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Managing Operational Risks in Water Supply Sector

Kandianawati[1]*, Mukhamad Najib[2], and Setiadi Djohar[3]
[1]School of Business, Bogor Agricultural University
[2]Faculty of Economics and Management, Bogor Agricultural University
[3]PPM School of Management

Abstract. *Water and sanitation sector is characterized with having many risks. The ability to manage risks is one of the success factors in providing clean water services to the community. The objective of this paper is to identify the operational risks in the water supply provision, to analyze the significant risks, and to formulate actions to manage the significant risks. The operational risks are analyzed using probability impact matrix. The research shows that the significant operational risks mostly occur during raw water extraction process, which are risks related to the quality and quantity of raw water, as well as reliability of the supporting facilities (intake and transmission pipe). Other significant risks are production failure, intermittent supply, low water pressure, and contractor availability for meter installation. Because significant operational risks are caused by process and external factor, the proposed risk management includes the development of procedures and guidelines, as well as the implementation of effective contractor management. Risk management also includes the establishment of effective communication and coordination with relevant stakeholders.*

Keywords: *Operational risk, probability impact matrix, risk management, water company, water supply provision*

Abstrak. *Sektor air dan sanitasi memiliki banyak risiko. Kemampuan untuk mengelola risiko yang muncul menjadi salah satu faktor keberhasilan penyediaan air bersih bagi masyarakat. Penelitian ini bertujuan untuk mengidentifikasi risiko operasional dalam penyediaan air bersih, menganalisa risiko yang signifikan, serta memformulasikan langkah-langkah penanganan risiko yang signifikan. Analisa risiko operasional dilakukan menggunakan matriks probability impact. Hasil penelitian menunjukkan bahwa risiko operasional signifikan paling banyak terjadi pada proses pengambilan air baku, yaitu risiko yang terkait kualitas dan kuantitas air baku, serta kehandalan fasilitas pendukung (bangunan sadap dan pipa transmisi). Risiko signifikan lainnya yaitu kegagalan produksi, gangguan suplai, tekanan air kecil, dan ketersediaan kontraktor pemasangan meter. Karena risiko operasional yang signifikan disebabkan oleh faktor proses dan eksternal, pengelolaan risiko yang diusulkan meliputi penyusunan prosedur dan pedoman kerja, serta penerapan pengelolaan kontraktor yang efektif. Pengelolaan risiko juga meliputi pengembangan komunikasi dan koordinasi yang efektif dengan pemangku kepentingan yang terkait.*

Kata kunci: *Matriks probability impact, pengelolaan risiko, penyediaan air bersih, perusahaan air bersih, risiko operasional.*

*Corresponding author. Email: Kandianakandiana@gmail.com
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Introduction

Water and sanitation sector is characterized with having many risks due to high capital intensity, the existence of various public policy objectives, the high cost of distributing water, and high levels of uncertainty about asset condition because most are underground (Haarmeyer & Mody, 1998). The involvement of various institutions in water governance, political pressure on tariff, high demand for water services and weak institutional capacity also added to the vulnerability of the sector to risk (ADB, 2010).

ADB (2010) categorizes generic risks in the water supply sector into institutional risk, organizational risk, and operational risk. Institutional risks are related to policies, legal framework and regulations in the water sector, while organizational risks include planning, financial management, procurement, and human resources aspects. Meanwhile, the risks that occur during the process of raw water extraction, water treatment, water distribution and customer management are categorized as operational risks.

Several studies have been conducted to identify the risks associated with water supply provision. Raw water availability is the main risk perceived by both regulator and operator (Wibowo & Mohamed, 2010). A study by Fahrudin and Vanany (2015) showed that low water discharge due to depleting water source and non-functioning pump has the highest Risk Priority Number (RPN) value in raw water extraction process. Raw water supply can also be affected by drought during dry season. This risk is different from the risk of water shortages/scarcity due to an imbalance between water supply and demand. Drought is more temporary due to the deviation from the amount of rainfall (Rossi & Cancelliere, 2013) Turbidity also determines raw water supply reliability as a high turbidity level can hamper the operation of a water treatment plant (Chang & Liao, 2012).

In water distribution process, the significant risk relates to the reliability of distribution pipes, that is the material used, the amount of traffic passing above the pipeline network, instantaneous pressure, pipe life, fault during pipe installation, and the impact of construction work around it (Kunkel, Leven, & Mergelas, 2008). Another common risk is the high level of Non-Revenue Water (NRW) due to poor management of apparent losses, poor training of workers and experts, lack of timely replacement of devices, and inappropriate quality selection of pipes and devices (Tabesh, Roozbahani, Roghani, Faghihi, & Heydarzadehet, 2018). Leaked pipes as well as inaccurate meter are also considered as high risks in distributing water to customers (Fahrudin & Vanany, 2015).There are also risks arising from human resources, namely erosion of tacit knowledge possessed by operators, ineffective procedure of preventive maintenance, poor water quality that poses health hazards to the community, and failure to identify threats to pipeline network infrastructure (Pastrana, Marin, Rabelo, & Lee, 2014).

