Building Water Independence For Baan Sai Ngam Moo 13

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Abstract

This project assisted the Royal Initiative Discovery Institute and provides supporting data to ensure a sufficient and safe water supply for Baan Sai Ngam Moo 13, an ethnic Hmong village in Sop Bong Subdistrict, Phu Sang District, Phayao. The study examined community water usage patterns, identified sources of contamination, and assessed the hydrogeology of local water resources. We conducted interviews, made field observations, and collected data to analyze the current water distribution system and its challenges. The findings reveal inadequate water management, excessive chemical use, and poor infrastructure maintenance contribute to water quality issues. Recommendations for sustainable water management strategies are provided to enhance long-term access to clean water based on these results.

Abstract (Thai)

โครงการนี้ช่วยจัดหาข้อมูลสนับสนุนแก่มูลนิธิปิดทองหลังพระสืบแนวพระราชดำริในการพัฒนาแหล่งน้ำใช้ที่เพียงพอ และปลอดภัยสำหรับบ้านไทรงาม หมู่ 13 ซึ่งเป็นหมู่บ้านชาวม้งในตำบลสบบง อำเภอภูซาง จังหวัดพะเยา แนวทางการศึกษาใช้วิธีตรวจสอบรูปแบบการใช้น้ำของชุมชน ระบุแหล่งและชนิดการปนเปื้อน และการประเมินคุณสมบัติทางธรณีวิทยาของแหล่งน้ำ ท้องถิ่น คณะผู้วิจัยใช้การสัมภาษณ์และการสังเกตการณ์ภาคสนามประกอบการวิเคราะห์ข้อมูลและตีความผลการศึกษาระบบ จ่ายน้ำของหมู่บ้านในปัจจุบันพบว่า การจัดการน้ำยังไม่เพียงพอต่อความต้องการของประชาชน คุณภาพน้ำที่ผลิตได้ต่ำกว่าเกณฑ์มาตรฐานเนื่องจากมีการใช้สารเคมีมากเกินไป และขาดการบำรุงรักษาระบบผลิตน้ำ คณะผู้วิจัยได้เสนอกลยุทธ์การจัดการน้ำ อย่างยั่งยืนเพื่อการเข้าถึงน้ำสะอาดในระยะยาวของหมู่บ้าน

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First of all, we would like to extend our deepest gratitude to the Royal Initiative Discovery Institute (Pid Thong Laung Phra Foundation) for their generous sponsorship throughout this research. Their commitment to sustainable community development has been instrumental in guiding our efforts to improve water accessibility and quality for Baan Sai Ngam Moo 13.

Second, we would like to thank the villagers of Baan Sai Ngam Moo 13, who generously shared their time, experiences, and perspectives. Their cooperation and willingness to participate in interviews and discussions were essential in shaping our understanding of the community's water challenges.

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Executive Summary

The Problem

Access to clean and sufficient water is a fundamental human right. However, Baan Sai Ngam Moo 13, a remote village in Sop Bong Subdistrict, Phu Sang District, Phayao, northern Thailand, faces significant water shortages and contamination challenges. The village struggles to maintain its tap water management system, resulting in poor water quality and a dependence on external water sources. This study investigated the causes of these water issues, identified the risks faced by the community, and provided sustainable recommendations to ensure a long-term and safe water supply system.

The Goal

This project aimed to assist the Royal Initiative Discovery Institute in addressing the challenges faced by the community. We aimed to provide recommendations for improving the water distribution system to improve the community's daily needs.

The Objectives

The Royal Initiative Discovery Institute seeks supporting data to understand the causes of the problem so they can collaborate with the Sop Bong Municipality to enhance the safe water supply in Baan Sai Ngam Moo 13. The objectives of this project were:

1. Study the community's water usage patterns and perceptions by conducting interviews and observations.
2. Investigate the presence and causes of water contamination in local water resources. Assess potential contamination from the distribution system by:
    - 2.1. Collecting the water quality data of Baan Sai Ngam Moo 13 and evaluating the current water conditions.
    - 2.2. Investigating the hydrogeological characteristics of the area and their impact on groundwater quality in Baan Sai Ngam Moo 13.
3. Identify recommendations and agencies to assist the sponsor in ensuring long-term sustainability and maintenance of the operation.

The Methods

The methods used to evaluate water availability, quality, and management involve conducting interviews and observations with residents, village leaders, water caretakers, and municipal authorities to gather insights on water usage and perceptions. Additionally, data on water quality were collected, focusing on various physical and chemical parameters, such as total dissolved solids (TDS), free chlorine residual levels, and bacteria levels. Furthermore, comparative studies were conducted to examine water management strategies from neighboring villages (Moo 5 and Moo 10) to identify best practices that could be adopted to improve the water management system in Baan Sai Ngam Moo 13.

Findings and Recommendations

Throughout the project, we collected and analyzed data. Based on interviews and observations of the villagers' daily lives, we identified socio-economic structures and challenges, which are detailed in findings 1 to 4. Findings 5 to 7 emerged from our analysis of the village's water supply. The identified findings include:

1. Water usage patterns vary by season, location, and whether households have personal wells. The current daily water supply of 60,000 to 90,000 liters is significantly below the demand of 240,000 liters for the village population, leading to water shortages, particularly during the dry season. Villagers living farther from the main water supply station experience more water shortages than those living closer. While some villagers rely on their wells and claim that their water is clean and clear, those residing further from the surface water pond face greater challenges during the dry season compared to those who live closer to the pond.

2. The physical properties of tap water, such as its color and odor, undermine the villagers' confidence in using it. Villagers are particularly concerned about the yellow color, rust-like smell, and skin irritation caused by the tap water. These issues have led many households with personal wells to prefer their well water over the village's tap water. Furthermore, there are worries about the topography of the surface water pond, which could potentially be contaminated by the surrounding agricultural area, ultimately affecting the water sources used to produce the tap water.

3. The social structure in Baan Sai Ngam Moo 13 presents challenges in tackling issues and fostering progress within the village. The village's decision-making process, shaped by its ethnic structure and the need for clan consensus, results in slow advancements in addressing water supply problems. Additionally, the prioritization of road development over water infrastructure has further impeded efforts to enhance the water system.

4. Improper management of greywater and waste can negatively impact groundwater quality and the environment. When villagers discharge greywater outside their homes, it elevates the risk of contaminating groundwater and local water sources. This poses significant long-term health and environmental risks.

5. Contamination in raw water may be affected by structural failures in well construction. If the second groundwater well experiences structural issues, it could lead to further water quality problems if the water is used to supply tap water for the community.

6. Improper methods in raw water treatment systems can decrease the efficiency of the system. Baan Sai Ngam Moo 13 employs two distinct water treatment systems: one for treating surface water and another for treating groundwater. The surface water system includes processes such as flocculation, coagulation, sedimentation, and filtration, while the groundwater system utilizes aeration and filtration. However, reversing these systems may lead to a reduction in overall water treatment efficiency, as each system is specifically designed to tackle different types of contaminants in the water.

