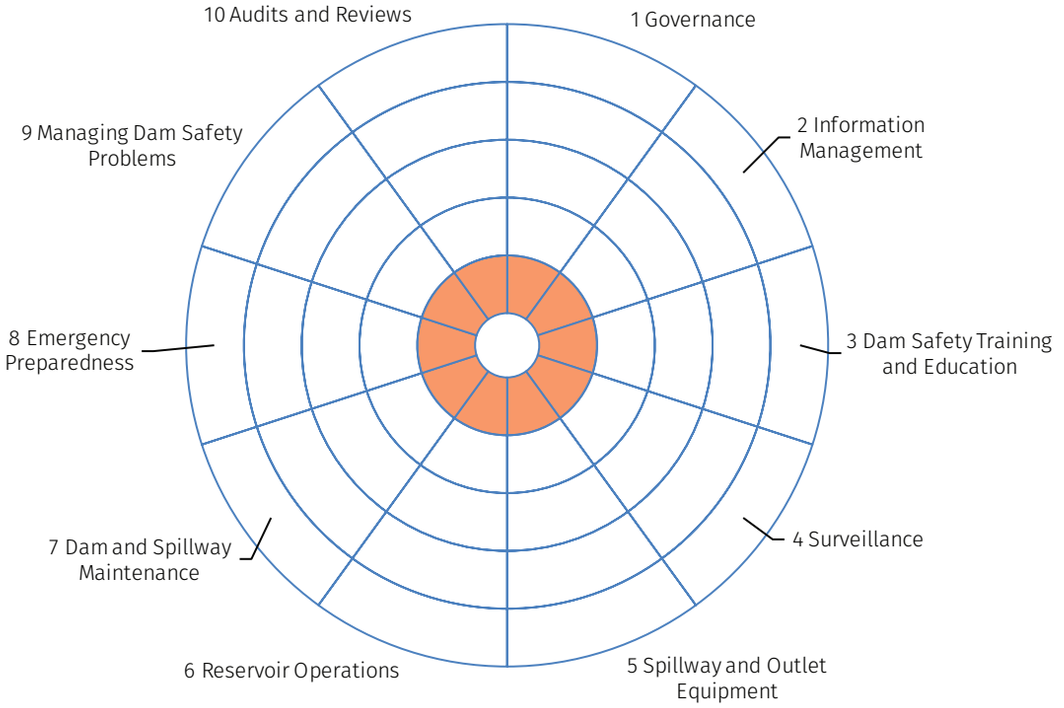

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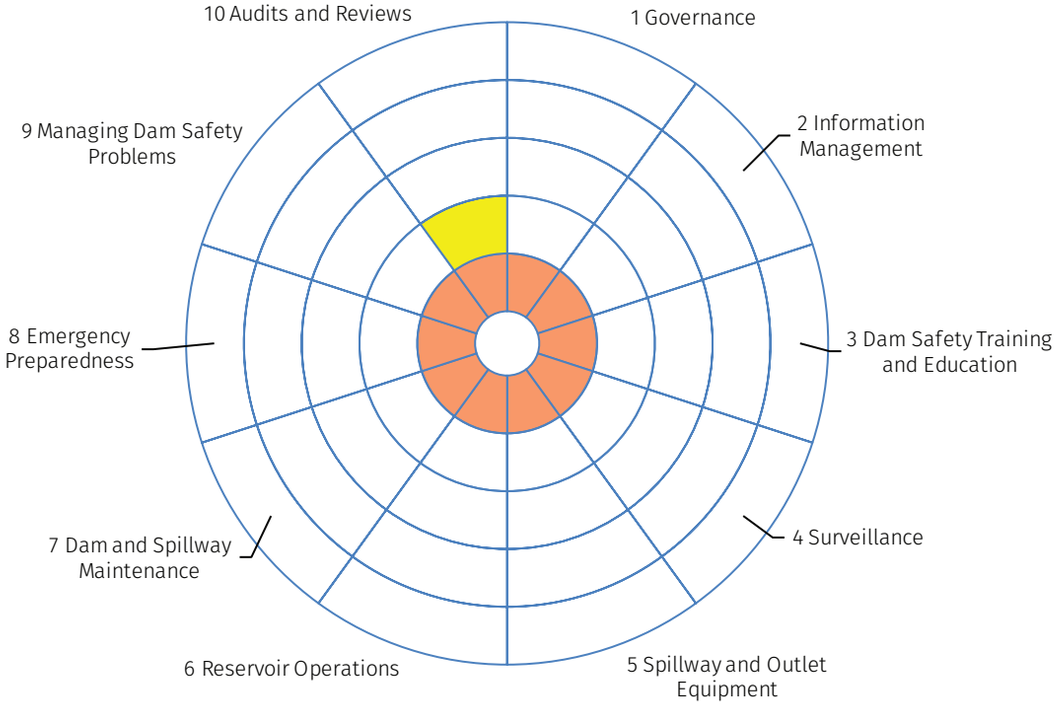

BWS Sumatera-I

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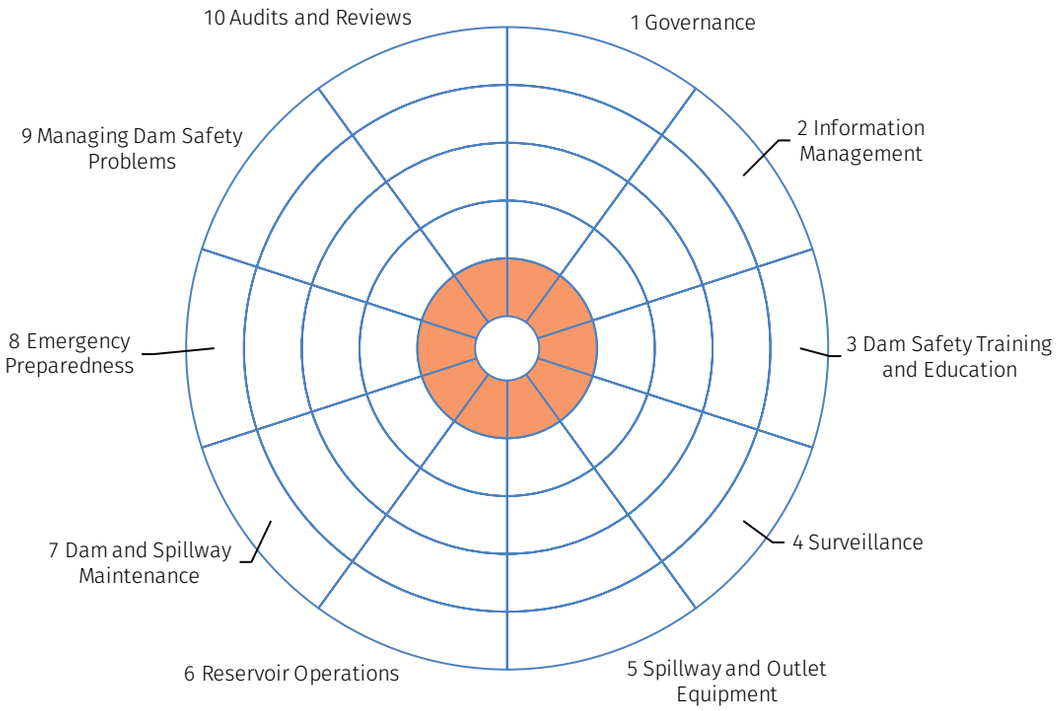

Workshop 3 (July 2017)
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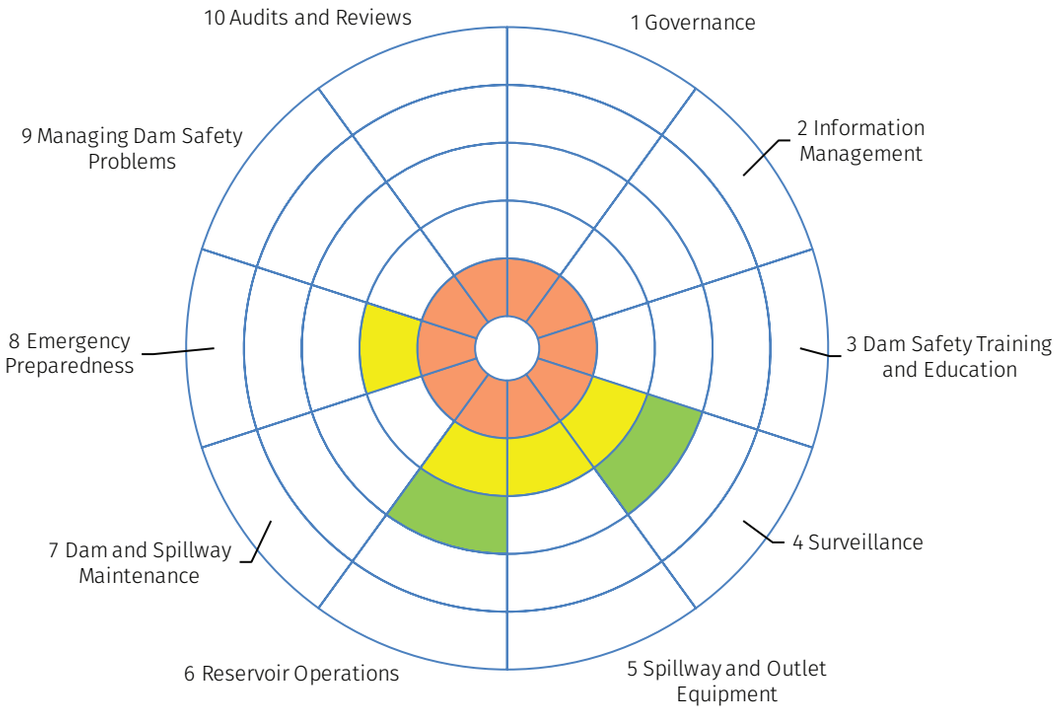
BWS Sumatra-IV

Workshop 2 (May 2017)

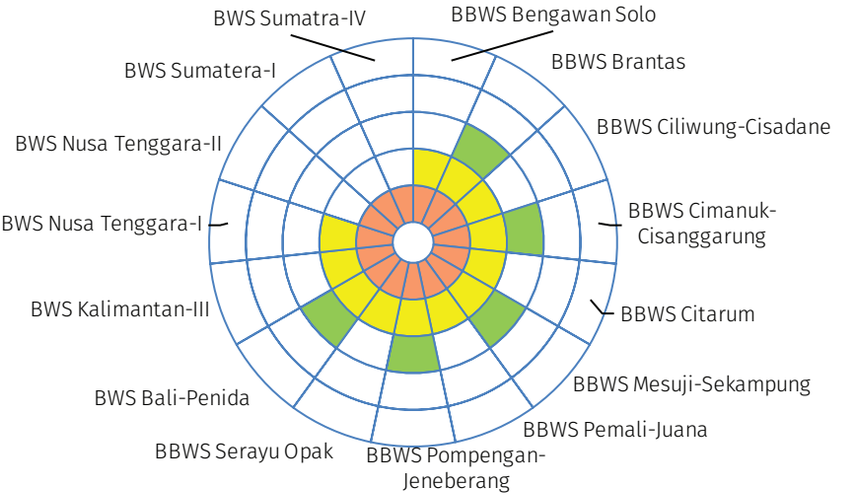


Workshop 3 (July 2017)
Not Present

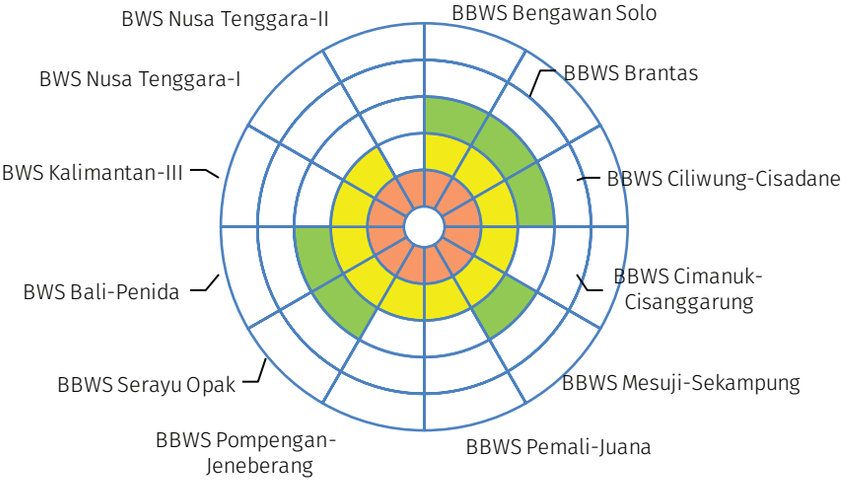
Appendix 2B: Comparison between Balais

1. Governance

Workshop 2 (May 2017)

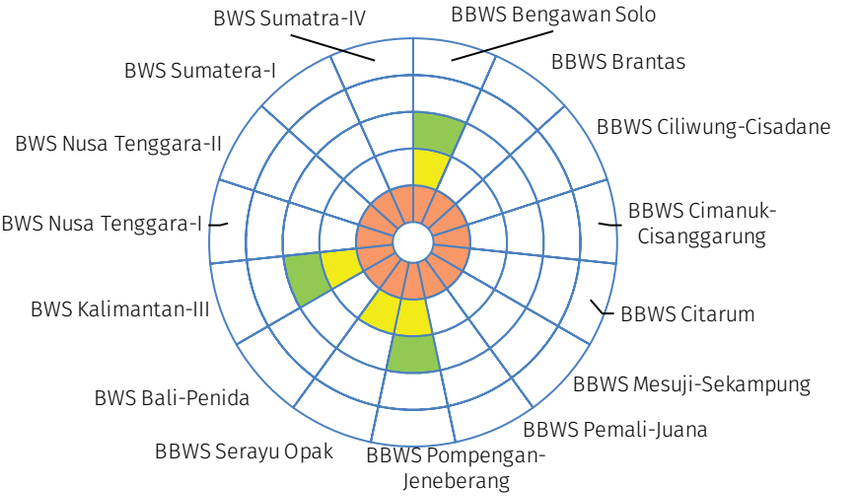


Workshop 3 (July 2017)