The purpose of risk management in water supply sector is to ensure the availability of safe drinking water, where no one becomes sick or dies after consuming it (Hrudey, Hrudey, & Pollard, 2006). The safety of water produced is not only guaranteed by building various barriers in water treatment technology, but also in protecting raw water sources, distribution network security, and surveillance capabilities. This is because the risks that occur are usually a combination of technical, management, and human errors.

The ability to manage risks that arise is one of the success factors in providing clean water services to the community. However, a survey conducted by Pangeran (2012) on several water service companies in Indonesia, both regionally owned and private companies with concession rights, showed that only a few of water companies in Indonesia have implemented risk management methods and tools as part of the companies' policy and strategy.

McNeil, Frey, and Embrechts (2005) defines risk as any event or action that can affect the ability of an organization to achieve its objectives and carry out its strategy, or the possibility of a loss or decline from a measurable estimate. Franzetti (2011) summarized risk as a factor or element that involves uncertain hazards, as a source of danger or the possibility of a loss, or as an attempt made without considering the possibility of loss or injury. There are two elements in risk, namely the possibility of occurrence and the impact or consequences if this happens. Thus, risk can be considered as a function of the probability of an event multiplied by the magnitude of the loss or profit from the event. This is what distinguishes between risk and uncertainty, where risk has attributes that can be calculated so that the risk tends to be insured (Raftery 2003).

Risks that affect the organization can result in economic performance and professional reputation, as well as environmental, safety and social impacts. Therefore, managing risk effectively helps organizations to work well in an environment that is full of uncertainty.

The Basel Committee defines risk management as a process to identify, evaluate, monitor, and control or mitigate all material risks and assess the adequacy of company resources related to that risk profile (Franzetti, 2011). Cooper, Grey, Raymond, and Walker (2005) define the same thing, where prioritization of risk is followed by the application of coordinated and economical resources to minimize, monitor and control the likelihood or impact of unfavourable events or to maximize the realization of opportunities.

ISO 31000 is one of the common guidelines for risk management. It is an on-going process that consists of five stages, namely establishing context, risk assessment (identification, analysis, and evaluation), risk treatment, monitoring and review, and communication and consultation.

In establishing the context, organizational goal as well as external and internal factors that can affect success in achieving these goals are defined (Purdy, 2010). Risks can be identified through brainstorming, interview, focus group discussion (FGD), or using other identification techniques such as Work Breakdown Structure (WBS) analysis, fault tree analysis or event tree analysis, as well as historical data, theoretical analysis, data and empirical analysis, and opinions from the team and stakeholders. Identified risks are then analysed based on the probability/ likelihood of occurrence and the impact/ consequence should the risk occurs. There are several methods used in risk analysis, including Value-at-Risk (VaR), Failure Mode and Effect Analysis (FMEA), Fuzzy Analytical Hierarchy Process (FAHP), Monte Carlo simulation, and Probability-Impact matrix.

Risk evaluation is conducted to determine the level of risk exposure based on the risk value, which is the multiplication between the likelihood of risk occurring and the impact caused. The values are then mapped into risk map to determine whether a certain risk is categorized into low, medium, or high/significant level of risk, based on the company's risk appetite. This level of risk serves as a guidance when identifying and formulating the risk treatment. The decisions about risk treatment taken will be based on the costs incurred compared to the expected risk reduction (Refsdal, Solhaug, & StØlen, 2015).

Several strategies to respond to risk include avoiding the risk by limiting the risk factor or business activity that triggers it, reducing the likelihood or the impact of the risk, transferring the risk to other party that can better manage it, and retaining the risk if the cost for treating it is more effectively to be carried out internally, or if the cost to reduce it is more expensive than the benefits (Merna & Al-Thani, 2005).

Operational risk itself is defined as the risks associated with running the business, which consists of failure risk and strategic risk. Operational failure risks are caused by human, process, and technology factors, while operational strategic risks are caused by external factors beyond the company's control, as well as the presence of new strategic initiative taken by the company (Crouhy, Galai, & Mark, 2000). These two types of risks are also referred to as internal and external risks. Operational risks arise from a lack of awareness and skills in detecting threats associated with those risks (Hemrit & Arab, 2013) or poor corporate governance (Drew & Kendrick, 2005). Therefore, operational risk management aims to prevent the recurrence of operational losses that can affect all sectors.