7. Differences in maintenance methods observed among the villages may lead to variations in water quality. In Moo 13, the water quality can be negatively affected by irregular maintenance and inconsistent treatment practices. The village's tap water system suffers from inadequate regular upkeep, resulting in debris accumulation. Furthermore, the flocculation system is not properly maintained, which could increase the risk of water contamination. Inconsistent chemical treatments and excessive use of alum—without precise measurement—can lead to fluctuations in water quality. Infrequent inspections of the pipeline also allow for bacterial growth, which can jeopardize water

safety. Overall, insufficient maintenance and monitoring processes can pose a significant risk of contamination in the village's tap water.

Based on our findings, we recommend that the Royal Initiative Discovery Institute use recommendations 1 to 3 to enhance the village's safe water sufficiency and implement recommendations 4 to 6 to improve water quality. The recommended actions include:

1. Contact the Department of Groundwater Resources for further inspection of well structure failure to enhance water supply.
2. Construction and installation of an additional water well, along with a water treatment and storage system.
3. Installing raw water storage tank.
4. Provide routine maintenance of water supply systems and proper alignment of water treatment systems with their respective water sources.
5. Inspection of raw water to modify the treatment methods and chemicals used for water purification.
6. Design and implement an efficient greywater system to ensure effective drainage.

Executive Summary (Thai)

<u>ปัญหา</u>

การเข้าถึงน้ำสะอาดและเพียงพอเป็นสิทธิพื้นฐานของมนุษย์ แต่สำหรับบ้านไทรงาม หมู่ 13 ซึ่งตั้งอยู่ในตำบลสบบง อำเภอภูซาง จังหวัดพะเยา ทางภาคเหนือของประเทศไทย ประสบปัญหาการขาดแคลนน้ำและน้ำประปาปนเปื้อนอย่างรุนแรง เนื่องจากหมู่บ้านมีความยากลำบากในการดูแลรักษาระบบจัดการน้ำประปา จึงส่งผลให้น้ำมีคุณภาพต่ำและจำเป็นต้องอาศัยใช้น้ำที่มาจากภายนอกของหมู่บ้าน การศึกษานี้มีวัตถุประสงค์ในการตรวจสอบปัญหาทางด้านความสกปรกของน้ำ ระบุความเสี่ยงที่ชุมชนเผชิญ และระบุข้อเสนอแนะที่ยั่งยืนเพื่อให้ระบบน้ำมีความปลอดภัยขึ้นในระยะยาว

<u>เป้าหมาย</u>

โครงการนี้มีเป้าหมายที่จะช่วยเหลือสถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระ สืบสานแนวพระราชดำริ ในการแก้ไขปัญหาที่ชุมชนเผชิญ โดยให้ข้อเสนอแนะในการปรับปรุงระบบการจัดสรรน้ำเพื่อยกระดับคุณภาพชีวิตประจำวันของชุมชน

<u>วัตถุประสงค์</u>

สถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระ สืบสานแนวพระราชดำริ ต้องการข้อมูลสนับสนุนในการทำความเข้าใจสาเหตุของปัญหา เพื่อเพิ่มความสามารถในการร่วมมือกับเทศบาลตำบลสบบงในการพัฒนาการจัดหาน้ำที่ปลอดภัยให้กับบ้านไทรงาม หมู่ 13 วัตถุประสงค์ของโครงการนี้คือ:

1. ศึกษารูปแบบการใช้น้ำและมุมมองของชุมชนที่มีต่อน้ำประปาของหมู่บ้าน โดยการสัมภาษณ์ และสังเกตการณ์
2. ตรวจสอบการปนเปื้อนของน้ำในแหล่งน้ำท้องถิ่น และประเมินความเสี่ยงที่อาจเกิดขึ้นจากระบบการจัดการน้ำโดย:
    - 2.1. รวบรวมข้อมูลคุณภาพน้ำของบ้านไทรงาม หมู่ 13 และประเมินสภาพน้ำในปัจจุบัน
    - 2.2. ศึกษาลักษณะทางอุทกธรณีวิทยาของพื้นที่ และผลกระทบต่อคุณภาพน้ำใต้ดินในบ้านไทรงาม หมู่ 13
    - 2.3. เสนอแนะหน่วยงานที่สามารถช่วยเหลือในการบำรุงรักษา และความยั่งยืนของการดำเนินงานในระยะยาว

วิธีการศึกษา

วิธีการที่ใช้ในการประเมินความพร้อมในการจัดหาน้ำ คุณภาพน้ำ และการจัดการน้ำประกอบด้วยการสัมภาษณ์และสังเกตการณ์ ชาวบ้าน ผู้นำหมู่บ้าน ผู้ดูแลระบบน้ำ และเจ้าหน้าที่เทศบาล เพื่อรวบรวมข้อมูลเกี่ยวกับการใช้น้ำและมุมมองเกี่ยวกับน้ำประปาหมู่บ้าน นอกจากนี้ยังมีการเก็บข้อมูลคุณภาพน้ำโดยการวัดพารามิเตอร์ต่างๆ เช่น ปริมาณของแข็งที่ละลายในน้ำ (TDS) ปริมาณคลอรีนคงเหลือ และแบคทีเรีย การศึกษาข้อมูลเชิงเปรียบเทียบจากหมู่บ้านข้างเคียง (หมู่ 5 และหมู่ 10) เพื่อตรวจสอบวิธีการจัดการน้ำที่สามารถนำมาปรับใช้ในการพัฒนาระบบจัดการน้ำของบ้านไทรงาม หมู่ 13

ผลการศึกษาและข้อเสนอแนะ

ในระหว่างการศึกษาเราได้รวบรวมและวิเคราะห์ข้อมูลจากการสัมภาษณ์และการสังเกตชีวิตประจำวันของชาวบ้าน รายละเอียดของโครงสร้างทางสังคมและปัญหาที่ชุมชนกำลังเผชิญได้ระบุในผลการศึกษาข้อที่ 1 ถึง 4 และ ผลการศึกษาข้อที่ 5 ถึง 7 มาจากการวิเคราะห์แหล่งน้ำของหมู่บ้าน ซึ่งมีดังต่อไปนี้:

1. รูปแบบการใช้น้ำที่แตกต่างกันตามฤดูกาล ตำแหน่งที่ตั้ง และขึ้นอยู่กับว่าแต่ละครัวเรือนมีบ่อน้ำตื้นส่วนตัวหรือไม่ ปัจจุบันกำลังการผลิตน้ำประปาในหมู่บ้านสามารถผลิตได้เพียง 60,000 ถึง 90,000 ลิตรต่อวัน ซึ่งน้อยกว่าความต้องการขั้นต่ำในการใช้น้ำที่ต้องการถึง 240,000 ลิตรต่อวัน จึงทำให้เกิดการขาดแคลนน้ำอย่างมาก โดยเฉพาะในช่วงฤดูแล้ง ชาวบ้านที่อาศัยอยู่ห่างจากประปาหมู่บ้านจะประสบปัญหาน้ำขาดแคลนมากกว่าผู้ที่อยู่อาศัยใกล้ประปาหมู่บ้าน ในขณะที่บางครัวเรือนที่มีบ่อน้ำส่วนตัวระบุว่าน้ำจากบ่อน้ำตื้นส่วนตัวของตนเองสะอาดและใสกว่าน้ำประปา แต่สำหรับผู้ที่มีบ่อน้ำตื้นส่วนตัวที่อยู่ห่างไกลออกไปจากบ่อน้ำผิวดินจะพบปัญหาน้ำในบ่อน้ำตื้นส่วนตัวขาดแคลนในช่วงฤดูแล้งเช่นกัน