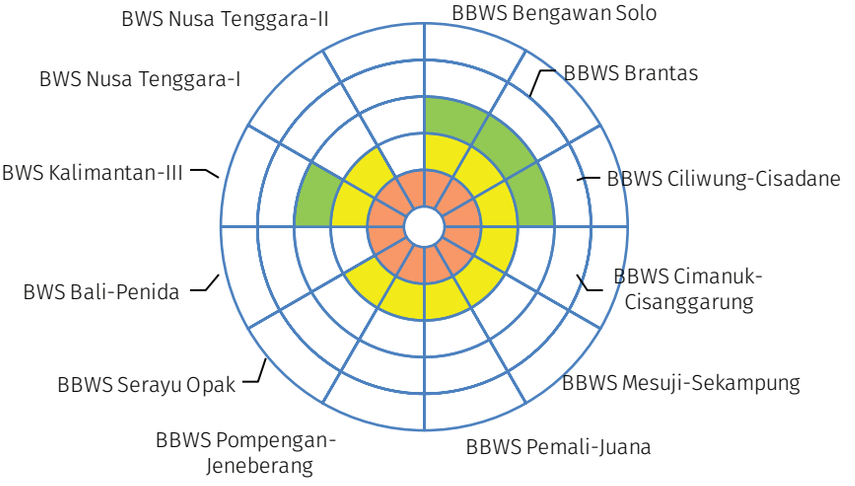


2. Information Management

Workshop 2 (May 2017)

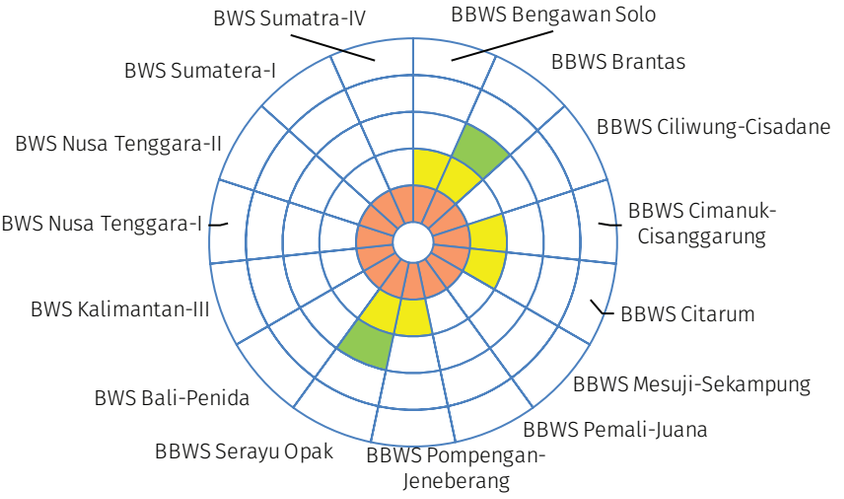


Workshop 3 (July 2017)

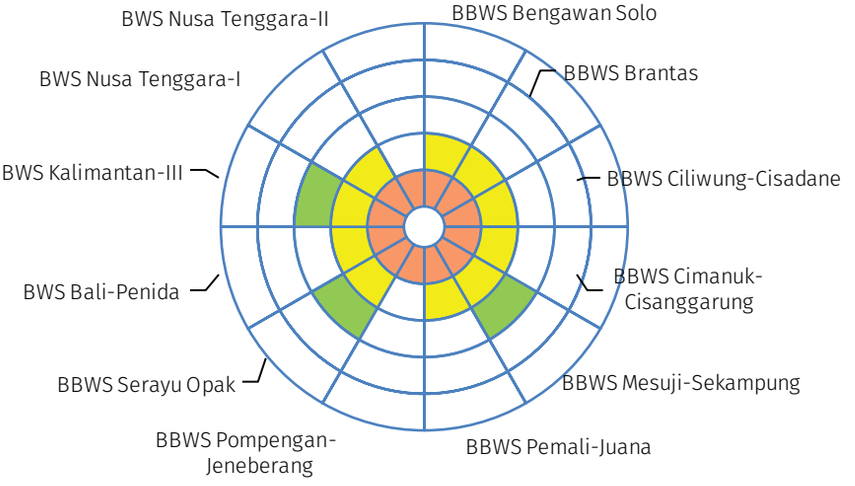


3. Dam Safety Training and Education

Workshop 2 (May 2017)

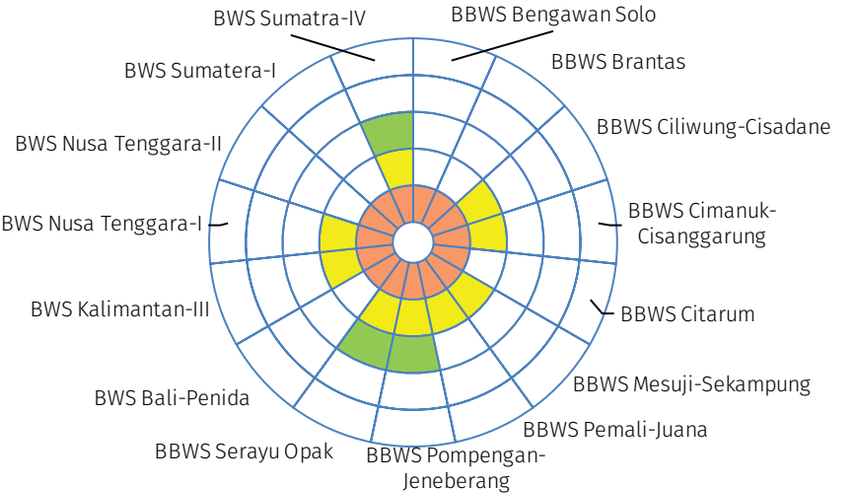


Workshop 3 (July 2017)

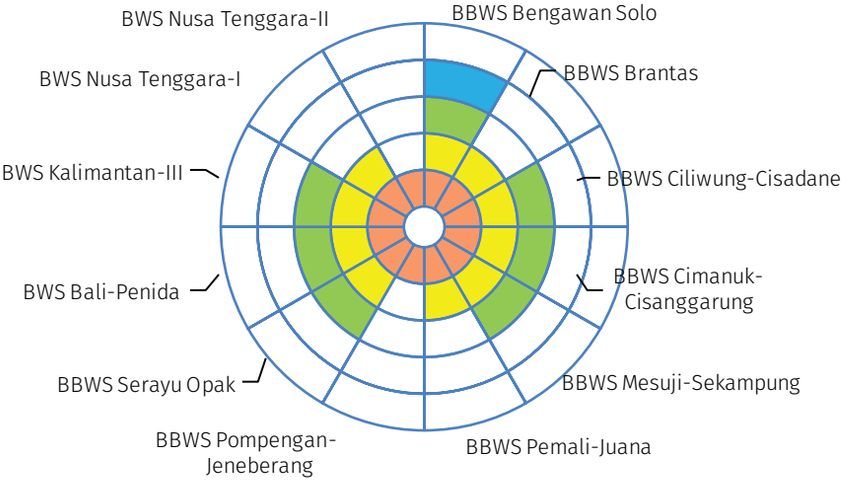


4. Surveillance

Workshop 2 (May 2017)

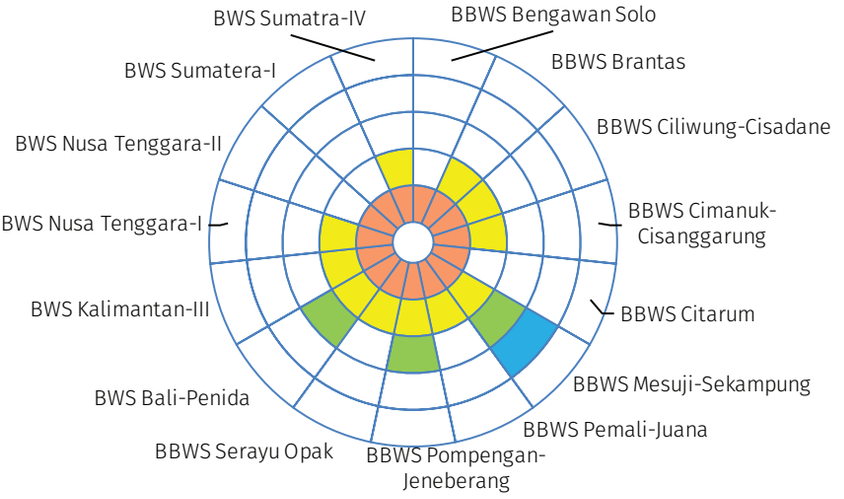


Workshop 3 (July 2017)

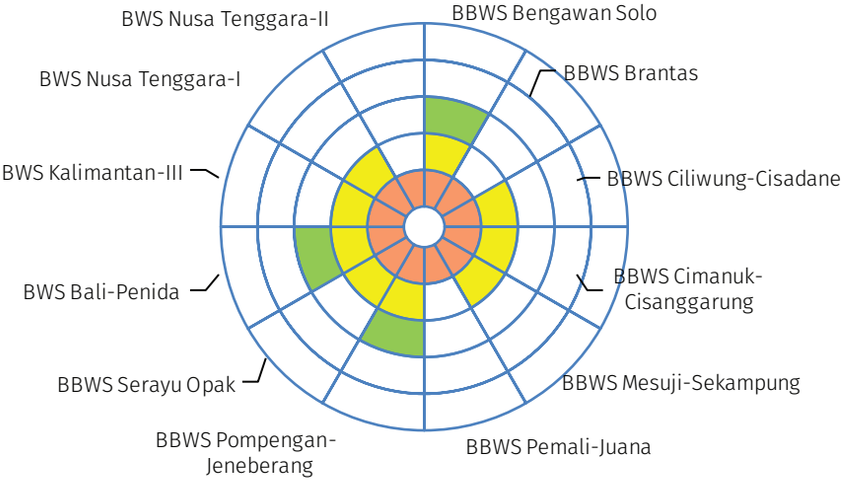


5. Spillway and Outlet Equipment

Workshop 2 (May 2017)

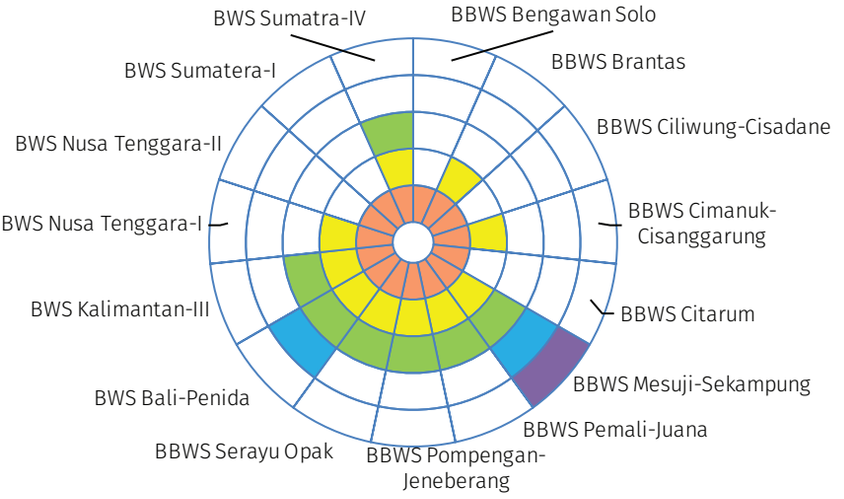


Workshop 3 (July 2017)

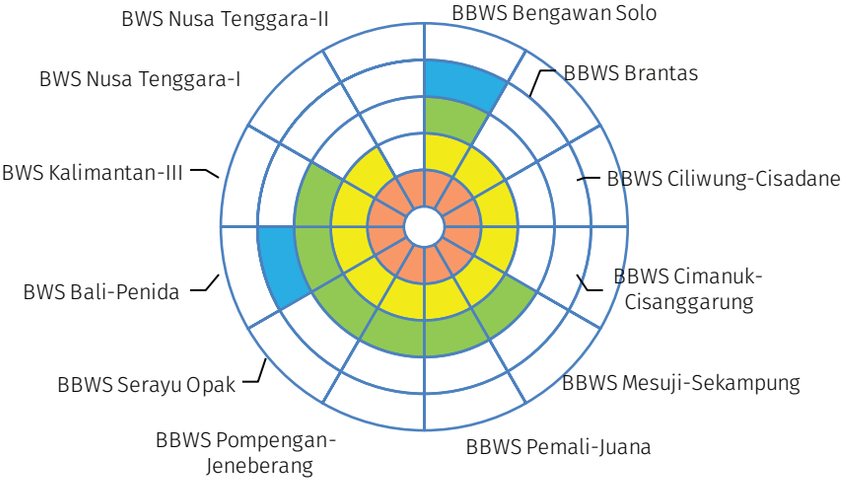


6. Reservoir Operations

Workshop 2 (May 2017)