Although studies have been conducted on the risks arising in the water supply sector, most of them are focusing on only one type of risks, as listed out previously. Limited literature is available on the operational risks in the value chain of the water supply provision. One comprehensive literature on the sector risks, including the operational risks, is presented by ADB (2010). The generic operational risks include the reliability of water supply (in the process of raw water extraction), the ability to meet the water quality standards (in the production process), the uneven access to services and collusion with water cartels to prevent the expansion of service coverage (in the distribution process), as well as delays in the new connection process, illegal connections, meter tampering, delays in the installation and replacement of meters (in the customer management process).

The literature and previous researches on operational risk management in the sector is also limited. Many literatures have discussed on the operational risk management in banking and supply chain, but limited study on integrated operational risk management is found on the value chain of water supply provision. With only a few of water companies in Indonesia have implemented risk management methods and tools as part of the companies' policy and strategy, this research will not only fill the literature gap, but can also be used as a guideline for the water companies in developing their own risk management framework.

Research Methodology

PT Aetra Air Tangerang (Aetra Tangerang), a private water company with 25-year concession right in Tangerang Regency, was used as a case study. As a relatively new water company, the focus of the company begins to shift from project to operational activities. Therefore, the company needs to start taken into account the operational risks arising. However, as with many water companies in Indonesia, Aetra Tangerang has not implemented risk management framework yet.

The study was conducted using qualitative and quantitative data. Primary data was collected through observation, interview, and questionnaires, while secondary data was obtained through literature study and internal data such as organizational structure, standard operating procedures, and indicators of minimum performance standard.

Respondents for interviews and questionnaires were selected using non-probability sampling with judgmental sampling or purposive sampling techniques. The selection was based on expertise of the subject under study. Nine middle and senior managers of Aetra Tangerang responsible for the value chain of water supply provision, namely production, distribution, key account management, sales operation, revenue management, billing and collection, were selected.

Data collection and analysis were conducted in three steps, as outlined table 1.

Table 1.
Data Collection and Analysis

Step	Objective	Tool	Output
1	Identifying operational risk	Interviews and literature study	Identified operational risks and the cause (human, process, technology, external factor)
2	Assessing risk	Questionnaire based on pre-defined likelihood and impact scales	List of significant risks
3	Formulating risk management for significant operational risks	Interviews and literature study	Proposed mitigation and contingency plans for each risk

In the first step, respondents were asked to identify events that are likely affect each stage of the value chain, either the ones that had happened in the past or a prediction of such events in the future. For each event, respondents also identified the cause and impact as well as the current prevention or control mechanism. The events were then summarized into a list of identified risks. The risks are categorized based on the cause – whether internal factors (people, process, technology) or external factor.

In the second step, respondents were asked to score each risk on the list based on its likelihood and impact using 5-point Likert scales. The likelihood is range from a rare event which has never occurred in the past five years (scale 1) to a very likely event with a chance of occurring more than five times in a year (scale 5). As a public company with customer service orientation, the consequences of a risk are expressed as a function of the impact on customers, as well as the financial impact. The scale is range from an event with no customer affected and no financial loss (scale 1) to an event which affects almost all customers with a potential of revenue loss more than 75% (scale 5).

A probability impact matrix was used to map the risk assessment result. The probability-impact matrix is the main technique used in qualitative risk assessment, where the possibility and impact of each risk are assessed on a certain scale and plotted in a two-dimensional matrix (Hillson, 2002). According to Cox (2008), a probability-impact matrix or risk matrix is widely used because in addition to providing easy documentation in terms of risk ranking and priority setting, it also allows users to apply the risk culture concept and risk appetite in matrix colouring.

As the subject company considers all risks with severe impact, regardless the probability of occurrence, as high or significant risks, the probability impact matrix used in this study is as follows:

A three-scale/colour matrix is used to show risk priorities. According to Cox (2008), a risk matrix with more than one priority levels satisfies the weak consistency if points in the top priority represent higher quantitative risks than the ones in the bottom priority. However, risk matrix with too many (more than three) colours will give spurious resolution.

The risk matrix shows whether a risk can be controlled or still within the tolerant limits of the company. Risks that are in the green box (risks with little possibility or small impact) have a low level of risk and can still be accepted /controlled by the company, so it can be ignored.