2. คุณสมบัติทางกายภาพของน้ำประปา เช่น สีและกลิ่น ทำให้ชาวบ้านขาดความเชื่อมั่นในการใช้น้ำประปา โดยเฉพาะสีน้ำที่เหลือง กลิ่นที่เหมือนสนิม และการระคายเคืองต่อผิวหนังซึ่งทำให้หลายครัวเรือนที่มีบ่อน้ำตื้นส่วนตัวเลือกใช้น้ำจากบ่อน้ำของตนเองมากกว่าการใช้น้ำประปาของหมู่บ้าน นอกจากนี้ยังมีความกังวลเกี่ยวกับภูมิประเทศของบ่อน้ำผิวดินที่อาจถูกปนเปื้อนจากพื้นที่การเกษตรรอบข้างซึ่งอาจส่งผลกระทบต่อแหล่งน้ำที่ใช้ในการผลิตน้ำประปา

3. โครงสร้างทางสังคมของบ้านไทรงาม หมู่ 13 ทำให้เกิดความท้าทายในการแก้ไขปัญหาและความคืบหน้าในการพัฒนาหมู่บ้าน กระบวนการตัดสินใจของหมู่บ้านซึ่งถูกกำหนดโดยโครงสร้างทางชาติพันธุ์ โดยปกติแล้วการตัดสินใจหรือการลงมือทำอะไรจะมีความจำเป็นที่ต้องได้รับการตกลงจากกลุ่มเครือญาติก่อน จึงทำให้เกิดความล่าช้าในการแก้ไขปัญหาการจัดหาน้ำ นอกจากนี้ การให้ความสำคัญกับการพัฒนาพื้นผิวถนนมากกว่าระบบน้ำประปายังเป็นอีกหนึ่งอุปสรรคในการปรับปรุงระบบน้ำประปาเช่นกัน

4. การจัดการน้ำเสีย น้ำทิ้ง และขยะที่ไม่เหมาะสมอาจส่งผลกระทบต่อคุณภาพน้ำใต้ดินและสิ่งแวดล้อม การที่ชาวบ้านทิ้งน้ำเสียนอกบ้านอาจเพิ่มความเสี่ยงในการปนเปื้อนของน้ำใต้ดินและแหล่งน้ำในหมู่บ้าน ซึ่งอาจมีผลกระทบในระยะยาวทั้งทางด้านสุขภาพและสิ่งแวดล้อม

5. การปนเปื้อนในน้ำดิบอาจเกิดจากความเสียหายของโครงสร้างในบ่อน้ำบาดาลที่สอง ซึ่งอาจทำให้เกิดปัญหาทางด้านคุณภาพน้ำเพิ่มเติมได้หากแหล่งน้ำดังกล่าวถูกใช้เป็นแหล่งน้ำประปาของหมู่บ้าน

6. วิธีการบำบัดน้ำดิบที่ไม่เหมาะสมอาจทำให้ประสิทธิภาพของระบบน้ำประปาลดน้อยลง เนื่องจากบ้านไทรงาม หมู่ 13 ใช้ระบบอยู่สองแบบในการจัดการน้ำที่แตกต่างกัน ประกอบไปด้วยระบบบำบัดน้ำผิวดินและระบบบำบัดน้ำบาดาล ระบบน้ำผิวดินมีการใช้กระบวนการต่างๆ เช่น การจับตัว การตกตะกอน และการกรอง ในขณะที่ระบบน้ำบาดาลใช้การฟอกอากาศและการกรองเป็กหลัก อย่างไรก็ตาม การสลับใช้งานระหว่างระบบเหล่านี้อาจลดประสิทธิภาพของการบำบัดน้ำได้ เนื่องจากแต่ละระบบถูกสร้างมาเพื่อกำจัดสารปนเปื้อนในน้ำดิบที่แตกต่างกัน

7. วิธีการบำรุงรักษาระบบบำบัดน้ำที่ไม่เหมาะสมที่ได้มาจากการสังเกตการณ์ในหมู่บ้านอาจทำให้คุณภาพน้ำประปาไม่คงที่ การบำรุงรักษาน้ำประปาที่ไม่มีแบบแผนและไม่เป็นไปตามระบบจะทำให้เกิดการสะสมของสิ่งปฏิกูล นอกจากนี้ระบบการตกตะกอนที่ไม่ได้รับการบำรุงรักษาอย่างถูกต้องอาจเพิ่มความเสี่ยงในการปนเปื้อนของน้ำได้

จากผลการศึกษาของเรา เราจึงแนะนำให้สถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระ สืบสานแนวพระราชดำริใช้ข้อเสนอแนะ 1 ถึง 3 เพื่อเสริมสร้างความเพียงพอของน้ำสะอาดในหมู่บ้านและประยุกต์ใช้ข้อเสนอแนะ 4 ถึง 6 เพื่อปรับปรุงคุณภาพน้ำประปา โดยข้อเสนอแนะทั้งหมดประกอบด้วย:

1. ติดต่อกรมทรัพยากรน้ำบาดาลเพื่อทำการตรวจสอบโครงสร้างบ่อน้ำบาดาลแหล่งที่สอง
2. ขุดบ่อน้ำบาดาลเพิ่มเติมรวมถึงติดตั้งระบบการบำบัดและจัดเก็บน้ำ
3. ติดตั้งถังเก็บน้ำดิบ
4. บำรุงรักษาระบบน้ำประปาเป็นประจำและปรับเปลี่ยนการบำบัดน้ำให้เหมาะสมกับประเภทของแหล่งน้ำ
5. ตรวจสอบคุณภาพน้ำดิบเพื่อปรับวิธีการและปริมาณสารเคมีให้เหมาะสมแก่การบำบัดน้ำ
6. ออกแบบและติดตั้งระบบการจัดการน้ำเสียและน้ำทิ้งที่มีประสิทธิภาพมากขึ้น

Authorship

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Abstract	Pimraphat	Sherlyn
Abstract (Thai)	Rinrada	Pimraphat
Acknowledgments	Pimraphat	Siriluk
Executive Summary	Siriluk Pimraphat	Anaphat
Executive Summary (Thai)	Siriluk Anaphat	Rinrada
Chapter 1: Introduction	All	All
Chapter 2: Background		
2.1. Background of Royal Initiative Discovery Institute	Pimraphat	Sherlyn
2.2. Overview and Geography of Baan Sai Ngam Moo 13	Pimraphat Rinrada	Anaphat
2.3. Hydrogeology		
2.3.1. Groundwater Layers	Pimraphat	Anaphat
2.3.2. Movement of Groundwater	Pimraphat	Siriluk
2.3.3. Groundwater Exploration	Sherlyn Pimraphat	Rinrada
2.3.4. Hydrogeologic Map of Phayao Province	Siriluk	Sherlyn
2.4. Sustainable Water Management Strategies		
2.4.1. Water Treatment for Households Used	Rinrada	Siriluk
2.5. Water Quality Testing Techniques		
2.5.1. Types and Methods for Water Quality Testing	Siriluk Pimraphat	Rinrada

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Chapter 1: Introduction

Access to clean and abundant water sources is a right that everyone should have. As stated by the United Nations, "*Everyone has the right to access sufficient, safe, and affordable water for personal and domestic use*" (*The Human Right to Water and Sanitation*, 2024). The insufficient water supply in Baan Sai Ngam Moo 13 is a major issue to address in this project. Inadequate water supply can increase the risk of illness for villagers as the amount of water needed to sustain an individual's daily routine has not met the requirements. The Royal Initiative Discovery Institute has deeply taken these issues into account and has been wanting to provide support for the village. However, due to their limited resources, it had been a challenge for them to accomplish the task.