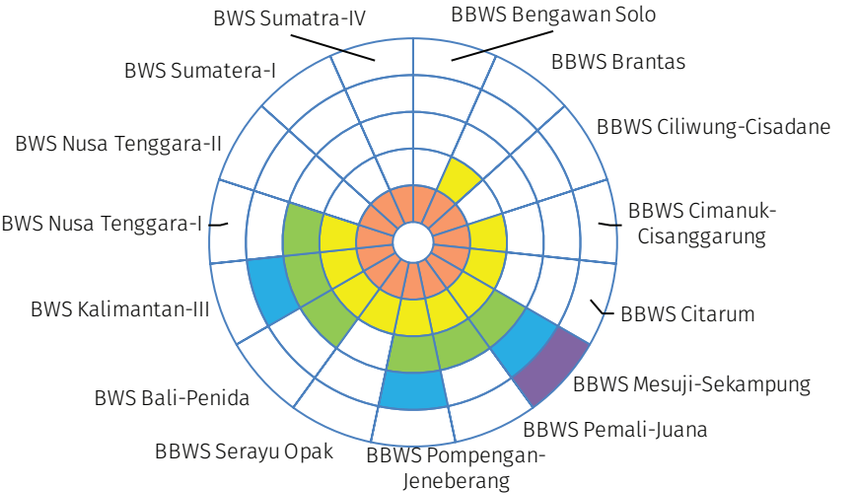


Workshop 3 (July 2017)

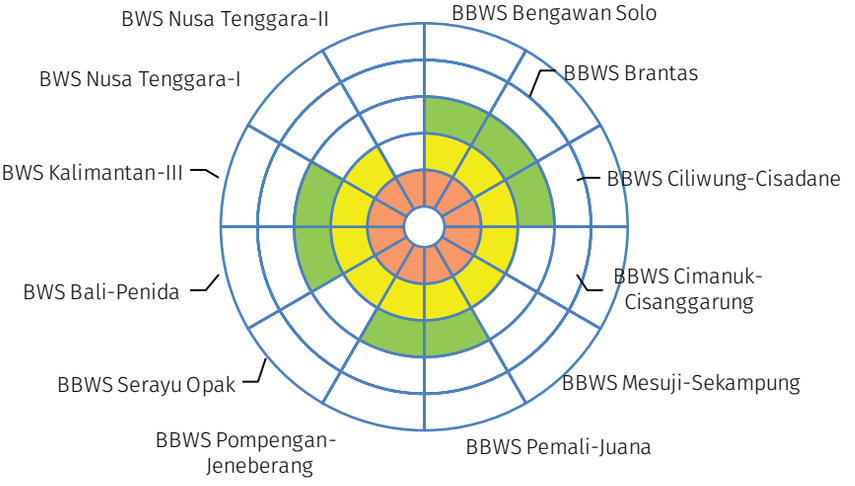


7. Dam and Spillway Maintenance

Workshop 2 (May 2017)

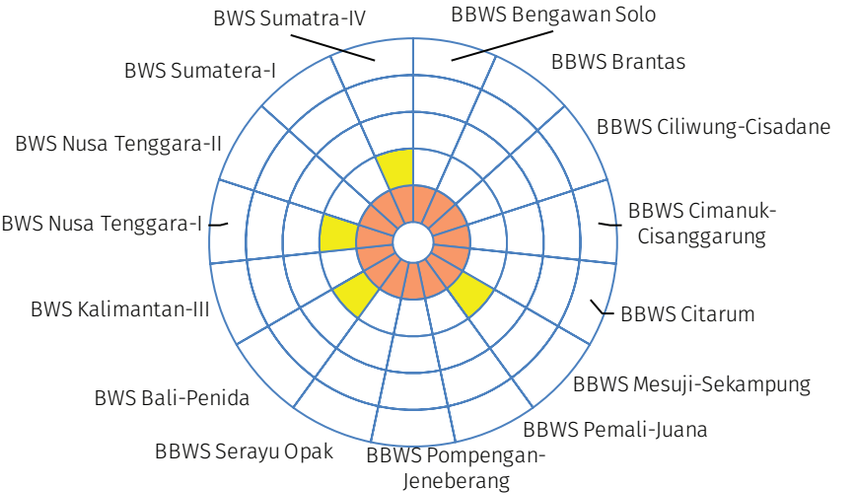


Workshop 3 (July 2017)

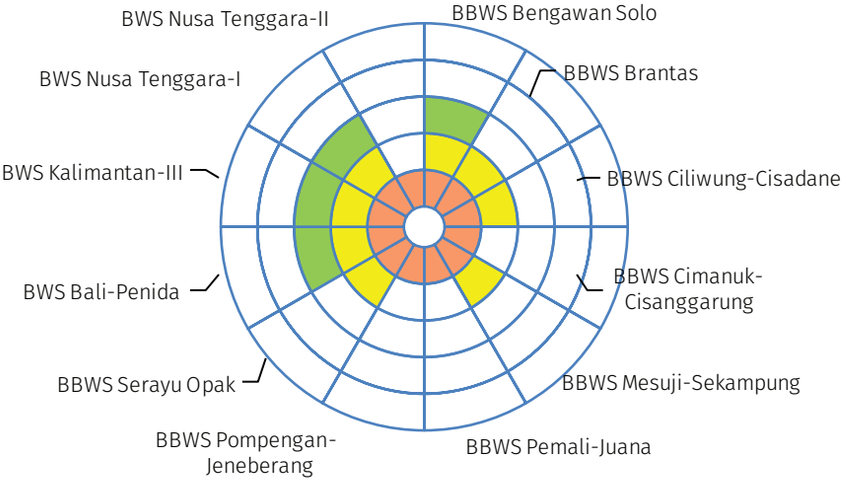


8. Emergency Preparedness

Workshop 2 (May 2017)

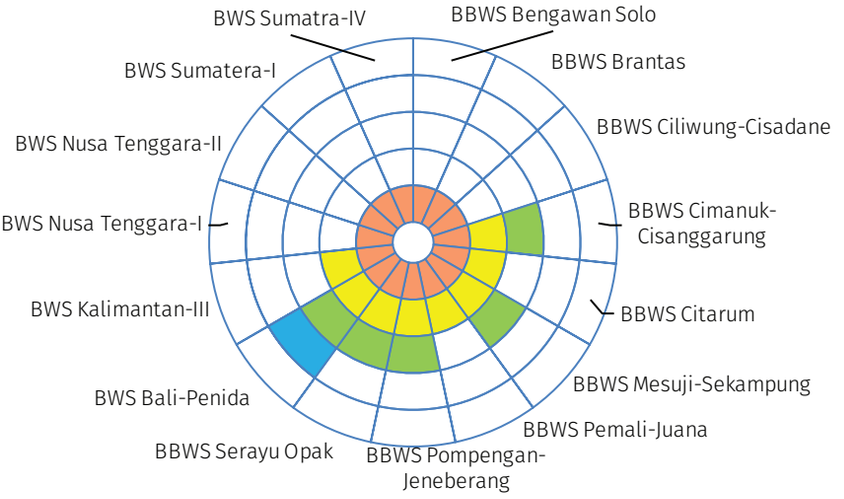


Workshop 3 (July 2017)

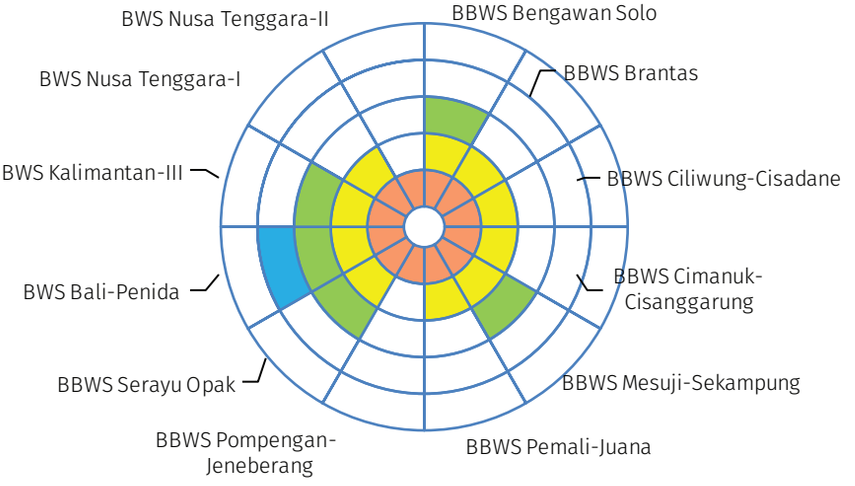


9. Managing Dam Safety Problems

Workshop 2 (May 2017)

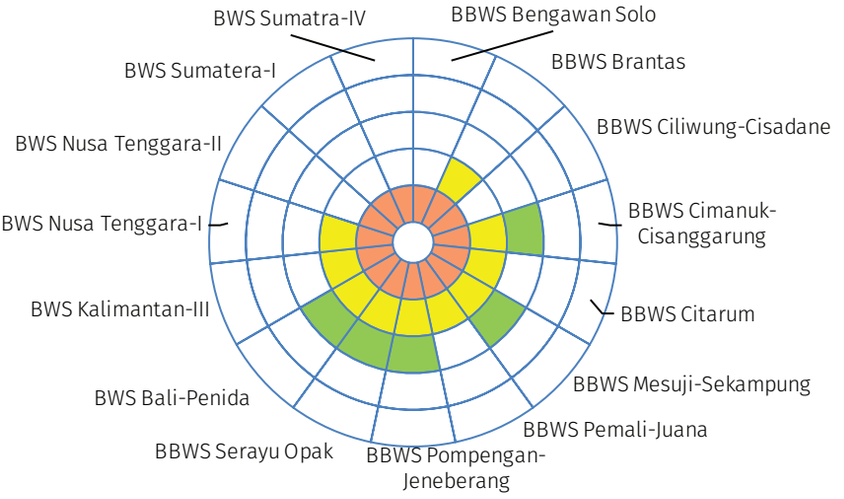


Workshop 3 (July 2017)

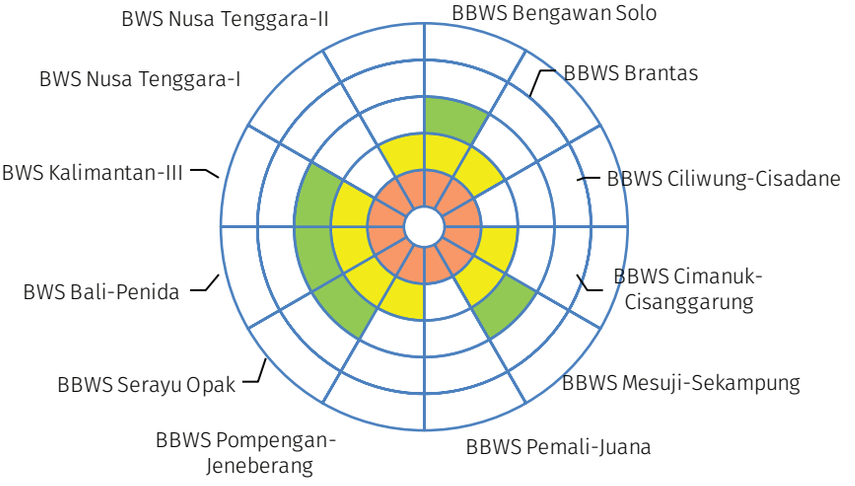


10. Audits and Reviews

Workshop 2 (May 2017)

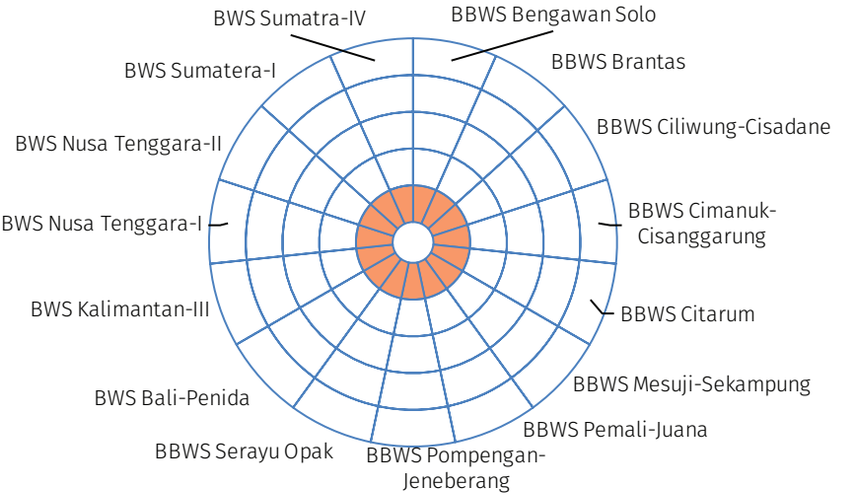


Workshop 3 (July 2017)

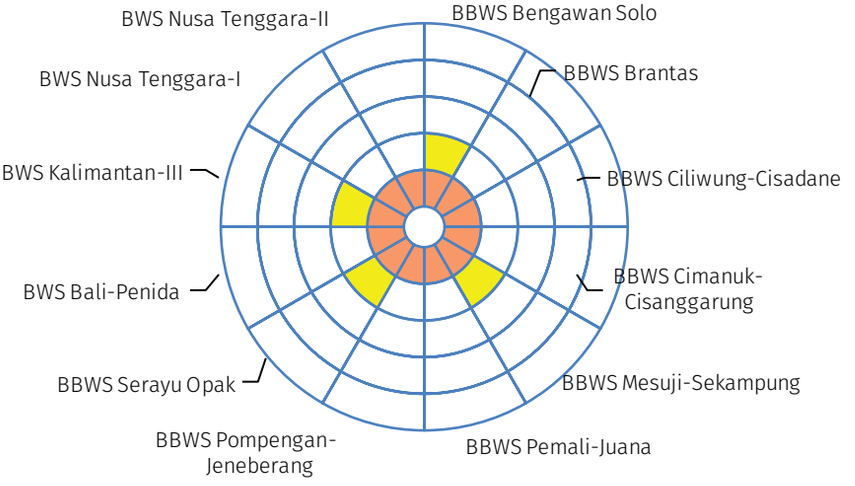


Component Overview

Workshop 2 (May 2017)



Workshop 3 (July 2017)



Appendix 3

This appendix defines the dam safety program component activities and differentiators for each of the 10 Component Matrices. The Maturity Matrices have been developed through a consultative process with dam safety officials from the river basin organisations in indonesia. They are intended to be specific to the Indonesian context and provide a method for assessing the effectiveness of the operation, maintenance, surveillance and emergency preparedness programs adopted by dam authorities.