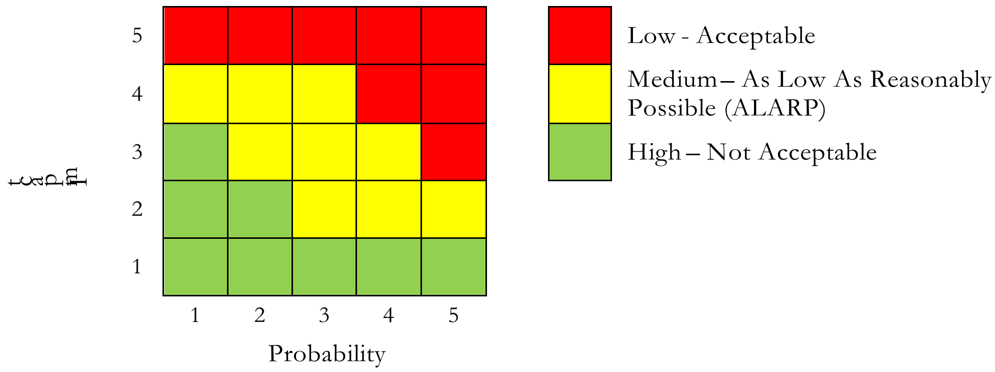

Figure 1.
Probability Impact Matrix

Risks that are in the red box (risks with a high likelihood or high impact) have a high level of risk that requires a more level of control to reduce the likelihood or impact of these risks. Risks that are in the yellow box (risks with a medium likelihood or moderate impact) are risks that need to be monitored, but with a minimum level of control (As Low As Reasonably Possible - ALARP). As long as the risk can be maintained at this level, the risk can still be accepted by the company.

As the paper is focused on the significant risks, mitigation and contingency plans for the risks in red boxes are then proposed as risk management strategy. The plans are formulated based on interviews and literature study.

Results and Discussion

Risk Identification

From the of risk identification process, the study resulted in 41 identified operational risks as presented in table 2, with customer management process having the most amount of risk. In raw water extraction process, most risks are caused by external factors because water source conditions, the location of water intake and the supporting facilities as well as water extraction permit are beyond the company's control.

In water treatment process, more than half of the risk is caused by process factor. In this process, work procedures are very important to ensure there is no production failure and that the water produced is in accordance with drinking water quality standard.

In water distribution process, risks caused by internal factor are leaked pipes, risks associated with quality (turbid water), quantity (low pressure), and continuity (intermittent supply) of water, availability of resources (material and contractor) and the quality of network installation work. Leaked pipe, turbid water and network installation quality can also be caused by external factor. Other risks caused by external factor are the non-functioning of supporting facilities, consent issue, and the relocation of distribution pipes.

Customer management process poses the most risks. Risks due to internal factor are mainly due to process factor, namely resources availability for new connection, meter reading accuracy, delay in new connection, technical problems in meter installation, data discrepancy, unpaid bills, incorrect new connection quotation, fraud, illegal use, and inaccurate demand forecast.

Table 2.
Identified Operational Risks

	Raw Water Extraction Process		Customer Management Process
1	Raw water quality	1	Inaccurate demand forecast
2	Raw water quantity	2	Rejection from prospective customer
3	Leaked transmission pipe	3	Delay in meter installation
4	Relocation of intake and/or transmission pipe	4	Inaccurate new connection quotation
5	Delay in water extraction permit renewal	5	Technical issue in meter installation
6	Poor maintenance of facilities	6	Availability of contractor for meter installation
	Water Treatment Process	7	Availability of meter and/or meter accessories
1	Raw water supply	8	Inaccurate meter reading
2	Disruption in chemical supply	9	Broken meter
3	Disruption in power supply	10	Demand uncertainty
4	Damaged equipment	11	Fraud
5	Production failure	12	Unpaid bills (arrears)
6	Unable to meet water quality standard	13	Data discrepancy (system vs actual)
	Water Distribution Process	14	Unable to access customer management system
1	Low quality of network installation	15	Low customersatisfaction
2	Low water pressure	16	Dependency to one personnel/position
3	Turbid water	17	Illegal consumption
4	Intermittent supply	18	Illegal connection
5	Leaked pipe	19	Termination of thirdparty service
6	Non-functioning supporting facilities		
7	Availability of contractor for O & M work		
8	Availability of largesize pipe		
9	Consent issue		
10	Relocation of distribution pipe		

Significant Risks

Based on the risk assessment on the probability and impact of each risk, there are eleven risks that are considered significant or high risk when mapped in the company's risk matrix, as presented in figure 2 and table 3.

Half of the significant risks occur during water extraction process. Although the probability of such risks is low, except for the raw water quality risk, they have severe impact to customers and company's revenue. It is the same for the production failure risk.

Although customer management process poses the highest risks, those risks are not significant. Contrary to the ones in water extraction and treatment processes, the significant risks in distribution and customer management processes have high probability of occurrence but only moderate impact.