Baan Sai Ngam Moo 13 locates in Sop Bong Subdistrict, Phu Sang District, Phayao. The village was originally a part of Moo 9, but due to the rapid population growth, a group of families decided to branch off and establish Moo 13. However, the main challenge that the village faced was the issue of insufficient water supply, which has become more serious with the rapid growth of the population. The limited budget and improperly managed water distribution system have contributed to a critical challenge for the village: encountering an inefficient water supply.

The previous research has shown signs of various aspects of water security in the communities. However, a significant gap in studies still needs to be addressed to improve the water quality at Baan Sai Ngam Moo 13. The contamination in the water has diminished villagers' confidence in using certain water sources. The Royal Initiative Discovery Institute initially presumed that the contamination in one of the village's main groundwater wells was attributable to the nearby landfill. However, after the field visit, the sources of contamination were mainly related to the failure of the well structure. The localized studies focusing on regional water management or urban systems lack studies addressing the specific water usage patterns, contamination issues, and trust dynamics in these unique settings. By examining the causes in detail, this study has provided a clearer picture of the water security issues that affect Baan Sai Ngam Moo 13.

Our research aimed to assist the sponsor in providing recommendations for improving the water distribution system to support the community's daily needs sufficiently. We set a mission to make a tangible difference in the lives of the community members. To achieve this, we set the following objectives to guide our study:

- Study the community's water usage patterns and perceptions by conducting an interview and observation.
- Investigate the presence and causes of water contamination in water resources. This is a key step in ensuring the community's water safety and assessing potential contamination from the distribution system.
- Identify recommendations and agencies that can assist the sponsor in ensuring long-term sustainability and operations maintenance. This is crucial as it ensures the sponsor's continued support and the community's water needs are met.

In summary, this research analyzed the gathered information from the presence of the village's water usage patterns. It investigated the possible contamination caused by groundwater sources and the distribution system. The collected data from residents and official reports can provide the Royal Initiative Discovery Institute with suitable solutions to aid the community with sufficient water supply. These recommendations would improve the water efficiency and quality, raise the community's confidence in using the water, and achieve the sponsor's goal as intended.

Chapter 2: Background

2.1. Background of Royal Initiative Discovery Institute

The sponsor of this project is the Royal Initiative Discovery Institute, also known as Pid Thong Laung Phra Foundation. The Royal Initiative Discovery Institute is interested in providing a sufficient water supply and improving water quality in Baan Sai Ngam Moo 13 to benefit villagers' well-being. The proposed project aimed to enhance the sufficient water supply by investigating contamination in water resources and comparing it with the standards to improve the quality of water.

Royal Initiative Discovery Institute was established on November 24, 2009, inspired by the philosophy of His Majesty King Bhumibol Adulyadej the Great, which is committed to sustainable community development in Thailand. The Foundation's initiatives aim to promote self-reliance by engaging local villagers to identify and solve problems through sustainable practices (*ปิดทองหลังพระ, โครงการในพระราชดำริ*, 2021).

The Foundation collaborates with government and private organizations to improve the quality of life in Thai communities and integrates local approaches to create comprehensive solutions. The Foundation also raises public awareness of sustainable practices and promotes knowledge transfer through community engagement. This approach, guided by the motto "Understand, Access, and Develop," focuses on working closely with communities to find practical solutions, involve everyone in the process, and ensure long-term benefits that improve villagers’ lives across Thailand (*ปิดทองหลังพระ, โครงการในพระราชดำริ*, 2021).

2.2. Overview and Geography of Baan Sai Ngam Moo 13

Baan Sai Ngam Moo 13 is an ethnic (Hmong) village in Sop Bong Subdistrict, Phu Sang District, Phayao. The village was separated from Baan Lai Moo 9 in 2023. Initially, it had 220 households, but by 2024, a survey found that the population had grown to 289 households. This population growth has caused the existing household water distribution system to become insufficient (*แบบเสนอโครงการของสถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระสืบสานแนวพระราชดำริเพื่อเสนอขอรับการสนับสนุนงบประมาณจากกระทรวงมหาดไทย ประจำปีงบประมาณ พ.ศ. ๒๕๖๘*, 2024). Investigating Baan Sai Ngam Moo 13 and Baan Lai Moo 9 on Google Maps shows that Baan Sai Ngam Moo 13 is about 1.56 km away from Baan Lai Moo 9, as shown in **Figure 1**.

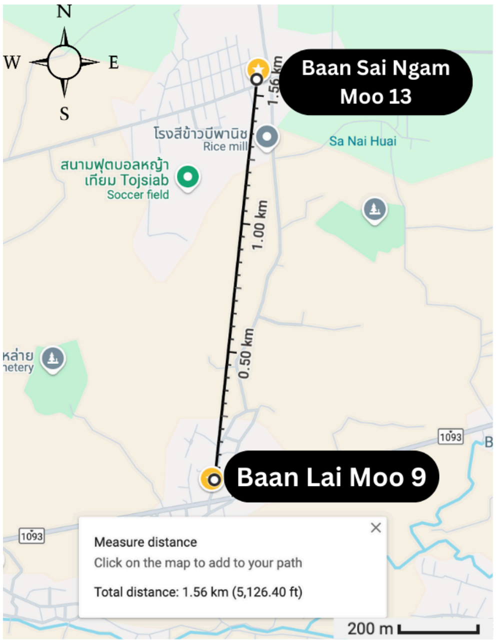

Figure 1. Distance between Baan Sai Ngam Moo 13 and Baan Lai Moo 9

Note. The black line shows the distance between Baan Sai Ngam Moo 13 and Baan Lai Moo 9.