Throughout it is important to keep in mind that it is an assessment of the dam safety activities across the whole portfolio of dams managed by the Dam Management Unit which is being assessed. The assessment is not for an individual dam within a Dam Management Unit portfolio of dams.

Using Maturity Matrices to Evaluate Dam Safety Programs
Dam Safety Program MASTER MATRIX

NB: Master Matrix provides general description of what is contained in the component. It is not used for assessment.
DMU refers to Dam Management Unit, the organisational unit responsible for the safety of the dam.

Component	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
1. Governance	Poor understanding of Dam Safety issues and risks, and poor recognition of resourcing needs	Incomplete understanding of Dam Safety problems and risks. Incomplete recognition of resourcing needs. Problem management considered generally in isolation from the organization's overall problem management policy and practice.	Generally complete understanding of Dam Safety problems. Generally complete recognition of resourcing needs. Problem management sometimes considered in conjunction with the organization's overall problem management policy and practice.	Comprehensive understanding of Dam Safety problems. Full recognition of resourcing needs throughout DMU. Problem management fully integrated with the organization's overall problem management policy and practice.	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of dam safety program governance.
2. Information Management	Little or no information cataloguing, security, and search and retrieval tools	Limited information cataloguing, security, and search and retrieval tools	Effective information cataloguing, security, and search and retrieval tools	Efficient information cataloguing, security, and search and retrieval tools, with appropriate training of DMU staff	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of dam safety information management.
3. Dam Safety Training and Education	Little or no training with no consideration of dam safety education, knowledge transfer and succession planning	Some training with little consideration of dam safety education, knowledge transfer and succession planning	Structured training with some consideration of dam safety education, knowledge transfer, succession planning, and dam safety portfolio problems	Comprehensive training with consideration of dam safety education, knowledge transfer and succession planning, and high level of understanding of dam safety portfolio problems	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of dam safety training and education.
4. Surveillance	Program developed with little or no consideration of consequences of failure. Program insufficient for dam safety assessment.	Program developed with some consideration of consequences of failure. Program sufficient for limited dam safety assessment.	Program developed with consideration of consequences of failure. Program sufficient for dam safety assessment.	Program developed with consideration of likelihood and consequences of failure. Program sufficient for comprehensive dam safety assessment.	Generally meeting Best Practice level, and also developing, trialing and implementing new technology, methods and systems to improve effectiveness of surveillance.
5. Spillway and Outlet Equipment	Program developed with little or no consideration of reliability or consequences of failure. Program insufficient for spillway and outlet equipment performance assessment.	Program developed with some consideration of reliability and consequences of failure. Program sufficient for limited spillway and outlet equipment system performance assessment.	Program developed with consideration of reliability and consequences of failure. Program sufficient for spillway and outlet equipment system performance assessment.	Program developed with consideration of reliability, likelihood and consequences of failure. Program sufficient for comprehensive spillway and outlet equipment system performance assessment.	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve reliability and performance assessment of spillway and outlet equipment.
6. Reservoir Operations	Reservoir operations established with little or no understanding of reservoir safety. Poor relationships with communities.	Reservoir operations established with some understanding of reservoir safety. Some functional relationships with communities.	Reservoir operations established with a good level of understanding of reservoir safety. Generally strong relationships and good level of common understanding with communities.	Reservoir operations established with a high level of understanding of reservoir safety. Strong relationships and high level of common understanding and collaboration with communities.	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of reservoir operations and safety of communities.
7. Dam and Spillway Maintenance	Unstructured maintenance with little or no consideration of consequences of failure	Maintenance considers some consequences of failure	Structured maintenance considers consequences of failure	Well structured maintenance based on failure modes and likelihood and consequences of failure	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of dam and spillway maintenance.
8. Emergency Preparedness	Emergency Preparedness Plans are non-existent or show little or no understanding of emergency issues	Basic level of understanding of emergency issues with Emergency Preparedness Plans based on some stakeholder and public consultation	Good level of understanding of emergency issues with Emergency Preparedness Plans based on established emergency processes and stakeholder and public consultation	High level of understanding of emergency issues with Emergency Preparedness Plans based on established emergency processes and high level of stakeholder public consultation	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of emergency preparedness.
9. Managing Dam Safety Problems	Little or no consideration of dam safety problems	Incomplete consideration of dam safety problems. Prioritization and resolution considers some consequences of failure.	Generally complete consideration of dam safety problems. Prioritization and resolution considers consequences of failure.	Comprehensive consideration of dam safety problems. Prioritization and resolution based on high level of understanding of failure modes, likelihood and consequences of failure risk.	Generally meeting Best Practice level, and also developing, trialling and implementing new technology, methods and systems to improve effectiveness of dam safety problem management.
10. Audits and Reviews	Poorly developed program. Low commitment and response to findings.	Incomplete consideration of Dam Management Unit's (DMU's) dam portfolio in program. Commitment and some response to some findings.	Generally complete consideration of DMU's dam portfolio in program. Demonstrated organizational commitment and response to findings.	Full consideration of DMU's dam portfolio and dam safety risks in program. High level of organizational commitment, transparency and active response to findings.	Generally meeting Best Practice level, and also developing, trialling and implementing new methods and systems to improve effectiveness of audits and reviews.

Using Maturity Matrices to Evaluate Dam Safety Programs

Component 1: Governance Maturity Matrix

Governance is defined as the organizational commitment to, and resourcing and oversight of, the effective delivery of a dam safety program and management of dam safety risk.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
1-A. Policy and Regulation [Regulations and Policy regarding dam safety.]	(a) Little or no understanding of relevant policies and regulations.	(a) Some understanding of relevant policies and regulations.	(a) Relevant policies and regulations generally understood.	(a) Relevant Policies and regulations well understood.	(a) Relevant Policies and regulations well understood, with good relationship with the Dam Safety Commission
	(b) Relevant policy and regulations not met.	(b) Relevant policies and regulations generally met.	(b) Relevant policy and regulations met.	(b) Relevant policies and regulations met and sometimes exceeded.	(b) Relevant policy and regulations met and generally exceeded.
1-B. Roles & Responsibilities [Roles and Responsibilities as they relate to the Dam Safety Program]	(a) Little or no definition and understanding of roles and responsibilities.	(a) Roles and responsibilities are poorly defined and understood.	(a) Roles and responsibilities are generally defined and understood.	(a) Roles and responsibilities are well defined and understood locally.	(a) Roles and responsibilities are well defined and understood throughout the Dam Management Unit (DMU) and Ministry.
	(b) Personnel not enabled to perform roles and responsibilities.	(b) Personnel poorly enabled to perform roles and responsibilities.	(b) Personnel enabled to perform roles and responsibilities.	(b) Personnel enabled and encouraged to perform roles and responsibilities.	(b) Personnel enabled and strongly encouraged to perform roles and responsibilities and improve dam safety outcomes.
1-C. Internal & External Communication [Internal communications within the DMU, Ministry of Public Works and Housing. External communication with the community]	(a) Poor communication within and between the DMU and Ministry.	(a) Communication confined to formal lines of communication within the DMU and between DMU and Ministry.	(a) Two-way formal and informal communication happens between all levels within the DMU and Ministry.	(a) Effective two-way formal and informal communication between all levels within the DMU and Ministry.	(a) Effective and regular two-way formal and informal communication between all levels within the DMU and Ministry.
	(b) Little or no external communication between the DMU and key stakeholders.	(b) Only informal external communication happens between the DMU and key stakeholders.	(b) Two-way external communication happens between the DMU and key stakeholders.	(b) Effective two-way external communication exists between the DMU and key stakeholders.	(b) Effective and regular two-way external communication happens between the DMU and key stakeholders.
1-D. Resourcing [Provision of appropriate human, financial and equipment resources for delivery of the Dam Safety Program]	(a) Financial and equipment resources fall well short to achieve basic outcomes of dam safety program	(a) Financial and equipment resources insufficient to achieve all basic outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve basic outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve a high level of outcomes of dam safety program	(a) Financial and equipment resources sufficient to achieve a high level of efficient outcomes of dam safety program and to implement improvement opportunities
	(b) Human resources fall well short to achieve basic outcomes of dam safety program	(b) Human resources insufficient to achieve all basic outcomes of dam safety program	(b) Human resources sufficient to achieve basic outcomes of dam safety program	(b) Human resources sufficient to achieve a high level of outcomes of dam safety program	(b) Human resources sufficient to achieve a high level of efficient outcomes of dam safety program and to implement improvement opportunities
	(c) Little or no succession planning.	(c) Succession planning and implementation is inadequate.	(c) Succession planning and implementation generally in place.	(c) Succession planning fully in place and implemented	(c) Succession planning fully in place to improve dam safety outcomes and implemented

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 2: Information Management Maturity Matrix

Information Management is defined as the collation, cataloguing, safe storage, retrieval and change control of all documented information relevant to the delivery of a dam safety program. Management of surveillance time-series data is evaluated in Surveillance Sub-Matrix Component 4.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
2-A. Indonesian Standards, Regulations, Policies, Plans and Procedures [Dam Safety related]	(a) Little or no information is stored	(a) Some information is stored and secure	(a) Information is stored and secure	(a) Information is stored and secure, with digital backup	(a) Information is stored and secure, with encryted digital backup
	(b) Limited catalogue of information	(b) Some information is catalogued	(b) Information is generally catalogued	(b) Information is well catalogued	(b) Information is comprehensively catalogued
	(c) Ineffective search and retrieval of information	(c) Effective search and retrieval of some information	(c) Effective search and retrieval of information	(c) Efficient search and retrieval of information	(c) Comprehensive search and retrieval of information
	(d) Little or no up-to-date information	(d) System for maintaining up-to-date information	(d) Effective system for maintaining up-to-date information	(d) Efficient system for maintaining up-to-date information	(d) Comprehensive system for maintaining up-to-date information, with notifications about updates
2-B. Physical Assets [Technical information (incl. drawings) on dams, appurtenant structures, spillway and outlet equipment, investigations, design and construction, upgrades, instruments, reservoir slopes, roads, services]	(a) Little or no information is stored	(a) Some information is stored and secure	(a) Information is stored and secure	(a) Information is stored and secure, with digital backup	(a) Information is stored and secure, with encryted digital backup
	(b) Limited catalogue of information	(b) Some information is catalogued	(b) Information is generally catalogued	(b) Information is well catalogued	(b) Information is comprehensively catalogued
	(c) Ineffective search and retrieval of information	(c) Effective search and retrieval of some information	(c) Effective search and retrieval of information	(c) Efficient search and retrieval of information	(c) Comprehensive search and retrieval of information
	(d) Little or no up-to-date information	(d) System for maintaining up-to-date information	(d) Effective system for maintaining up-to-date information	(d) Efficient system for maintaining up-to-date information	(d) Comprehensive system for maintaining up-to-date information, with notifications about updates
2-C. Operational Information [Information that documents the ongoing operation, maintenance and surveillance of dams and their reservoirs. Includes procedures, maintenance history, photos and videos, incident reports, changes in operation.]	(a) Little or no information is stored	(a) Some information is stored and secure	(a) Information is stored and secure	(a) Information is stored and secure, with digital backup	(a) Information is stored and secure, with encryted digital backup
	(b) Limited catalogue of information	(b) Some information is catalogued	(b) Information is generally catalogued	(b) Information is well catalogued	(b) Information is comprehensively catalogued
	(c) Ineffective search and retrieval of information	(c) Effective search and retrieval of some information	(c) Effective search and retrieval of information	(c) Efficient search and retrieval of information	(c) Comprehensive search and retrieval of information
	(d) Little or no up-to-date information	(d) System for maintaining up-to-date information	(d) Effective system for maintaining up-to-date information	(d) Efficient system for maintaining up-to-date information	(d) Comprehensive system for maintaining up-to-date information, with notifications about updates
2-D. Studies, Reviews and Reports (incl. compliance) [Information that documents studies and reviews undertaken on, or in relation to, dams and their reservoirs. Includes dam classifications, identification of threats, performance assessments, safety reviews, reporting to the Dam Safety Commission.]	(a) Little or no information is stored	(a) Some information is stored and secure	(a) Information is stored and secure	(a) Information is stored and secure, with digital backup	(a) Information is stored and secure, with encryted digital backup
	(b) Limited catalogue of information	(b) Some information is catalogued	(b) Information is generally catalogued	(b) Information is well catalogued	(b) Information is comprehensively catalogued
	(c) Ineffective search and retrieval of information	(c) Effective search and retrieval of some information	(c) Effective search and retrieval of information	(c) Efficient search and retrieval of information	(c) Comprehensive search and retrieval of information
	(d) Little or no up-to-date information	(d) System for maintaining up-to-date information	(d) Effective system for maintaining up-to-date information	(d) Efficient system for maintaining up-to-date information	(d) Comprehensive system for maintaining up-to-date information, with notifications about updates