Some of the significant risks are similar to the previous researches, where raw water reliability is considered as the main risk (Wibowo & Mohamed, 2010; ADB, 2010), whether due to water source depletion (Fahrudin & Vanany, 2015), drought (Rossi & Cancelliere, 2013), or high turbidity (Chang & Liao, 2012).

Leaked pipes are also considered as high risks in distributing water (Kunkel, Leven, & Mergelas, 2008; Fahrudin & Vanany, 2015), while in customer management, the risk of meter installation delay is also significant (ADB, 2010). However, the risks that are considered unique to the subject company are the relocation of facilities, production failure due to force majeure, reliability of supply, and availability of contractor for meter installation.

Low raw water quality is triggered during dry season, where the concentration of iron, manganese and dissolved solids exceed the required threshold. Based on Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control, raw water quality for drinking water has a threshold of 0.3 mg/liter iron content, 1 mg/liter manganese content, and 1000 mg/liter of total dissolved solids. Even though iron and manganese do not cause health problems, they can cause aesthetic problems because of the metallic taste which causes them to be uncomfortable to consume. In addition, iron can also cause orange or brown stains in sinks and laundry, while manganese often produces black stain. So, if the water distributed contains iron and manganese levels that exceed the threshold, there will be potential complaints.

Raw water quantity is a risk that many water companies face. In the subject company, the risk is due to the increasingly critical water balance of the source, which is the Cisadane River. The water balance will be a consideration in giving technical recommendation on the amount of water allowed to be extracted from the river. The impact of a critical water balance calculation is the reduced capacity of raw water extraction permit.

Raw water quantity is also affected by the water level. There is a minimum level for the treatment plant to operate optimally. For the subject company, the risk is unique because the water intake is located near flood control gates, therefore the river water level is affected by the operation of the gates.

If the facility is dysfunctional because the sluice gate cannot be closed or is leaking, the impact is a decrease in the water level of the River below the intake pump level, causing raw water cannot be extracted.

Leaked pipes are also a common risk faced by water companies. For the subject company, the transmission pipe that lays for 6.3 km along the irrigation canal from the intake to the treatment plant possess a significant risk. The risk of leakage is caused by the breakdown of the irrigation embankment due to water theft as well as pipe burst caused by the impact of the third parties construction work. Another unique risk of the subject company is because the intake building and transmission pipe are located on leased land, so they are at risk of relocation if the lease permit is not extended.

Production failure in water treatment plants can be caused by several things. In the subject company, natural disasters such as floods and earthquakes are considered to be more significant causes of production failure compared to other causes. Continuity of water supply is the expected service standard in providing clean water. In reality, water supply is often disrupted due to emergencies such as pipeline leaks and leak repair work. In the subject company, this risk is significant due to the high frequency of disturbances due to leak repair. If it is not handled properly, supply disruption will have an impact on increasing customer complaints.

Water pressure affects the quantity of water received by the customer. Normally, water pressure is influenced by distance and elevation between the location of the water treatment plant or reservoir to the service point. The farther the service point of the treatment plant, the lower the water pressure. In addition, water pressure is also affected by the use of booster pumps along the distribution network. Currently, the subject company only has one booster pump, and the farthest point of customer from the booster pump is 23 km away, causing some points will have pressure below one bar, as required.