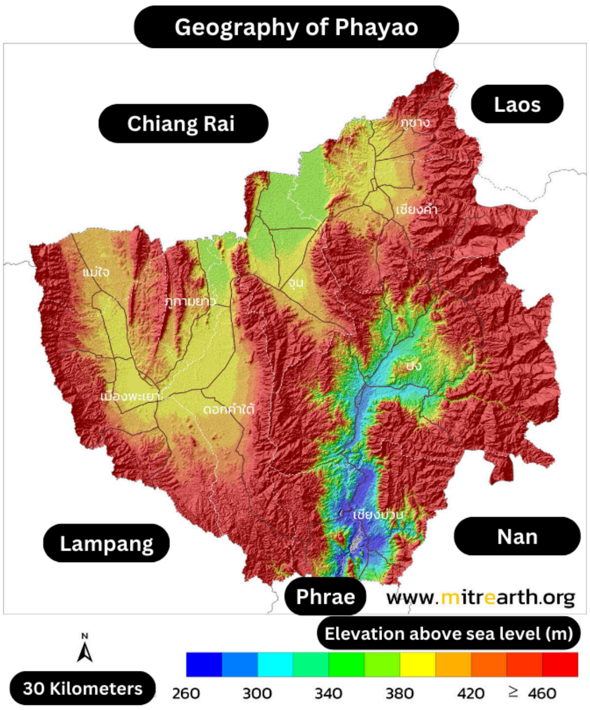

Figure 2a. Phayao Elevation Map (Pailoplee, 2019)

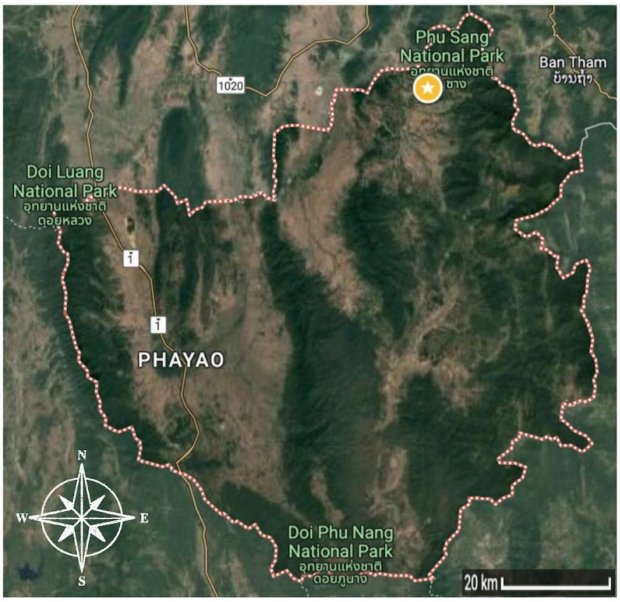

Figure 2b. Baan Sai Ngam Moo 13 Location in Phayao

Note. The star symbol indicates the location of Baan Sai Ngam, Moo 13 on the Phayao map.

Baan Sai Ngam Moo 13 is a plateau that overlays the geography of Phayao, **Figure 2a**, with the location of the village, marked by Google Maps, **Figure 2b**. The Ing River and Yom River are the two main rivers that flow through Phayao, but they do not pass through the Sop Bong Subdistrict. However, the Mae Lao River does flow across the Sop Bong Subdistrict, as shown in **Figure 3** (*รายงานผลการดำเนินงานของจังหวัดพะเยา (Annual Report) ประจำปีงบประมาณ พ.ศ. ๒๕๖๖*, 2023). According to Google Maps, two primary canals branch off from the Mae Lao River: Khlong Bong and Khlong Rai (**Figure 4**). Additionally, three canals branch off from Khlong Rai.

Figure 3. Phayao Tourist Map by Tourism Authority of Thailand (Province of Phayao, 2023)

Figure 4. Rivers and Canals Flow Over the Sop Bong Subdistrict

Note. The red labels represent rivers and canals flow while blue label represents Baan Sai Ngam Moo 13

Nong Kut is a natural water source in Baan Sai Ngam Moo 13 with 75m width, 120m length, 2m depth and a approximately 18,000 cubic meters water capacity storage (*แบบเสนอโครงการของสถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระสืบสานแนวพระราชดำริเพื่อเสนอขอรับการสนับสนุนงบประมาณจากกระทรวงมหาดไทย ประจำปีงบประมาณ พ.ศ. ๒๕๖๘*, 2024). According to the water management plan at the subdistrict level for Sop Bong Subdistrict, Ban Sai Ngam, Nong Kut efficiently enhances water supply management and increases water quantity for the community, especially during the dry season (*แบบเสนอโครงการของสถาบันส่งเสริมและพัฒนากิจกรรมปิดทองหลังพระสืบสานแนวพระราชดำริเพื่อเสนอขอรับการสนับสนุนงบประมาณจากกระทรวงมหาดไทย ประจำปีงบประมาณ พ.ศ. ๒๕๖๘*, 2024).

Figure 5. Location of Nong Kut

2.3. Hydrogeology

2.3.1. Groundwater Layers

There are two underground rock layers, aquitard, and aquifer, defined by the porosity and permeability of the soil and rock layers in each area. Aquitard is a rock layer of low porosity, leading to impermeable properties, such as shale or dense metamorphic rock. An aquifer is a rock layer with high porosity and permeability, such as well-sorted sandstone or gravel. Porosity describes the measure of the void space within the material, while permeability is the ability of that material to transmit fluids. Aquifers can be classified into two types based on pressure within the water-bearing layer, including unconfined and confined aquifers (Pailoplee, 2019)

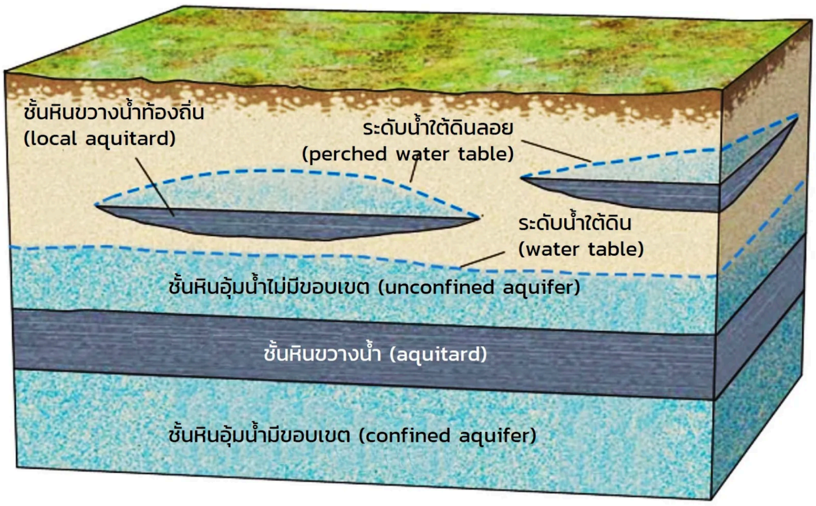

Figure 6. Groundwater Layers (Pailoplee, 2019)

An unconfined aquifer is an aquifer that is not covered by an overlying aquitard. The groundwater level in this type of aquifer corresponds to the local water table. It directly receives water infiltration from surface water, making it the most easily accessible groundwater source. However, as it is the uppermost groundwater layer, it is more susceptible to contamination from chemicals or pollutants that percolate down from the surface. In some cases, if an aquitard underlies an aquifer at a high elevation above the normal groundwater level, it may create a perched water table feature. When water flows out through fractures in the rock, it can form a spring, which flows down from a high elevation (Pailoplee, 2019).

A confined aquifer is an aquifer that is overlain by an aquitard, which creates more significant pressure in the water compared to an unconfined aquifer. It is sometimes called a pressure aquifer or artesian aquifer. The groundwater level in a confined aquifer is influenced by the geological structure of the aquitard, such as the tilt of the rock layers, fractures, or faults. As an aquitard covered by an aquifer, it is less susceptible to contamination. However, if contamination does occur, it takes a long time for the water to purify. If a confined aquifer is tapped in an area under hydrostatic pressure, the water will flow upward naturally without the need for pumping equipment known as an artesian well (Pailoplee, 2019).