Using Maturity Matrices to Evaluate Dam Safety Programs

Component 3: Dam Safety Training and Education Maturity Matrix

Dam Safety Training and Education of persons responsible for and involved with the Dam Safety Program as appropriate to the nature of the dam safety activities and level of risk involved with each.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
3-A. Dam Safety Training [Training program for managers, supervisors, engineers and surveillance inspectors]	(a) Training in principles of dam safety management focussed on responsibilities of Dam Management Unit (DMU) managers* and supervisors of Dam Safety Unit and Dam Management Unit	(a) Comprehensive training in principles of dam safety management focussed on responsibilities of DMU managers* and supervisors of Dam Safety Unit and Dam Management Unit	(a) Comprehensive training, including refresher courses, in principles of dam safety management focussed on responsibilities of DMU managers* and supervisors of Dam Safety Unit and Dam Management Unit	(a) Comprehensive training in principles of dam safety management focussed on responsibilities of DMU managers* and supervisors of Dam Safety Unit and Dam Management Unit	(a) Comprehensive training, including refresher courses, in principles of dam safety management focussed on responsibilities of DMU managers* and supervisors of Dam Safety Unit and Dam Management Unit
	(b) Training in dam behaviour, failure modes and features of DMU's dams, their dam instrumentation and the analysis of surveillance data to establish safety status of dams, for DMU engineers and technicians in dam safety program	(b) Comprehensive training in dam behaviour, failure modes and features of DMU's dams, their dam instrumentation and the analysis of surveillance data to establish safety status of dams, for DMU engineers and technicians in dam safety program	(b) Comprehensive training, including refresher courses, in dam behaviour, failure modes and features of DMU's dams, their dam instrumentation and the analysis of surveillance data to establish safety status of dams, for DMU engineers and technicians in dam safety program	(b) Comprehensive training in dam behaviour, failure modes and features of DMU's dams, their dam instrumentation and the analysis of surveillance data to establish safety status of dams, for DMU engineers and technicians in dam safety program	(b) Comprehensive training, including refresher courses, in dam behaviour, failure modes and features of DMU's dams, their dam instrumentation and the analysis of surveillance data to establish safety status of dams, for DMU engineers and technicians in dam safety program
	(c) Training in dam inspections, instrumentation readings, maintenance and calibration, general dam behaviour and warning signs and actions specific to DMU's dams, for DMU surveillance inspectors	(c) Comprehensive training in dam inspections, instrumentation readings, maintenance and calibration, general dam behaviour and warning signs and actions specific to DMU's dams, for DMU surveillance inspectors	(c) Comprehensive training, including refresher courses, in dam inspections, instrumentation readings, maintenance and calibration, general dam behaviour and warning signs and actions specific to DMU's dams, for DMU surveillance inspectors	(c) Comprehensive training in dam inspections, instrumentation readings, maintenance and calibration, general dam behaviour and warning signs and actions specific to DMU's dams, for DMU surveillance inspectors	(c) Comprehensive training, including refresher courses, in dam inspections, instrumentation readings, maintenance and calibration, general dam behaviour and warning signs and actions specific to DMU's dams, for DMU surveillance inspectors
	(d) General monitoring of training program content and its implementation	(d) Monitoring of training program content and its implementation	(d) Monitoring of training program content and its implementation, with continuous improvement	(d) Monitoring of training program content and its implementation	(d) Monitoring of training program content and its implementation, with continuous improvement
3-B. Spillway and Outlet Equipment [Training program for persons involved with the operation, maintenance, inspection and testing of spillway and outlet equipment essential for safe control of the reservoir]	(a) Training in equipment operation and maintenance, reliability requirements, equipment failure modes, consequences of equipment failure, and effect on dam safety, for DMU equipment engineers	(a) Comprehensive training in equipment operation and maintenance, reliability requirements, equipment failure modes, consequences of equipment failure, and effect on dam safety, for DMU equipment engineers	(a) Comprehensive training, including refresher courses, in equipment operation and maintenance, reliability requirements, equipment failure modes, consequences of equipment failure, and effect on dam safety, for DMU equipment engineers	(a) Comprehensive training in equipment operation and maintenance, reliability requirements, equipment failure modes, consequences of equipment failure, and effect on dam safety, for DMU equipment engineers	(a) Comprehensive training, including refresher courses, in equipment operation and maintenance, reliability requirements, equipment failure modes, consequences of equipment failure, and effect on dam safety, for DMU equipment engineers
	(b) Training in practical operation and maintenance of equipment, with an appreciation of reliability requirements, equipment failure modes, and consequences of equipment failure, for operators and maintainers	(b) Comprehensive training in practical operation and maintenance of equipment, with an appreciation of reliability requirements, equipment failure modes, and consequences of equipment failure, for operators and maintainers	(b) Comprehensive training, including refresher courses, in practical operation and maintenance of equipment, with an appreciation of reliability requirements, equipment failure modes, and consequences of equipment failure, for operators and maintainers	(b) Comprehensive training in practical operation and maintenance of equipment, with an appreciation of reliability requirements, equipment failure modes, and consequences of equipment failure, for operators and maintainers	(b) Comprehensive training, including refresher courses, in practical operation and maintenance of equipment, with an appreciation of reliability requirements, equipment failure modes, and consequences of equipment failure, for operators and maintainers
	(c) General monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation, with continuous improvement	(c) Monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation, with continuous improvement

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
3-C. River Basin Management and Reservoir Operation [Training program for persons involved with the operation of river basins and reservoirs, as relevant to dam safety function]	(a) Training in operating rules for management of river basin reservoir flows to avoid overtopping; critical dam and equipment features and impacts; impact on communities vulnerable to flooding, for DMU River Basin Manager(s)	(a) Comprehensive training in operating rules for management of river basin reservoir flows to avoid overtopping; critical dam and equipment features and impacts; impact on communities vulnerable to flooding, for DMU River Basin Manager(s)	(a) Comprehensive training, including refresher courses, in operating rules for management of river basin reservoir flows to avoid overtopping; critical dam and equipment features and impacts; impact on communities vulnerable to flooding, for DMU River Basin Manager(s)	(a) Comprehensive training in operating rules for management of river basin reservoir flows to avoid overtopping; critical dam and equipment features and impacts; impact on communities vulnerable to flooding, for DMU River Basin Manager(s)	(a) Comprehensive training, including refresher courses, in operating rules for management of river basin reservoir flows to avoid overtopping; critical dam and equipment features and impacts; impact on communities vulnerable to flooding, for DMU River Basin Manager(s)
	(b) Training in operating rules, equipment operation and performance and effect on dam safety and communities vulnerable to flooding, for DMU's Reservoir Manager	(b) Comprehensive training in operating rules, equipment operation and performance and effect on dam safety and communities vulnerable to flooding, for DMU's Reservoir Manager	(b) Comprehensive training, including refresher courses, in operating rules, equipment operation and performance and effect on dam safety and communities vulnerable to flooding, for DMU's Reservoir Manager	(b) Comprehensive training in operating rules, equipment operation and performance and effect on dam safety and communities vulnerable to flooding, for DMU's Reservoir Manager	(b) Comprehensive training, including refresher courses, in operating rules, equipment operation and performance and effect on dam safety and communities vulnerable to flooding, for DMU's Reservoir Manager
	(c) General monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation, with continuous improvement	(c) Monitoring of training program content and its implementation	(c) Monitoring of training program content and its implementation, with continuous improvement
3-D. Incident and Emergency Preparedness Training and Education [Training and Education program for persons involved with incident and emergency management, including dam safety personnel, operational personnel and wider ministry officials]	(a) Training in incident management and emergency preparedness plans, and downstream consequences of failure, of DMU managers, engineers, and supervisors in dam safety program	(a) Comprehensive training in incident management and emergency preparedness plans, and downstream consequences of failure, of DMU managers, engineers and supervisors in dam safety program	(a) Comprehensive training, including refresher courses, in incident management and emergency preparedness plans, and downstream consequences of failure, of DMU managers, engineers and supervisors in dam safety program	(a) Comprehensive training in incident management and emergency preparedness plans, and downstream consequences of failure, of DMU managers, engineers and supervisors in dam safety program	(a) Comprehensive training, including refresher courses, in incident management and emergency preparedness plans, and downstream consequences of failure, of DMU managers, engineers and supervisors in dam safety program
	(b) Training in incident management and emergency equipment operation, and consequences of equipment failure, of DMU operators and their supervisors	(b) Comprehensive training in incident management and emergency equipment operation, and consequences of equipment failure, of DMU operators and their supervisors	(b) Comprehensive training, including refresher courses, in incident management and emergency equipment operation, and consequences of equipment failure, of DMU operators and their supervisors	(b) Comprehensive training in incident management and emergency equipment operation, and consequences of equipment failure, of DMU operators and supervisors	(b) Comprehensive training, including refresher courses, in incident management and emergency equipment operation, and consequences of equipment failure, of DMU operators and supervisors
	(c) Education in incident management and emergency preparedness, of wider ministry officials that contribute to dam safety outcomes	(c) Comprehensive education in incident management and emergency preparedness, of wider ministry officials that contribute to dam safety outcomes	(c) Comprehensive education, including refresher courses, in incident management and emergency preparedness, of wider ministry officials that contribute to dam safety outcomes	(c) Comprehensive education in incident management and emergency preparedness, of wider ministry officials that contribute to dam safety outcomes	(c) Comprehensive education, including refresher courses, in incident management and emergency preparedness, of wider ministry officials that contribute to dam safety outcomes
	(d) General monitoring of training program content and its implementation	(d) Comprehensive monitoring of training program content and its implementation	(d) Comprehensive monitoring of training program content and its implementation, with continuous improvement	(d) Monitoring of training program content and its implementation	(d) Monitoring of training program content and its implementation, with continuous improvement

* DMU managers includes both those with dam safety responsibility and those with responsibility for whole of organization decisions and financial approvals

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 4: Surveillance Maturity Matrix

Surveillance is defined as the close monitoring of dam behaviour, including collection, analysis and evaluation of data from visual inspections and instrumentation. Includes containment or outlet structures that have a dam (reservoir) safety function. May include a variety of appurtenant structures including tunnels, penstocks, supply outlets and spillways including their energy dissipation facilities.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
4-A. Surveillance Program [It is about the DMU management of the surveillance programs carried out for their portfolio of dams, the way this management is set up, and it's execution. It si not about the activities required to either implement the surveillance of each dam, or to manage the overall surveillance program.]	(a) Program developed with little or no consideration of consequences of failure, dam height or reservoir volume	(a) Program developed with consideration of consequences of failure including dam height and reservoir volume	(a) Program developed with consideration of consequences of failure, including downstream consequences, dam type and performance history	(a) Program developed with consideration of consequences of failure, failure modes, and performance history	(a) Program developed based on consequences of failure (dam break analysis), failure modes and performance history
	(b) Little or no documentation of surveillance program	(b) Partial documentation of surveillance program	(b) Generally complete documentation of surveillance program	(b) High degree of documentation of surveillance program	(b) High degree of detailed documentation of surveillance program
	(c) Minimal delivery of program	(c) Incomplete delivery of program.	(c) Program delivered and generally meets quality assurance objectives	(c) Program delivered and meets quality assurance objectives	(c) Program delivered and exceeds quality assurance objectives
	(d) Little or no process for escalation of surveillance issues	(d) Process exists for escalation of surveillance issues	(d) Structured process and practice for escalation of surveillance problems	(d) Structured process and practice for escalation and tracking of surveillance problems.	(d) Well-structured process and practice for escalation of surveillance problems tracked to resolution
4-B. Inspections [Visual inspection of dams and appurtenant structures]	(a) Unstructured inspections with little or no consideration of consequences of failure including dam height and reservoir volume	(a) Inspections with some structure and consideration of consequences of failure including dam height and reservoir volume	(a) Structured inspections consider consequences of failure including downstream consequences, dam type and performance history	(a) Well-structured inspections with consideration of consequences of failure, failure modes, and performance history	(a) Scope and frequency of inspections based on consequences of failure (dam break analysis) and failure modes, performance history
	(b) Little or no recording and reporting of inspections	(b) Incomplete recording and reporting of inspections	(b) Generally complete recording and reporting of inspections	(b) Systematic and thorough recording and reporting of inspections.	(b) Systematic and thorough recording and reporting of inspections, evidenced by specific attention to anomalies (e.g. photographic record, leakage water samples, measurements)
	(c) Little or no process for escalation of inspection problems	(c) Process exists for escalation of inspection problems	(c) Structured process exists for escalation of inspection problems	(c) Structured process exists for escalation and tracking of inspection problems	(c) Well-structured process exists for escalation of inspection problems and problems tracked to resolution
4-C. Instrumentation and Data Management (includes Lake Levels and Surveys) - applies to whole dam portfolio [Instruments installed, maintained, and monitored for assessing dam performance and detecting failure modes. Data management relates to the overall system used for data collection, telemetry, storage, retrieval and quality assurance.]	(a) Little or no instrumentation contributing to Dam Safety Assessments.	(a) Instrumentation contributing to some Dam Safety Assessments.	(a) Reliable instrumentation contributing to key Dam Safety Assessments.	(a) Reliable instrumentation contributing to most Dam Safety Assessments.	(a) Comprehensive, reliable instrumentation contributing to all Dam Safety Assessments.
	(b) Little or no instrument maintenance for calibration and functionality	(b) Reactive instrument maintenance for calibration and functionality	(b) Instruments generally maintained for calibration and functionality	(b) Instruments systematically maintained for calibration and functionality	(b) Proactive instrument maintenance for calibration and functionality
	(c) Little or no documentation of installation, operation and maintenance	(c) Incomplete documentation of installation, operation and maintenance	(c) Generally complete documentation and good level of understanding of installation, operation and maintenance	(c) Comprehensive documentation and understanding of installation, operation and maintenance	(c) Complete documentation and understanding of installation, operation and maintenance
	(d) Little or no instrument data collection, data management and quality assurance	(d) Some planned instrument data collection and basic data management with some quality assurance	(d) Generally complete instrument data collection, data management, quality assurance and data security, with data accessible as time-history	(d) Comprehensive instrument data collection, well-structured data management, quality assurance and data security, with data accessible and suitable for time-history and other analysis	(d) Comprehensive instrument data collection, well-structured data management, quality assurance and data security, with data accessible and suitable for time-history and other analysis. Capability to install data logging or remote reading of instruments, when necessary.
	(e) Little or no process for identification and escalation of instrument alarm issues	(e) Ad-hoc process exists for identification and escalation of instrument alarm issues	(e) Structured process in place for identification, recording and escalation of instrument alarm problems, and problems tracked	(e) Well-structured process in place for identification, recording and escalation of instrument alarm problems and problems tracked to resolution	(e) Well-structured process in place for identification, recording and escalation of instrument alarm problems and problems tracked to resolution in suitable time-frame.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
4-D. Dam Safety Assessment [Analysis and evaluation of the dam's condition and performance, resulting in an assessment of its safety status]	(a) Little or no condition and performance evaluation. No statement of safety status of each dam.	(a) Condition and performance evaluation considers dam type, inspection and instrumentation information and the performance history of the dam. Lacking clear statement of safety status of each dam.	(a) Condition and performance evaluation considers dam type, inspection and instrumentation information, performance history of the dam, knowledge of the expected performance of the design, some awareness and consideration of failure modes. Clear statement of safety status of each dam.	(a) Condition and performance evaluation considers dam type, inspection and instrumentation information, performance history of the dam, knowledge of the expected performance of the design with consideration of failure modes. Clear statement of safety status of each dam.	(a) Condition and performance evaluation based on consequences of failure, dam type, inspection and instrumentation information, the performance history of the dam, knowledge of the expected performance of the design with full consideration of applicable failure modes. Clear statement of safety status of each dam.
	(b) No review of dam safety assessment.	(b) Little review of dam safety assessment.	(b) Review of dam safety assessment by dam safety engineer.	(b) Review of dam safety assessment by senior dam safety engineer.	(b) Review of dam safety assessment by dam safety specialist.
	(c) Little or no reporting of evaluation findings and surveillance problems	(c) Incomplete reporting of evaluation findings and surveillance problems	(c) Generally complete reporting of evaluation findings and surveillance problems tracked	(c) Comprehensive reporting of evaluation findings and surveillance problems tracked to resolution	(c) Comprehensive reporting of evaluation findings and surveillance problems tracked to resolution in a suitable time-frame.
	(d) Little or no identification and referral of dam safety problems	(d) Some identification and referral of dam safety problems	(d) Generally complete identification and referral of dam safety problems	(d) Complete identification and referral of dam safety problems	(d) Complete identification and referral of dam safety problems in a suitable time-frame