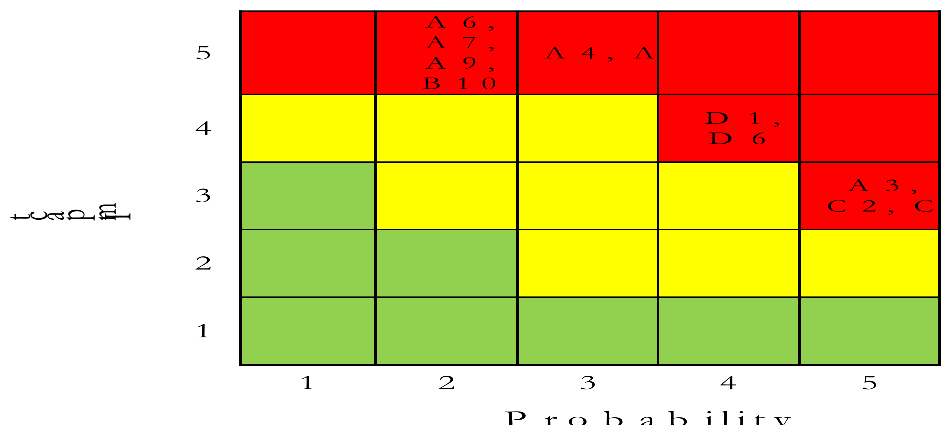

Figure 2.
Significant Risks on Risk Matrix

Table 3.
List of Significant Risks

Risk	Cause	Code	Risk Owner	Probability Scale	Impact Scale
Raw water quality	Increased iron, manganese and dissolved content	A3	Production Manager	4.3	2.3
Raw water quantity	Decrease in water level due to infrastructure failure	A4		2.0	4.8
	Critical water balance	A6	Distribution Manager	1.6	4.0
Leaked transmission pipe	Water theft along the transmission pipeline	A7		1.5	4.3
	Third party construction work	A8		2.6	4.3
Relocation of facilities	Lease permit not extended	A9	Legal Manager	1.3	4.9
Production failure	Force majeure	B9	Production Manager	1.5	4.5
Low water pressure	Lack of pressure at the farthest point	C3	Distribution Manager	4.4	2.4
Intermittent supply	Leak repair	C12		4.4	2.4
Delay in meter installation	Limited number of contractors	D8	Procurement Manager	3.4	3.0.
Availability of contractor for meter installation		D14		3.4	3.0

Although most operational risks are identified in the customer management process, the availability of contractors for the installation of new connections and delays in the new connection process are considered as significant risks because they occur quite frequently and have an impact on company revenues. The risks are triggered by the limited number of contractors, as well as the experience and expertise of the contractors, which determine the type of work that can be done.

Managing the Risks

With the significant risks in the water supply provision, the following are the proposed action plans to manage those risks:

Raw Water Quality

The risk of low quality of raw water cannot be prevented because it is related to external factors. Therefore, steps to detect raw water quality are part of operational procedures and process monitoring. Hou, Song, Zhang, Zhang, and Loaiciga (2013) proposed the development of an urban drinking water quality early warning and control system (DEWS) for detecting, reporting, and handling water quality contamination events, with one of its capabilities including risk assessment and evaluation risk of water quality events based on threats to human health and the treatment capacity of water utilities.

In an activity level, detection should be carried out through laboratory testing of clean water samples after the treatment process is complete. If the water quality is below standard, then the water is circulated back to the production process and chemicals are regulated.

In addition to the need for an SOP to control the production, it is also necessary to conduct training and certification of the human resources who operate it to ensure that the production process is controlled according to the standards.

Water company also needs to develop an operational monitoring plan that contains information on water requirements, water supply, production facilities, availability of testing and safety equipment, testing parameters and frequencies, types of laboratory testing, calibration tools, and other matters need to be inspected in the production process.

Raw Water Quantity

According to Maniar (2010), the most effective measures to mitigate risk related to environment is by creating appropriate lines of communication and contacts with government authorities and agencies.

To control the risk of raw water quantity, risk owner and legal manager, as the one responsible for arranging the water extraction permit, needs to closely coordinate with Balai Besar Wilayah Sungai, as the one who calculates water balance and issues technical recommendation. Another mitigation plan is to develop Corporate Social Responsibility (CSR) programs on promoting greening activities and educating the community on the importance of watershed conservation.

A risk specific to the subject company is the operational failure of flood control gates located near the water intake. This resulted in the decrease in water level to the minimum level that can be extracted. Although the water treatment plant can still operate normally, it will affect production capacity, which in turn affects the quantity and continuity of clean water supply to the community. Effective communication and coordination are established between the risk owner and Public Works and Spatial Planning unit as the one responsible for operating the flood control gate. This is to ensure the company gets initial information if there are obstacles in the facility operation.

Another mitigation plan is to periodically monitor the water level by intake operator and report it to management. Water company should also determine minimum water level that will trigger mitigation actions to extract raw water. In addition, periodic maintenance of water intake facility, including dredging mud at the mouth of intake pumps, must be a routine program of the company. This is to ensure that sludge does not affect the quantity and quality of raw water extracted.

Leaked transmission pipe
Leaks can occur due to the quality of the material used, the load on the pipe, among others, due to the impact of the surrounding construction work, the age of the pipe, and errors during the pipe installation. When it happens in the transmission pipe, it becomes a significant risk because transmission pipe is generally a single and large-diameter pipe, so any issues in it will require longer time and special expertise to repair and will affect the supply of raw water to the water treatment plant.

Because the transmission pipe of the subject company lays along the irrigation canal, a specific cause for leaked transmission pipe risk is irrigation water theft by digging holes underneath the pipeline, which makes the transmission pipe cracks as the ground can no longer support it. The risk is mitigated by building sheet piles along irrigation canal, especially in areas that are considered prone to water theft. The company through risk owner also needs to carry out regular physical checks to identify activities that are likely to endanger the transmission network. Indications of activities that pose a risk should be coordinated the Water Resources Office and other relevant parties for preventive measures.