Figure 7. Model of Confined Aquifer and Artesian Well (Pailoplee, 2019)

2.3.2. Movement of Groundwater

Groundwater is water that comes from the infiltration of surface water. Therefore, when considering the movement of groundwater, geologists divide the surface into two types of areas: recharge area and discharge area. A recharge area is an area that receives water from the surface water or rainfalls and seeps into the groundwater system. This is typically located at higher elevations. On the other hand, a discharge area is a low-lying area where groundwater discharges into streams or other surface water. When water is added to the groundwater system from the recharge area, it seeps through various rock layers and flows in layers. The time it takes for water to travel from the recharge to the discharge area depends on the flow rate and distance. It may take only a few days for shallow water layers or several thousand years for deeper layers (Pailoplee, 2019).

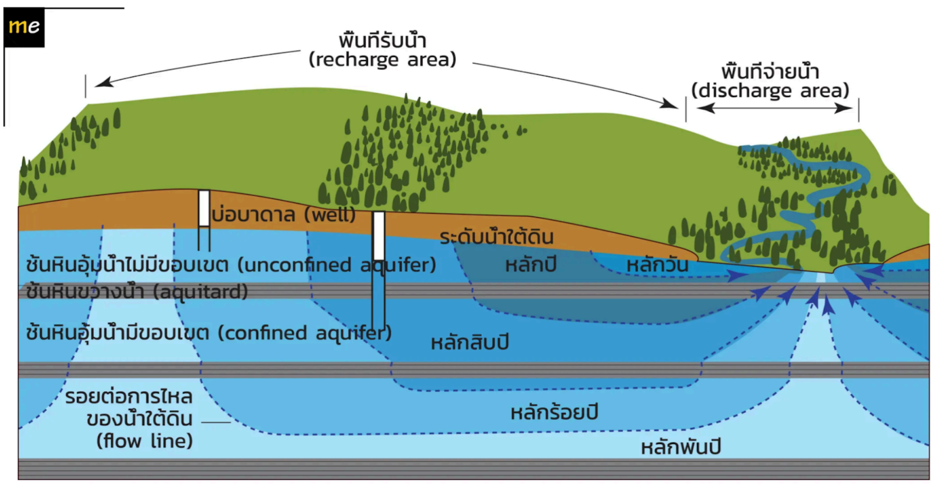

Figure 8. Model of Classification of Rock Layers and Recharge and Discharge Areas with the Travel Time of Water in Each Groundwater Layer (Pailoplee, 2019)

2.3.3. Groundwater Exploration

Groundwater exploration is a critical field of study in hydrogeology that plays a vital role in addressing global water scarcity for remote communities. Exploring groundwater helps this project find underground water sources and ensures the water is safe and reliable for daily use. It also supports long-term water security, reducing the community's dependence on surface water, which can be unreliable and unsafe. Locating groundwater is a complex process that requires a fundamental understanding of its position within the subsurface geological framework (Balasubramanian, 2007).

A resistivity method is one of the groundwater exploration methods. The principle of this method is to inject the current underground through a pair of electrodes, which are the current electrodes. Then measured the potential difference between another pair of electrodes, which are the potential electrodes. Thus, the apparent resistivity (ohm-m) is calculated from the potential difference. The apparent resistivity (ohm-m) is used to plot a graph against the distance (m), resulting in an electrical resistivity profile that provides a simulation of the subsurface as shown in **Figure 9** (Geosearch International, 2021).

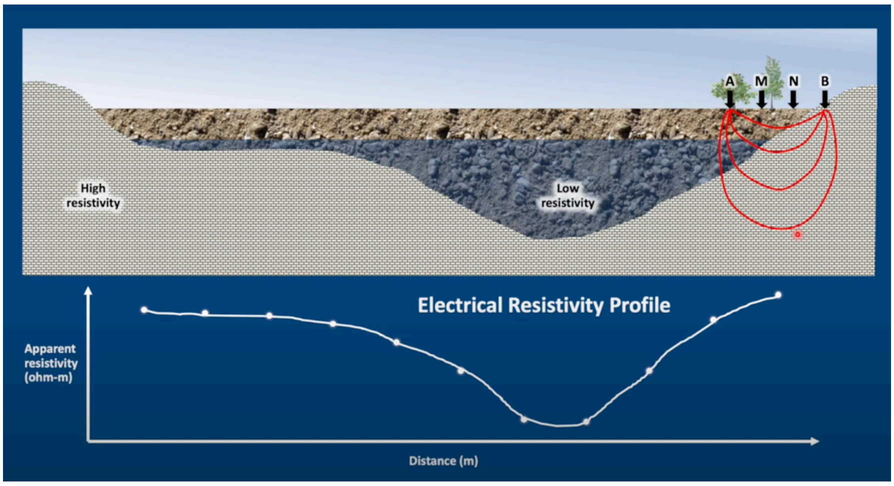

Figure 9. An Electrical Resistivity Profile (Geosearch International, 2021)

Moreover, the resistivity method can simulate the subsurface because different types of water and rocks have different resistivity values (**Figure 10**). These differences allow the identification of various rock formations and water types underground (Geosearch International, 2021).

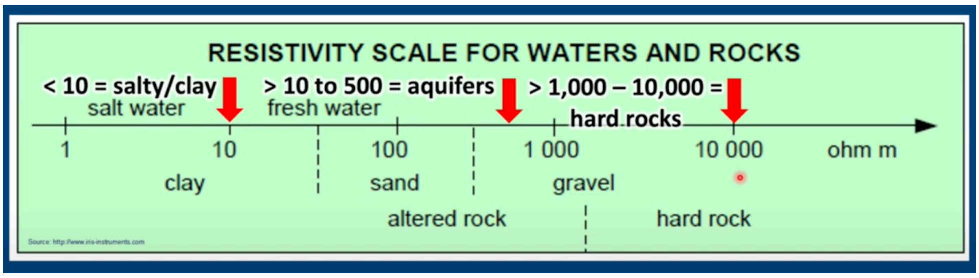

Figure 10. Resistivity Scale for Waters and Rocks (Geosearch International, 2021)

2.3.4. Hydrogeologic Map of Phayao Province

The hydrogeological map of Phayao Province created by the Department of Groundwater Resources illustrates the types of aquifers or water-bearing rock formations. It reveals that the Sop Bong Subdistrict contains aquifers classified as Older Terrace Deposits. This aquifer is composed of gravel, coarse sand, clay, and slit, with a water depth ranging from 50 to 80 meters. The extractable water volume is approximately 2-10 cubic meters per hour (*แผนที่น้ำบาดาล (รายจังหวัด)*, 2017).