Using Maturity Matrices to Evaluate Dam Safety Programs

Component 5: Spillway and Outlet Equipment Maturity Matrix

Spillway and Outlet Equipment is defined as gates, valves and associated power supplies, control systems and communications that contribute to safety of the dam and reservoir. Includes equipment for outlet structures that perform a dam safety containment function i.e., electrical and mechanical components.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
5-A. Spillway and Outlet Equipment Program [It is about the spillway and outlet equipment program itself, the way it is set up, and its delivery. It is not about the activities required to deliver it.]	(a) Program developed with little or no consideration of reliability or likelihood of failure	(a) Program developed with some consideration of reliability and likelihood of failure	(a) Program developed with consideration of reliability and likelihood of failure. Some consideration of consequences of failure	(a) Program developed with consideration of reliability, likelihood and consequences of failure	(a) Program developed with consideration of reliability, likelihood and consequences of failure and failure modes
	(b) Little or no documentation	(b) Partial documentation	(b) Generally complete documentation	(b) High degree of documentation	(b) High degree of up-to-date documentation with digital backup
	(c) Poor delivery of program	(c) Incomplete delivery of program with some quality issues	(c) Program generally meets quality assurance objectives	(c) Program meets all quality assurance objectives	(c) Program meets or exceeds all quality assurance objectives
	(d) Little or no process for escalation of equipment problems	(d) Process exists for escalation of equipment problems	(d) Structured process and practice for escalation of equipment problems	(d) Well-structured process and practice for escalation of equipment problems and problems tracked to resolution	(d) Well-structured process and practice for escalation of equipment problems and problems tracked to resolution in a suitable time-frame
5-B. Inspections and Maintenance [Inspections and maintenance of spillway and outlet equipment to assess condition and reliability]	(a) Unstructured inspections and maintenance with little or no consideration of reliability or likelihood of failure	(a) Inspections and maintenance includes some consideration of reliability and likelihood of failure	(a) Inspections and maintenance based on reliability and likelihood of failure. Some consideration of consequences of failure	(a) Well-structured inspections and maintenance based on reliability, likelihood and consequences of failure	(a) Well-structured inspections and maintenance based on reliability, failure modes and likelihood and consequences of failure
	(b) Reliance on corrective maintenance but commonly delayed. Little or no preventive maintenance.	(b) Some corrective maintenance completed promptly. Some preventive maintenance.	(b) Emphasis on preventive maintenance. Corrective maintenance generally completed promptly	(b) Comprehensive preventive maintenance based on high level of understanding. Corrective maintenance completed promptly.	(b) Comprehensive preventive maintenance based on high level of understanding. Corrective maintenance completed promptly and considering enhancements requirements
	(c) Little or no recording and reporting of inspections and maintenance	(c) Incomplete recording and reporting of inspections and maintenance	(c) Generally complete recording and reporting of inspections and maintenance	(c) Systematic and thorough recording and reporting of inspections and maintenance	(c) Systematic and thorough recording and reporting of inspections and maintenance, included in a maintenance management system.
	(d) Little or no contingency plans and spares	(d) Some contingency plans and spares	(d) Generally complete contingency plans and spares inventory considering reliability and likelihood of failure	(d) Contingency plans and spares inventory based on reliability, failure modes and likelihood of failure	(d) Contingency plans and spares inventory based on reliability, failure modes and likelihood of failure and updated continuously.
	(e) Little or no process for escalation of inspection and maintenance issues	(e) Process exists for escalation of inspection and maintenance issues	(e) Structured process exists for escalation of inspection and maintenance problems	(e) Well-structured process exists for escalation of inspection and maintenance problems and problems tracked to resolution	(e) Well-structured process exists for escalation of inspection and maintenance problems and problems tracked to resolution in a suitable time-frame.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
5-C. Equipment Testing [Functional testing of spillway and outlet equipment, under a range of loading conditions, using all combinations of power supply and control, to confirm reliable operation]	(a) Testing program is insufficient to demonstrate performance of the equipment	(a) Testing program established as a routine and mostly sufficient to demonstrate performance of the equipment	(a) Testing program established as a routine and sufficient to demonstrate performance of the equipment, including wet tests of gates	(a) Testing program established as a routine and sufficient to demonstrate performance of the equipment, including wet tests of gates. Some testing of power supplies, instrumentation, controls, backup systems including measurement of electrical/ hydraulic loads, and operator capability	(a) Testing program established as a routine and sufficient to demonstrate performance of the equipment, including wet tests of gates. Key facilities identified for comprehensive testing of power supplies, instrumentation, controls, backup systems including measurement of electrical/ hydraulic loads, operator capability
	(b) Testing procedures are incomplete and developed with little or no consideration of operator safety, operating constraints, operator capability and training opportunities. Little or no documentation of test procedures.	(b) Testing procedures mostly complete with some consideration of operator safety, operating constraints, operator capability and training opportunities. Test procedures are mostly documented.	(b) Testing procedures generally consider operator safety, operating constraints, operator capability and training opportunities. Test procedures are documented. Consideration of communities impacted by testing	(b) Testing procedures fully consider operator safety, operating constraints, operator capability and training opportunities. Testing procedures are well documented, regularly revised and kept up-to-date. Communities impacted by equipment testing advised	(b) Testing procedures fully consider operator safety, operating constraints, operator capability and training opportunities. Testing procedures regularly revised and kept up-to-date. Communities impacted by equipment testing advised and managed to ensure public safety
	(c) Little or no testing carried out. Little or no documentation of test results.	(c) Testing is irregular and incomplete. Test results mostly documented in a check-sheet format.	(c) Programmed testing is mostly implemented. Test results are documented in a check-sheet format	(c) Programmed testing is implemented. Test results are well documented and include description of any problems	(c) Programmed testing is implemented. Test results are well documented and include description of any problems, along with suggested improvements
	(d) No process in place for recording, analysing, assessing and referral of equipment performance and test problems	(d) Incomplete process in place for recording, analysing, assessing and referral of equipment performance and test problems	(d) Process in place for recording, analysing, assessing and referral of equipment performance and test problems	(d) Process in place for recording, analysing, assessing and referral of equipment performance and test problems. Problems tracked to resolution	(d) Process in place for recording, analysing, assessing and referral of equipment performance and test problems. Problems tracked to resolution in a suitable time-frame
5-D. System Performance Assessment [Criteria for assessment of spillway and outlet equipment and overall system performance are the Indonesian dam safety standards, regulations and applicable guidelines]	(a) Little or no condition and performance assessment	(a) Condition and performance assessment considers reliability, consequences of failure and the performance history of the equipment	(a) Condition and performance assessment against criteria and considers problems identified during inspection, maintenance and testing, consequences of failure, the design and performance history of the equipment. Limited consideration of applicable failure modes.	(a) Condition and performance assessment against criteria and considers problems identified during inspection, maintenance and testing, consequences of failure, the design and performance history of the equipment. Consideration of applicable failure modes.	(a) Condition and performance assessment against criteria and considers problems identified during inspection, maintenance and testing, consequences of failure, the design and performance history of the equipment. Consideration of applicable failure modes, likelihood and consequence of failure.
	(b) Little or no consideration of inspection, maintenance and testing problems	(b) Some consideration of inspection, maintenance and testing problems	(b) Assessment includes most problems identified during inspection, maintenance and testing	(b) Assessment includes all problems identified during inspection, maintenance and testing	(b) Assessment includes all problems identified during inspection, maintenance and testing and other reviews
	(c) Little or no reporting of assessment findings and equipment problems	(c) Incomplete reporting of assessment findings and equipment problems	(c) Generally complete reporting of assessment findings and equipment problems. Preliminary level of prioritization of problems.	(c) Comprehensive reporting of assessment findings and equipment problems. All problems prioritized.	(c) Comprehensive reporting of assessment findings and equipment problems. All problems prioritized and a prioritized schedule of measures to restore functionality.
	(d) Little or no identification and referral of equipment-related dam safety problems	(d) Some identification and referral of equipment-related dam safety problems	(d) Referral of prioritized equipment-related dam safety problems	(d) Comprehensive referral of prioritized equipment-related dam safety problems and tracked to resolution	(d) Comprehensive referral of prioritized equipment-related dam safety problems and tracked to resolution in a timely manner

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 6: Reservoir Operations Maturity Matrix