For the leaks caused by construction works around the pipeline, distribution manager as the risk owner needs to coordinate with related parties to obtain information about construction work that will be carried out, especially those close to the transmission pipeline location, and to carry out joint supervision on the work. In the medium term, it is necessary to have regulations that require that the granting of licenses or technical recommendations for construction work must pay attention to the existence of utility facilities, to avoid disruption to these facilities.

Relocation of intake and transmission pipe
This is a specific risk to the subject company as the location of those facilities is on a leased land. Relocation of facilities will have a tremendous impact on customer service sustainability, and it is very costly for the company to move and rebuild the facilities. According to Jung (2012), utility relocation costs include redesign costs, relocation costs, project delay costs resulting from relocations, project delay costs caused by the discovery of unexpected utilities, change orders, and claims costs of contractors and subcontractors. Therefore, this risk has to be removed. A close coordination must take place between management and the relevant parties, especially with Water Resources Office as the landowner, to lobby and negotiate the lease status issue. This landowner should also be involved in socialization activities to the community and CSR programs so that more understanding is obtained that the provision of clean water by the company provides great benefits to the community, and one of them is strongly supported by raw water extracted through intake facilities.

As the significant risks affect public service, water company needs to develop an Emergency Response Plan as part of risk management. This document prepares the company for all emergencies, especially regarding the quality, quantity and continuity of water supply. The document outlines information on:
1) Communication and authority - parties who must contact and be contacted in the event of an emergency and the authority they have;
2) Security of water supply systems - including the security of the facilities location, chemical storage and usage, security of employees, and security of the technology used;
3) Periodic review of hazards or threats that can occur - identify and correct any deficiencies or damages that occur in clean

water supply facilities and their supporters, and reduce potential hazards and ensure that these facilities receive proper care;
4) Emergency supply and equipment - including the availability of electricity, inventories and supplies needed to maintain the minimum operation of water supply, reserve water storage, water rationing plans, alternative water supply including mutual aid agreement;
5) Emergency response procedures to control the impact of an emergency.

Production failure
Damage due to natural disasters causes production facilities to be inoperable. This can cause the cessation of the clean water supply. In addition to causing losses due to physical damage, the company also suffers potential revenue losses. The risk is managed by transferring it to a third party through insurance.

Water companies need to insure all assets related to production, distribution and head office facilities. Generally, the protection covers the risk of damage from fire, lightning, explosion, aircraft impact, and smoke (FLEXAS), and can be extended to cover damage from riots, strikes, malicious damage and civil commotions (RSMDC), as well as from flood, typhoon, storm and water damage (FTSWD). Besides property insurance that only covers physical damage, water companies also need to ensure income if there is a business interruption as an additional protection that includes loss of income suffered after a disaster. With property insurance and business disruption insurance, losses due to assets damage and loss of potential income caused by natural disasters are minimized with compensation claims.

Intermittent supply
Water supply is often disrupted due to emergencies such as pipe leaks and leak repair work. The larger the diameter of the leaking pipe, the greater the area or customer affected. In some cases, it is considered more cost-effective to reduce leakage volumes by reactively repair broken pipes than to proactively replace them, despite large leakage losses (Malm, Moberg, Rosen, & Pettersson, 2015). The risk of intermittent supply is managed by minimizing the probability and impact of leakage through leak detection. As summarized by Boulos and Aboujaoude (2011), current state of leak detection and management includes pressure reduction, leak noise correlation using acoustic loggers, and flow-step testing by closing valves during the period of minimum nighttime flow.

Water companies can do the following methods as an active leak prevention:
a) Leak detection using acoustic equipment;
b) District Metered Area (DMA) implementation, by isolating an area and installing master meter to monitor the flow entering the area.

By actively detecting leaks, companies can plan repairs before the leak becomes bigger and harder to handle.

Water companies also need to develop Leak Detection and Repair Guideline that contains common leakage problems, as well as detection and leak repair methods. The guideline includes the method of assessing the scale of leakage based on pipe diameter, as well as the number of customers and the average volume in the affected area. From the assessment result, a leak repair plan is prepared, including communication methods to customers and mitigation plan to provide temporary water supply to reduce the impact of leak repair. The guideline specifies the responsible and authority limits for each activity, including during emergency conditions such as pipe burst, or during a long holiday. If the scale of leakage is extensive, the guideline should cover communication procedure to the media or public, so that information to external parties can be controlled (communication in crisis).

Low water pressure
The risk of low water pressure is managed by conducting regular pressure checks regularly to identify and map areas that have the potential of low water pressure.