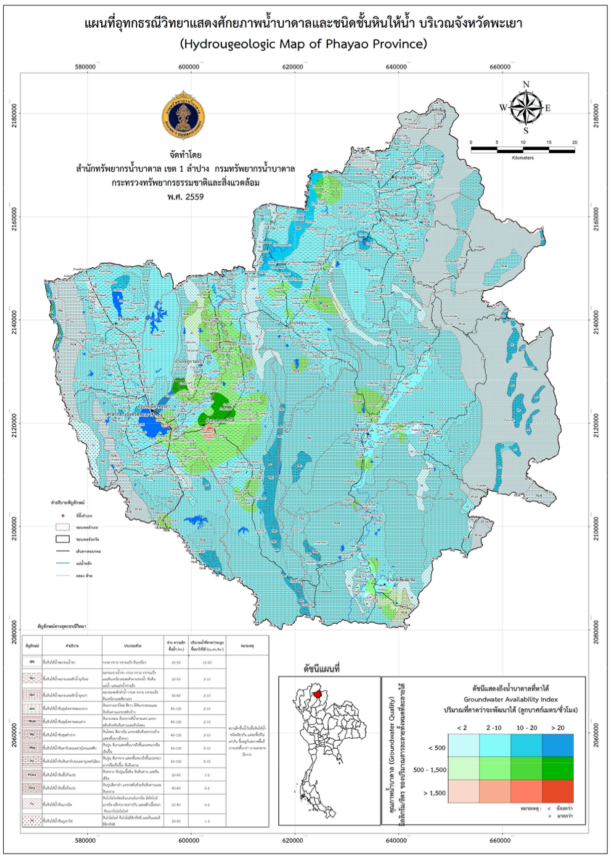

Figure 11. Hydrogeologic Map of Phayao Province (*แผนที่น้ำบาดาล (รายจังหวัด)*, 2017)

2.4. Sustainable Water Management Strategies

2.4.1. Water Treatment for Households Used

Wastewater treatment processes can be divided into physical, chemical, and biological treatments. Physical treatment is the primary solution for wastewater treatment. The treatment separates numerous contaminants in water, involving food scraps, plastic, sand, gravel, oil, fats, and large solids. This type of treatment can be done using screens to trap waste, sand and gravel traps, sedimentation tanks, and fat and oil traps to reduce the quantity of solids in the water. Chemical treatment is the use of chemicals to react with water contamination. To use this type of treatment, the characteristics of the water should be excessively high or low pH level, consist of heavy metals, toxic pollutants, difficult-to-settle suspended solids, dissolved oils and fats, high phosphorus or nitrogen levels, or contamination by pathogens. The equipment used includes slow mixing, rapid mixing, filtration, sedimentation, and disinfection tanks. Biological treatment is the method that uses biological processes or microorganisms, especially in wastewater with excessive levels of organic carbon, nitrogen and phosphorus, which serve as food for microorganisms in the aeration tanks, allowing the microorganisms to grow and break down the pollutants in the wastewater. Examples of biological treatment include activated sludge systems, recirculating channel systems, and aerated lagoons (Mittwater, 2023).

Water treatment starts with primary wastewater treatment, which focuses on eliminating large solids and sediment from water to prevent blockage and damage to equipment. This process can be done by using fine screens and coarse screens and passing through shredders or grinders to reduce the size of solids before moving on to the sand and gravel separation process and removing fats and oils. Secondary wastewater treatment focuses on treating water with dissolved organic matter or colloid particles using a biological treatment that relies on bacteria to break down the contaminants. Afterward, microbial sludge is separated from the water using a sedimentation tank and passed through a disinfection system. Lastly, advanced wastewater treatment methods aim to remove nitrogen, phosphorus, color, difficult-to-settle suspended solids, and other contaminants that remain in the second stage. This method involves complex processes that require specialists, expertise, and a big budget (Mittwater, 2023).

2.5. Water Quality Testing Techniques

2.5.1. Types and Methods for Water Quality Testing

Water quality testing enables a detailed analysis of its composition, impurities, and pollutants. One way to test the water quality is through physical testing, which focuses on the physical properties of water such as temperature, pH level, turbidity, and electrical conductivity. Water temperature displayed in water sources can affect the amount of oxygen dissolved. Next, the pH level indicates the acidity or alkalinity of water. Turbidity reflects the amount of solids in the water and electrical conductivity emphasizes the concentration of dissolved salts in the water (Petro-Instruments Co., Ltd., 2024). These parameters will help determine if water meets safety standards and assist in addressing potential contamination or suitability for various uses. For instance, if water has a high electrical conductivity value, it suggests that the water may have a high contaminant, thus requiring a water filtration or treatment process (Apure, 2022).

The second way is chemical testing which tests Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Suspended Solid (TSS), and Total Dissolved Solids (TDS) as described by Parkerizing (2022). COD is a parameter that measures all organic matter by using strong oxidizing chemicals (potassium dichromate), sulfuric acid, and heat (Omer, 2019). The COD value indicates the amount of oxygen needed for chemicals to decompose organic matter; if the value is high it suggests that there is high chemical contamination (Parkerizing, 2022). BOD is a parameter that indicates the amount of oxygen needed for microorganisms to decompose organic matter (Parkerizing, 2022). DO is an important parameter for testing water pollutants; a higher DO indicates better water quality. There are three ways to measure DO: the colorimetric method, the Winkler titration method, and the electrometric method (Omer, 2019). TSS are particles that are large enough to be filtered while TDS are particles that are too small and able to pass through a filtration medium. The higher amount of TSS increases turbidity and the amount of TDS affects the conductivity, salinity, alkalinity, and hardness of as it includes mineral and salt in water (*Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) - Water Quality Guide*, 2024). Moreover, the hardness of water is one of the important parameters that indicate mineral content. Dissolved minerals in water, such as calcium and magnesium, can lead to problems such as scale buildup in hot water pipes and reduced ability to produce lather with soap. The hardness of water can be quantified by titration with ethylene diamine tetra acidic acid or (EDTA) using the Eriochrome Black T indicator. Water with more than 300 mg/L of hardness is considered to be hard and water with less than 75 mg/L is considered to be soft as shown in **Table 1**. Furthermore, chemical testing also tests the level of water chemicals that affect the water quality of water such as chloride, sulfate, nitrogen, fluoride, iron, manganese, copper, and zinc (Omer, 2019).

Water Classification	Total Hardness Concentration as mg/L as $CaCO_3$
Soft water	0-75 mg/L as $CaCO_3$
Moderately Hard	75-100 mg/L as $CaCO_3$
Hard Water	100-300 mg/L as $CaCO_3$
Very Hard	>300 mg/L as $CaCO_3$

Table 1. Classification of Water Hardness (Metropolitan Waterworks Authority, 2022)

The last property is biological testing which focuses on living organisms in water including bacteria, algae, and viruses. Bacteria play a significant role in waterborne diseases such as typhoid, cholera, leptospirosis, and gastroenteritis. Algae can produce toxins that harm animals and humans and cause taste and odor problems in water. Viruses in water can cause diseases such as hepatitis and poliomyelitis. These living organisms in water can cause serious harm to human health, and disinfection is required for safety (O'Donnell, 2021). However, bacteriological testing requires expertise, specialized equipment, and skilled personnel. A common practice for fieldwork is to collect water samples from the source and send them to a laboratory for examination (Parkerizing, 2022).