Reservoir Operations is defined as the safe operation of dams and their reservoirs in the context of water management, operational and duty of care requirements and public safety.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
6-A. Operation Rules and Responsibilities [Rules, responsibilities and activities for the safe operation of dams and their reservoirs under all operating conditions]	(a) Procedures developed and maintained to operate the reservoir with little or no consideration of equipment capability and safety, and dam failure	(a) Procedures developed and maintained to operate the reservoir with some consideration of equipment capability and safety, and dam failure	(a) Procedures developed and maintained to operate the reservoir with consideration of equipment capability and safety, dam failure and safety of communities	(a) Procedures developed and maintained to operate the reservoir with consideration of equipment capability and safety, failure modes and safety of communities	(a) Procedures developed and maintained to operate the reservoir with consideration of equipment capability and safety, failure modes, likelihood of dam failure and safety of communities
	(b) Little or no understanding of reservoir operation and safety requirements by Dam Management Unit (DMU) staff	(b) Some understanding of reservoir operation and safety requirements by DMU staff	(b) Understanding of reservoir operation and safety requirements by DMU staff	(b) Understanding of reservoir operation and safety requirements by DMU staff including dam-specific critical failure modes	(b) Understanding of reservoir operation and safety requirements by DMU staff including dam-specific critical failure modes and relevant monitoring instrumentation
	(c) Little or no recording and reporting of reservoir operations	(c) Some recording and reporting of reservoir operations	(c) Mostly complete and adequate recording and reporting of reservoir operations	(c) Complete and adequate recording and reporting of reservoir operations	(c) Complete and up-to date adequate recording and reporting of reservoir operations
	(d) Little or no identification or management of reservoir operating problems	(d) Unstructured process for identification and management of reservoir operating problems	(d) Structured process for identification and management of reservoir operating problems	(d) Structured process for identification and management of reservoir operating problems, and problems tracked to resolution	(d) Structured process for identification and management of reservoir operating problems, and problems tracked to resolution in a timely manner
6-B. Relationships with Communities [Liaison and relationship with external communities affected by reservoir operation, including land and water users and public]	(a) Weak or no community relationships with little or no common understanding of reservoir operations and their effects	(a) Functional community relationships with some common understanding of reservoir operations and their effects	(a) Mostly strong community relationships with good level of common understanding of reservoir operations and their effects	(a) Strong community relationships with common understanding of reservoir operations and their effects	(a) Excellent community relationships with common understanding of reservoir operations and their effects
	(b) Little or no contacts with community	(b) Some contacts with community kept up-to-date	(b) Contacts with community kept up-to-date	(b) Contacts with community kept up-to-date and DMU staff kept informed of changes	(b) Contacts with community kept up-to-date and DMU staff and community kept informed of changes
	(c) Little or no communications with communities	(c) Topics and frequency of communications not well planned or executed	(c) Topics and frequency of communications planned and executed	(c) Topics and frequency of communications planned and executed, and communication problems tracked to resolution	(c) Topics and frequency of communications planned and executed, and communication problems tracked to resolution in a timely manner
6-C. Debris Management [The identification and mitigation of dam safety risk associated with debris in reservoirs blocking spillways and outlets]	(a) Debris Management Plans not developed or developed with little or no understanding of the threat posed by debris and the means available to manage those threats	(a) Debris Management Plans developed with some understanding of the threat posed by debris and the means available to manage those threats	(a) Debris Management Plans developed with understanding of the threat posed by debris and the means available to manage those threats	(a) Debris Management Plans developed with strong understanding of the threat posed by debris and the means available to manage those threats, with continuous improvement	(a) Debris Management Plans developed with strong understanding of the threat posed by debris and the means available to manage those threats, with continuous improvement and review of plans
	(b) Little or no monitoring and management during floods with limited understanding of problems caused by debris	(b) Monitoring and management during floods with some understanding of problems caused by debris	(b) Monitoring and management during floods with understanding of problems caused by debris	(b) Documented monitoring and management during floods with strong understanding of problems caused by debris	(b) Documented monitoring and management during floods with strong understanding of problems caused by debris, with continuous improvement
	(c) Debris removal not implemented or inadequate to protect the dam and equipment	(c) Little or no effective debris removal to protect the dam and equipment	(c) Effective routine debris removal to protect the dam and equipment	(c) Effective routine debris removal to protect the dam and equipment, with continuous improvement	(c) Effective routine debris removal to protect the dam and equipment, with continuous improvement including developing, trialling and implementing new technology and methods.

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 7: Dam and Spillway Maintenance Maturity Matrix

Dam and Spillway Maintenance is defined as the maintenance of civil structures and constructions associated with the dam and reservoir. Includes structural maintenance or repairs, erosion protection, vegetation control and drain maintenance (surface and internal relief drainage) and other activity necessary to maintain safety and functionality of the dam and components. Includes spillways and outlets that perform a dam safety function, along with their electrical and mechanical components.
Note: Spillway and Outlet Equipment maintenance is evaluated in Component 5.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
7-A. Dam, Reservoir and Access Maintenance [Maintenance of the dam structure, reservoir features and dam access routes, including security of physical assets]	(a) Corrective maintenance performed on an as-needed basis	(a) Maintenance mostly follows an established routine procedure	(a) Maintenance follows an established routine procedure	(a) Maintenance follows an established routine procedure based on failure modes, Emergency Preparedness Plans and good practice.	(a) Maintenance follows an established proactive procedure based on failure modes, Emergency Preparedness Plans and good practice incorporating advances in technology
	(b) Little or no maintenance performed or constrained by availability of budget, materials and equipment.	(b) Mostly corrective maintenance performed depending on availability of budget, materials and equipment.	(b) Emphasis on preventive maintenance. Corrective maintenance generally completed promptly; budget, materials and equipment generally available.	(b) Emphasis on preventive maintenance. Corrective maintenance completed promptly; budget, materials and equipment available.	(b) Emphasis on preventive maintenance. Corrective maintenance completed promptly; budget, materials and equipment available with continuous improvement in efficiencies
	(c) Little or no recording and reporting of maintenance activities	(c) Some recording and reporting of maintenance activities	(c) Recording and reporting of maintenance activities is mostly complete	(c) Recording and reporting of maintenance activities is complete and easily accessed in electronic form	(c) Recording and reporting of maintenance activities is complete and easily accessed in electronic form, across the Dam Management Unit (DMU) and Ministry
	(d) Little or no process for escalation of maintenance problems	(d) Unstructured process for escalation of maintenance problems	(d) Structured process exists for escalation of maintenance problems	(d) Structured process exists for escalation of maintenance problems and problems tracked to resolution	(d) Structured process exists for escalation of maintenance problems and problems tracked to resolution in a timely manner
7-B. Spillway Maintenance [Maintenance of spillways and their access routes, including security of physical assets]	(a) Corrective maintenance performed on an as-needed basis	(a) Maintenance mostly follows an established routine procedure	(a) Maintenance follows an established routine procedure	(a) Maintenance follows an established routine procedure based on failure modes, Emergency Preparedness Plans and good practice.	(a) Maintenance follows an established proactive procedure based on failure modes, Emergency Preparedness Plans and good practice incorporating advances in technology and methods
	(b) Little or no maintenance performed or constrained by availability of budget, materials and equipment.	(b) Mostly corrective maintenance performed depending on availability of budget, materials and equipment.	(b) Emphasis on preventive maintenance. Corrective maintenance generally completed promptly; budget, materials and equipment generally available.	(b) Emphasis on preventive maintenance. Corrective maintenance completed promptly; budget, materials and equipment available.	(b) Emphasis on preventive maintenance. Corrective maintenance completed promptly; budget, materials and equipment available with continuous improvement.
	(c) Little or no recording and reporting of maintenance activities	(c) Some recording and reporting of maintenance activities	(c) Recording and reporting of maintenance activities is mostly complete	(c) Recording and reporting of maintenance activities is complete and easily accessed in electronic form	(c) Recording and reporting of maintenance activities is complete and easily accessed in electronic form, across the DMU and Ministry
	(d) Little or no process for escalation of maintenance problems	(d) Unstructured process for escalation of maintenance problems	(d) Structured process exists for escalation of maintenance problems	(d) Structured process exists for escalation of maintenance problems and problems tracked to resolution	(d) Structured process exists for escalation of maintenance problems and problems tracked to resolution in a timely manner

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 8: Emergency Preparedness Maturity Matrix

Emergency Preparedness is the identification of dam failure consequences and planning for response to events that might lead to dam failure. Includes hazard and consequence identification, emergency plan preparation, external relationship building, and emergency tests and exercises.
BNPB refers to Badan Nasional Penanggulangan Bencana, which is Indonesia's National Agency for Disaster Management.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
8-A. Threat and Consequence Identification [Identifying and understanding of threats, dam incidents, failure sequences, and their consequences for inclusion in the Emergency Preparedness Plans, which include Emergency Action Plans]	(a) Little or no understanding, evaluation or documentation of threats and potential failure modes and vulnerabilities. The Emergency Preparedness Plan is not formulated or does not adequately address the above.	(a) Some understanding, evaluation and documentation of threats and potential failure modes and vulnerabilities. The Emergency Preparedness Plan is formulated to address some or most of the above.	(a) Threats and potential failure modes evaluated, understood and vulnerabilities documented. The Emergency Preparedness Plan is formulated to address all of the above.	(a) Threats and potential failure modes thoroughly evaluated, understood and vulnerabilities documented using readily available analysis techniques. The Emergency Preparedness Plan is formulated to address all of the above.	(a) Threats and potential failure modes thoroughly evaluated, understood and vulnerabilities documented using state-of-art analysis techniques and research. The Emergency Preparedness Plan is formulated to address all of the above.
	(b) Little or no understanding, evaluation or documentation of consequences of failure of the dam and equipment	(b) Some consequences of failure of the dam and equipment are evaluated, understood and documented	(b) Consequences of failure of the dam and equipment are evaluated, understood and documented	(b) Consequences of failure of the dam and equipment are thoroughly evaluated, understood and documented using readily available analysis techniques	(b) Consequences of failure of the dam and equipment are thoroughly evaluated, understood and documented using state-of-art analysis techniques and research
	(c) Little or no consideration of flood monitoring and event forecasting	(c) Flood monitoring and event forecasting considered to some extent	(c) Flood monitoring and event forecasting considered	(c) Generally complete flood monitoring and event forecasting	(c) Comprehensive flood monitoring and event forecasting, with inputs from specialist organisations
	(d) Little or no reviews for changes in threat, potential failure modes or consequences of failure	(d) Infrequent or unstructured reviews for changes in threat, potential failure modes and consequences of failure	(d) Reviews for changes in threat, potential failure modes and consequences of failure e.g., 5 yearly	(d) Reviews for changes in threat, potential failure modes, likelihood and consequences of failure e.g., 5 yearly	(d) Reviews by panel comprising internal and external reviewers, for changes in threat, potential failure modes, likelihood and consequences of failure e.g., 5 yearly
8-B. DMU Emergency Action Plans [Emergency Action Pans to prepare for and act during a dam safety emergency]	(a) Emergency Action Plans do not exist and little or no understanding of Emergency Action Plans by Dam Management Unit (DMU) staff.	(a) DMU's Emergency Action Plans are documented, practical, demonstrate some understanding of emergency identification and response	(a) DMU's Emergency Action Plans are documented, practical, demonstrate good understanding of emergency identification and response	(a) DMU's Emergency Action Plans are documented, practical, demonstrate comprehensive understanding of emergency identification and response among key DMU staff	(a) DMU's Emergency Action Plans are documented, practical, demonstrate comprehensive understanding of emergency identification and response among all DMU staff
	(b) Emergency Action Plans do not exist or are developed with little or no collaboration with BNPB Services and Police	(b) Emergency Action Plans are developed in collaboration with BNPB Services and Police, and with little or no public consultation and education	(b) Emergency Action Plans are developed and alarm systems introduced in collaboration with BNPB Services and Police, and with public consultation and education	(b) Emergency Action Plans are developed and alarm systems introduced in collaboration with BNPB Services and Police, and with public consultation, education and participation	(b) Emergency Action Plans are developed and alarm systems introduced in collaboration with BNPB Services and Police, and with public consultation, education and participation. Emergency Action Plans are reviewed and updated with inclusion of DMU staff.
	(c) Little or no definition and understanding of roles and responsibilities	(c) Some definition and understanding of roles and responsibilities	(c) Good definition and understanding of roles and responsibilities among key DMU staff	(c) Comprehensive definition and understanding of roles and responsibilities among all DMU staff	(c) Comprehensive definition and understanding of roles and responsibilities, including all DMU staff, BNPB Services and Police.
	(d) Little or no review or updating of Emergency Action Plans	(d) Infrequent review and updating of Emergency Action Plans	(d) Generally complete and frequent review and updating of Emergency Action Plans every 3 years, and also after an emergency event to include lessons learnt.	(d) Regular review and updating of Emergency Action Plans every 3 years, and also after an emergency event to include lessons learnt.	(d) Regular review and updating of Emergency Action Plans every 3 years, and also after tests and exercises and also an emergency event to include lessons learnt.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
8-C. Relationships with Community and External Agencies (including BNPB and Police) [Maintain relationships and communication with the community, and External Agencies, for effectiveness of response to emergencies]	(a) Weak or no relationships, with little or no understanding of emergency actions and responsibilities	(a) Mostly functional relationships, and some understanding of emergency actions and responsibilities by some or all parties involved	(a) Mostly strong relationships, and good understanding of emergency actions and responsibilities by all parties involved	(a) Strong relationships and understanding of emergency actions and responsibilities by all parties involved	(a) Excellent relationships and understanding of emergency actions and responsibilities by all parties involved
	(b) Little or no relationship continuity included in the plan	(b) Some relationship continuity included in the plan	(b) Relationship continuity mostly included in the plan	(b) Relationship continuity included in the plan	(b) Relationship continuity included in the plan and continuously improved upon
	(c) Little or no compatibility between communication systems and emergency command structures across area of DMU responsibility	(c) Some compatibility between communication systems and emergency command structures across area of DMU responsibility	(c) Mostly compatible communication systems and emergency command structures across area of DMU responsibility	(c) Compatible communication systems and emergency command structures across area of DMU responsibility	(c) Compatible communication systems and emergency command structures across area of DMU responsibility, and with other DMUs in the area.
	(d) Little or no maintenance of contact information	(d) Infrequent maintenance of contact information	(d) Mostly complete and frequent maintenance of contact information	(d) Complete and frequent maintenance of contact information	(d) Complete and frequent maintenance of contact information, with alternative contact information
8-D. Tests and Exercises [Test and exercise Emergency Action Plans and preparedness at appropriate intervals to assess effectiveness, and identify improvements]	(a) Little or no tests and exercises internal to DMU organisation	(a) Tests and exercises internal to DMU organisation, mock emergency exercises as the need arises	(a) Tests and exercises internal to DMU organisation, mock emergency exercises as the need arises or every 2 years	(a) Tests and exercises internal to DMU organisation, mock emergency exercise as the need arises or every 2 years, involving two to three dams within the DMU	(a) Tests and exercises internal to DMU organisation, mock emergency exercise as the need arises or every 2 years, involving multiple dams and river systems within the DMU
	(b) Little or no tests and exercises including External Agencies	(b) Tests and exercises sometimes including External Agencies, mock emergency exercises as the need arises	(b) Tests and exercises including External Agencies, mock emergency exercises as the need arises or every 5 years	(b) Tests and exercises including External Agencies, mock emergency exercises as the need arises or every 5 years, involving two to three dams within the DMU	(b) Tests and exercises including External Agencies, mock emergency exercises as the need arises or every 5 years, involving multiple dams and river systems within the DMU
	(c) Few tests and exercises are documented, lessons learnt analysed or communicated.	(c) Some tests and exercises are documented, some lessons learnt analysed and communicated. Some improvements to Emergency Preparedness Plans and Emergency Action Plans are implemented	(c) Tests and exercises are documented, lessons learnt analysed and communicated. Improvements to Emergency Preparedness Plans and Emergency Action Plans are implemented	(c) Tests and exercises are documented, lessons learnt analysed, communicated and improvements to Emergency Preparedness Plans and Emergency Action Plans are routinely implemented. Tests and exercises include staff from other dams within the DMU	(c) Tests and exercises are documented, lessons learnt analysed, communicated and improvements to Emergency Preparedness Plans and Emergency Action Plans are routinely implemented. Tests and exercises include staff from other DMUs