Routine network checks are also carried out to ensure there are no blockages in the distribution pipeline due to retained deposits or garbage.

Mohapatra, Sargaonkar and Labhasetwar (2014) proposed that disallowing the practice of direct tapping of water from the transmission main and control the leakage are necessary in order to maintain the pressure head.

The strategic long-term mitigation is to build a booster pump to increase water pressure to the farthest service areas. In addition, the company also needs to conduct periodic network modeling to review whether the water demand in an area can still be met with current network capacity. Based on the results of network modeling, if it turns out that the demand in an area is close to the maximum capacity of the network, budget allocation is needed for uprating network capacity, or limiting the number of customers by not adding new customers in the area.

Contractor availability and delays in meter installation
The risks are triggered when the duration for new connection process is beyond the agreed service level agreement. The risks can be managed through careful work planning and effective application of contractor management.

In managing the contractor, beside the availability of documented systems and prior performance data, contractors must also be assessed on a continual basis, independent of prior performance. There should be constant communication of expectations and verification in the form of frequent site audits, regular site visits, fact-based evaluations, regular reporting, contractor interactions, post-job reviews or any other means of assessment, whether formal or informal (Malhotra, 2019).

The first thing to manage the risk is by careful work planning. Work planning is done by projecting the number of new connections in accordance with the annual business plan to determine the workload to be outsourced to the contractor. After the workload is determined, the company needs to establish a service level agreement (SLA) for meter installation to be offered to prospective customers. Although the new connection SLA is not included in the minimum performance standard, the faster the SLA, the faster the new connection is converted into revenue. Projected workloads and service levels will determine the number of new connection teams needed.

Effective implementation of contractor management is carried out through the following steps:

1) Setting up requirement
   The number of teams is determined based on the projected workload and SLA, while the qualifications are determined based on the characteristics of the new connection or the type of targeted customer.
2) Contractor procurement through tight and competitive tenders
3) Performance-based contracting
   The contract type aims to optimize contractor performance by giving emphasis on the expected results, setting the performance standards to be assessed from the contractor, and implementing incentive and penalty schemes to contractor.
4) Building effective communication
   Effective communication ensures that contractor understands the company's policy and procedures regarding new connection as well as the presence of open discussion on potential conflicts or issues.
5) Measuring performance on a regular basis and communicating the results
6) Providing incentives for successful performance
   This stimulates contractors to be able to fulfil contracts based on agreed performance.

Contractor management will increase the performance and quality of work. However, if there is still a backlog in meter installation, in addition to applying a penalty to the contractor, the risk can be managed by temporarily diverting the work to the internal technical team. Job prioritization will be based on the urgency (duration of the backlog) as well as the potential lost income for delay installation. In this case, the team needs to be equipped with adequate skills and equipment to be able to carry out the work of installing new connections.

This study has limitations as it was conducted in just one water company, therefore it might not represent the overall operational risks faced by other water companies. Some risks are specific to the subject company.

The risk treatments for certain type of risk also depend on the risk cause, as different cause requires different treatment to manage the risk. This study also has limitation as it does not assess the risks' level after implementing/adopting the proposed mitigation plans.

Further studies can be carried out to identify and analyze operational risks in other water companies, especially in the Tangerang and the surrounding areas, to find out whether similar operational risks are faced by those companies, and which specific risks are possessed by certain water companies. Another possible study is to analyze the effectiveness of the proposed mitigation plans in companies that have embedded them as part of the risk management strategy.

In addition, as this research only focuses on managing significant operational risks, companies need to formulate risk treatment for other operational risks to reduce the possibility of occurrence and the impact. Risk management ensures that these risks are controlled and do not shift from low and medium risks to significant risks. The results of this study can be used in developing other operational risk management.

Conclusion

Based on this research, it can be concluded that the operational risks faced by water companies in providing clean water supply are mostly caused by process and external factors. Customer management process poses the highest number of risks, but most of them are not significant in terms of possibility and impact. Significant operational risks are mostly found in raw water extraction process. Those risks are low quality and quantity of raw water, leaked transmission pipe and relocation of facilities. Other significant risks are production failure, intermittent supply, low water pressure, and contractor availability for meter installation.

Because significant operational risks are caused by process and external factor, the proposed risk management includes the development of procedures and guidelines such as operational monitoring guideline, emergency response procedure, leak detection and repair guideline, as well as the implementation of effective vendor management. Risk management also includes the establishment of effective communication and coordination with relevant stakeholders, as well as the involvement of stakeholders in CSR programs to provide an understanding of the importance of stakeholders' role in the sustainability of water supply provision.

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