Using Maturity Matrices to Evaluate Dam Safety Programs

Component 9: Managing Dam Safety Problems Maturity Matrix

Managing Dam Safety Problems is defined as collecting, categorizing, tracking, prioritizing, investigating, assessing, treating and reporting dam safety issues. Dam Safety Problems are categorized as Non-conformances, Physical Infrastructure Issues and Dam Safety Deficiencies. In a Dam Safety Program, dam safety problems are usually identified in the Surveillance, Reservoir Operations, Emergency Preparedness, Spillway and Outlet Equipment, Dam and Spillway Maintenance, and Audit and Review components. For the purpose of Maturity Matrices, Managing dam safety problems does not include implementation of remedial works. This assessment deals with Dam Safety Programs as far as they relate to the 'Operation and Maintenance' of dams. Implementation of dam remedial works relates to 'Life Extension and Upgrade', which is outside the scope of this assessment.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
9-A. Dam Safety Problem Management System [The overall system for collecting, categorizing, tracking, prioritizing, investigating, assessing, treating and reporting dam safety problems. The system would usually consist of documented processes and procedures, and supporting tools.]	(a) Little or no collection of problems from identification sources	(a) Incomplete identification and collection of problems from identification sources	(a) Organized identification and collection of problems from identification sources	(a) Organized and thorough identification and collection of problems from identification sources	(a) Organized, thorough and up-to-date identification and collection of problems from identification sources
	(b) Little or no recording of problem details	(b) Incomplete recording of problem details	(b) Generally complete recording of problem details	(b) Comprehensive recording of problem details	(b) Comprehensive and up-to-date recording of problem details
	(c) Problems not categorized	(c) Incomplete categorization of problems	(c) Most problems categorized	(c) Complete categorization of problems	(c) Complete and up-to-date categorization of problems
	(d) Little or no tracking and reporting of problem status	(d) Incomplete tracking and reporting of problem status	(d) Generally complete tracking and reporting of problem status	(d) Comprehensive tracking and reporting of problem status	(d) Comprehensive and up-to-date tracking and reporting of problem status
9-B. Managing Program Non-Conformances [The prioritization and resolution of Non-conformances, investigation, assessment, treatment and reporting.]	(a) Little or no assessment of effects of non-conformances on dam safety program	(a) Some assessment of effects of non-conformances on dam safety program	(a) Assessment of effects of most non-conformances on dam safety program	(a) Assessment of effects of all non-conformances on dam safety program	(a) Assessment of effects of all non-conformances on dam safety program and reservoir operations
	(b) Corrective measures not identified	(b) Corrective measures are identified for some non-conformances	(b) Corrective measures are identified for most non-conformances	(b) Corrective measures are identified for all non-conformances	(b) Corrective measures are identified for all non-conformances with consideration of improvements
	(c) Non-conformances not prioritized or scheduled	(c) Some non-conformances prioritized and scheduled to restore dam safety program outcomes	(c) Most non-conformances prioritized and scheduled to restore dam safety program outcomes	(c) All non-conformances prioritized and scheduled to restore dam safety program outcomes	(c) All non-conformances prioritized and scheduled to restore dam safety program outcomes and maintain safe reservoir operations
	(d) Corrective measures not taken or reported	(d) Some corrective measures taken and reported	(d) Most corrective measures taken and reported	(d) All corrective measures taken and reported	(d) All corrective measures taken, reported and tracked to resolution and their effectiveness proven
9-C. Managing Dam Safety Infrastructure Problems [The prioritization and resolution of Physical Infrastructure problems, investigation, assessment, treatment and reporting.]	(a) Little or no assessment of effects of dam safety infrastructure problems on dam safety program	(a) Some assessment of effects of dam safety infrastructure problems on dam safety program	(a) Assessment of effects of most dam safety infrastructure problems on dam safety program	(a) Assessment of effects of all dam safety infrastructure problems on dam safety program	(a) Assessment of effects of all dam safety infrastructure problems on dam safety program and reservoir operations
	(b) Corrective measures not identified	(b) Corrective measures are identified for some non-conformances	(b) Corrective measures are identified for most problems	(b) Corrective measures are identified for all problems	(b) Corrective measures are identified for all Problems with consideration of improvements
	(c) Problems not prioritized or scheduled	(c) Some problems prioritized and scheduled to restore dam safety program outcomes	(c) Most problems prioritized and scheduled to restore dam safety program outcomes	(c) All Problems prioritized and scheduled to restore dam safety program outcomes	(c) All problems prioritized and scheduled to restore dam safety program outcomes and maintain reservoir operations
	(d) Corrective measures not taken or reported	(d) Some corrective measures taken and reported	(d) Most corrective measures taken and reported	(d) All corrective measures taken and reported	(d) All corrective measures taken, reported and tracked to resolution and their effectiveness proven
9-D. Managing Dam Safety Deficiencies [The prioritization and resolution of Dam Safety Deficiencies, investigation, assessment, treatment and reporting.]	(a) Little or no assessment of effects of dam safety deficiencies	(a) Some assessment of effects of dam safety deficiencies	(a) Most deficiencies assessed based on likelihood and consequence of dam failure	(a) All deficiencies assessed based on likelihood and consequence of dam failure	(a) All deficiencies assessed based on likelihood and consequence of dam failure. Some critical deficiencies assessed using advanced methods.
	(b) Corrective measures not identified	(b) Corrective measures identified for some deficiencies	(b) Unacceptable deficiencies assessed for treatment	(b) Corrective measures are identified for all deficiencies	(b) Corrective measures are identified for all deficiencies with consideration of improvements
	(c) Deficiencies not prioritized or scheduled for treatment	(c) Some deficiencies prioritized and scheduled for treatment	(c) Unacceptable deficiencies prioritized and scheduled for treatment	(c) All deficiencies prioritized and scheduled to restore dam safety program outcomes	(c) All deficiencies prioritized and scheduled to restore dam safety program outcomes and maintain reservoir operations
	(d) Little or no reporting of deficiencies or planned treatment	(d) Some reporting of deficiencies, their treatment plan and current status	(d) An inventory of unacceptable deficiencies, their treatment plan and current status is reported	(d) An inventory of unacceptable deficiencies, their treatment plan and current status is reported regularly	(d) An inventory of unacceptable deficiencies, their treatment plan and current status is reported regularly and tracked to resolution

Using Maturity Matrices to Evaluate Dam Safety Programs
Component 10: Audits and Reviews Maturity Matrix

Audits and Reviews are defined as:
1. Dam Safety Program Audits and Reviews:
   - Dam Safety Program Audits are usually to check that the Dam Management Unit's (DMU's) dam safety program's systems, processes and procedures are being followed.
   - Dam Safety Program Reviews review the effectiveness of a dam safety program and the appropriateness of its systems and processes.
2. Dam Safety and Spillway and Outlet Equipment Reviews:
   - Dam Safety Reviews review the dam safety status and dam safety management practices of individual dams.
   - Spillway and Outlet Equipment Reviews review the functional performance and management practices of a dam's equipment.

Activity	Maturity Level				
	1. Needing Development	2. Elementary	3. Good Practice	4. Very Good Practice	5 Best Practice
10-A. Dam Safety Program Audits [Audit of a DMU's dam safety programs, to check that stated objectives and procedures are being achieved]	(a) Little or no audit of DMU's dam safety program.	(a) Audits are usually programmed and scope is usually aligned with DMU's dam portfolio.	(a) Audits are programmed and scope is aligned with DMU's dam portfolio.	(a) Audits are programmed and scope is aligned with DMU's dam portfolio and consequences of failure.	(a) Audits are programmed and scope is aligned with DMU's dam portfolio, failure modes and consequences of failure.
	(b) Little or no consideration of auditor experience and competence during selection of auditor	(b) Auditor experience and competence is sometimes considered during selection of auditor	(b) Auditor experience and competence generally considered during selection of auditor	(b) Auditor experience and competence is considered during selection of auditor	(b) Auditor experience and competence is comprehensively considered during selection of auditor
	(c) Little or no participation in the audit by the Dam Management Unit (DMU)	(c) Usually positive participation in the audit by the DMU	(c) Positive participation in the audit by the DMU	(c) Positive and proactive participation in the audit by the DMU	(c) Positive and proactive participation in the audit by the DMU, with continuous improvement
	(d) Little or no referral of audit findings to DMU management.	(d) Some audit findings referred to DMU management and identified actions prioritized for implementation.	(d) Audit findings referred to DMU management and identified actions prioritized for implementation.	(d) Audit findings referred to DMU management and identified actions prioritized for implementation and tracked to resolution.	(d) Audit findings referred to DMU management and identified actions prioritized and implemented in a timely manner
10-B. Dam Safety Program Reviews [Review of the effectiveness of a DMU's dam safety programs]	(a) Little or no review of DMU's dam safety program.	(a) Reviews are usually programmed and scope is usually sometimes aligned with DMU's dam portfolio.	(a) Reviews are programmed and scope is aligned with DMU's dam portfolio.	(a) Reviews are programmed and scope is aligned with DMU's dam portfolio and consequences of failure.	(a) Reviews are programmed and scope is aligned with DMU's dam portfolio, failure modes and consequences of failure.
	(b) Little or no consideration of reviewer experience and competence during selection of reviewer	(b) Reviewer experience and competence is sometimes considered during selection of reviewer	(b) Reviewer experience and competence generally considered during selection of reviewer	(b) Reviewer experience and competence considered during selection of reviewer	(b) Reviewer experience and competence comprehensively considered during selection of reviewer
	(c) Little or no participation in the review by the DMU	(c) Usually positive participation in the review by the DMU	(c) Positive participation in the review by the DMU	(c) Positive and proactive participation in the review by the DMU	(c) Positive and proactive participation in the review by the DMU, with continuous improvement
	(d) Little or no referral of review findings to DMU management.	(d) Some review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution in a timely manner.
10-C. Dam Safety Reviews [Review of the dam safety management practices including Emergency Preparedness Plans and dam safety status of individual dams; includes spillways and outlet structures]	(a) Little or no review of dam safety.	(a) Review scope and frequency usually consider dam performance and consequences of failure	(a) Review scope and frequency consider dam performance and consequences of failure.	(a) Review scope and frequency consider dam performance, and likelihood and consequences of failure.	(a) Review scope and frequency consider dam performance, failure modes, and likelihood and consequences of failure.
	(b) Little or no consideration of reviewer experience and competence in the type of dam during reviewer selection	(b) Some consideration of reviewer experience and competence in the type of dam during reviewer selection	(b) General consideration of reviewer experience and competence in the type of dam during reviewer selection	(b) Consideration of reviewer experience and competence in the type of dam during reviewer selection	(b) Comprehensive consideration of reviewer experience and competence in the type of dam during reviewer selection
	(c) Little or no commitment and response by the DMU to findings of the dam safety review	(c) Some commitment and response by the DMU to findings of the dam safety review	(c) Demonstrated commitment and response by the DMU to findings of the dam safety review	(c) Proactive commitment and response by the DMU to findings of the dam safety review	(c) Proactive commitment and response by the DMU to findings of the dam safety review, with continuous improvement
	(d) Little or no referral of review findings to DMU management.	(d) Some review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution in a timely manner.
10-D. Spillway and Outlet Equipment Reviews [Review of the management practices and functional performance of a dam's spillway and outlet equipment]	(a) Little or no review of spillway and outlet equipment.	(a) Review scope and frequency usually consider equipment performance and consequences of failure.	(a) Review scope and frequency consider equipment performance and consequences of failure.	(a) Review scope and frequency consider equipment performance, and likelihood and consequences of failure.	(a) Review scope and frequency consider equipment performance, failure modes, and likelihood and consequences of failure.
	(b) Little or no consideration of reviewer experience and competence in the type of equipment during reviewer selection	(b) Some consideration of reviewer experience and competence in the type of equipment during reviewer selection	(b) General consideration of reviewer experience and competence in the type of equipment during reviewer selection	(b) Consideration of reviewer experience and competence in the type of equipment during reviewer selection	(b) Comprehensive consideration of reviewer experience and competence in the type of equipment during reviewer selection
	(c) Little or no commitment and response by the DMU to findings of the spillway and outlet equipment review	(c) Some commitment and response by the DMU to findings of the spillway and outlet equipment review	(c) Demonstrated commitment and response by the DMU to findings of the spillway and outlet equipment review	(c) Proactive commitment and response by the DMU to findings of the spillway and outlet equipment review	(c) Proactive commitment and response by the DMU to findings of the spillway and outlet equipment review, with continuous improvement
	(d) Little or no referral of review findings to DMU management.	(d) Some review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution.	(d) Review findings referred to DMU management and identified actions prioritized for implementation. Actions are tracked to resolution in a timely manner.

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