2.6. Assessment of Water Standards, Sample Preparation, and Testing Parameters

2.6.1. Tap Water Quality Standards

Provincial Waterworks Authority Regional Office 9 is responsible for ensuring the quality and availability of water in the upper northern region. It currently has 27 branch waterworks under its jurisdiction, including Phayao (ภาพรวมการประปาส่วนภูมิภาคเขต 9, 2021). Therefore, the tap water standards implemented on Baan Sai Ngam Moo 13 can rely on PWA Regional Office 9, which oversees water quality in the Phayao area. These parameters in **Table 2** should be considered and comply with the standards to ensure tap water safety and quality for households based on PWA Regional Office 9.

PWA Regional Office 9 Tap Water Quality Parameter		
Parameters	**Units**	**Tap Water Quality Standards**
Physical Characteristics		
Appearance Color	Pt-Co Unit	≤ 15
Taste and Odor	-	No objectionable smell or taste
Turbidity	NTU	≤ 4
pH	-	6.5 - 8.5
Chemical Characteristics		
Total Dissolved Solids	mg/L	≤ 600
Iron, Manganese, Zinc	mg/L	≤ 0.3
Copper	mg/L	≤ 2.0
Total hardness as $CaCO_3$	mg/L	≤ 300
Sulfate, Chloride	mg/L	≤ 250
Fluoride	mg/L	≤ 0.7
Nitrate as NO_3	mg/L	≤ 50
Nitrate as NO_2	mg/L	≤ 3
Microbiological Characteristics		
Total Coliform bacteria	Per 100 mL	None Detectable
E.Coil	Per 100 mL	None Detectable
Staphylococcus aureus	Per 100 mL	None Detectable
Salmonella spp.	Per 100 mL	None Detectable
Clostridium perfringens	Per 100 mL	None Detectable
Toxic Substances		
Inorganic mercury	mg/L	≤ 0.001
Lead, Arsenic, Selenium	mg/L	≤ 0.01

PWA Regional Office 9 Tap Water Quality Parameter		
Parameters	**Units**	**Tap Water Quality Standards**
Toxic Substances (continue)		
Chromium	mg/L	≤ 0.05
Cadmium	mg/L	≤ 0.003
Barium	mg/L	≤ 0.7
Cyanide	mg/L	≤ 0.07
Pesticide and Herbicide		
Aldrin and dieldrin, Heptachlor and heptachlor epoxide	µg/L	≤ 0.03
Chlodane	µg/L	≤ 0.2
DDT, Hexachlorobenzene	µg/L	≤ 1
Lindane	µg/L	≤ 2
Methoxychlor	µg/L	≤ 20
Trihalomethanes		
Chloroform	µg/L	≤ 300
Bromodichloromethane	µg/L	≤ 60
Dibromochloromethane, Bromoform	µg/L	≤ 100
Total Trihalomethane Ratio	-	≤ 1
Radioactive Substances		
Gross alpha activity	Bq/L	≤ 0.5
Gross beta activity	Bq/L	≤ 1

Remark: The residual chlorine in the tap water distribution system must not be less than 0.2 mg/L.

Table 2. Tap Water Quality Standards (Provincial Waterworks Authority, 2011)

2.6.2. Raw Water Standards

The raw water standard set by the World Health Organization (WHO) aims to ensure that water sources can be treated and made safe for tap water use. This groundwater source must meet the necessary criteria in **Table 3** for treatment into tap water.

WHO Raw Water Quality Standards		
Parameters	**Unit**	**Maximum Permissible Level**
Physical Characteristic		
Color	Pt-Co	300
Chemical Characteristic		
Total Dissolved Solids (TDS)	mg/L	1500
Iron (Fe)	mg/L	50
Manganese (Mn)	mg/L	5
Copper (Cu), Zinc (Zn), Fluoride (F)	mg/L	1.5
Magnesium + Sodium Sulfate ($MgSO_4$ + $NaSO_4$)	mg/L	1000
Alkyl Benzyl Sulfonate	mg/L	0.5
Nitrate as NO_3	mg/L	45
Toxic Substances		
Phenolic Substance	mg/L	0.002
Arsenic (As), Lead (Pb), Chromium (Cr hexavalent)	mg/L	0.05
Cadmium (Cd), Selenium (Se)	mg/L	0.01
Cyanide (CN)	mg/L	0.2
Gross Beta Radioactivity	mg/L	1
Pollution Characteristics		
Chemical Oxygen Demand (COD)	mg/L	10
Biochemical Oxygen Demand (BOD)	mg/L	6

WHO Raw Water Quality Standards		
Parameters	**Unit**	**Maximum Permissible Level**
Pollution Characteristics (continue)		
Total Nitrogen (NO_3)	mg/L	1
Ammonia (NH_3), Carbon Chloroform Extract (CCE)	mg/L	0.5
Grease	mg/L	1
Bacteriological Water Quality Standard		
Classification	**MP/100 ml coliform bacteria**	**Usage Notes**
Class 1	0 - 50	Water is suitable for use as tap water after disinfection.
Class 2	50 - 5,000	Requires sedimentation, filtration, and disinfection before use as tap water.
Class 3	5,000 - 50,000	Additional treatment processes are required beyond those for Class 2.
Class 4	> 50,000	Not suitable for tap water use unless treated using specialized methods as a last resort.

Table 3. WHO Raw Water Quality Standards (Enviresearch, 2020)

2.6.3. Groundwater Testing Parameters

The total parameters for Thailand's groundwater quality standard for drinking water consist of 23 parameters, however, to implement these parameters to the project scope which focuses on groundwater quality standards for daily and household usage, it is not necessary to test all 23 parameters (*Groundwater Quality Index for Water Supply Production*, 2013). The parameters that will be tested on the groundwater sample from Baan Sai Ngam Moo 13 are physical and chemical parameters including pH level, turbidity, heavy metals (Fe, Mn, Zn, Cu), and total dissolved solids (TDS).

A landfill waste site can warn and contaminate groundwater due to leachate (*Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India,* 2012). Leachate consists of high concentrations of various heavy metals, including Cd, Cr, Cu, Fe, Ni, Pb, Fe, and Zn which lead to the rise in the concentration of Cl^-, NO_3^-, SO_4^{2-}, NH_4^+ in groundwater (*Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India,* 2012). Therefore, testing heavy metal parameters in groundwater samples from Baan Sai Ngam Moo 13 can identify whether the cause of groundwater contamination is from the landfill waste site within the area.

Total dissolved solids or TDS is the measurement of the total concentration of inorganic and organic substances dissolved in groundwater, typically suspended molecules or ions (*Total Dissolved Solids Solutions*, 2024). This parameter can illustrate the number of minerals and contaminants dissolved in water which warns the purity of groundwater (*Total Dissolved Solids Solutions*, 2024). Additionally, physical parameters, involving pH levels and turbidity are primary parameters that should be considered while testing groundwater to gather basic scientific information of the groundwater sample from Baan Sai Ngam Moo 13.

Chapter 3: Methodology

This project aimed to provide recommendations for improving the water distribution system to sufficiently support the community's daily needs. Additionally, the project aimed to use hydrology and hydrogeology data into existing water quality data to assess contamination causes, at groundwater and surface water interactions. The data provided insights into the sources and the contamination extent in Baan Sai Ngam Moo 13. These findings will help ensure a reliable and sufficient water supply that meets the community's daily demands. There are a total of three objectives that were determined to complete the goal. The three objectives of the project include:

3.1. Study the community's water usage patterns and perceptions by conducting an interview and observation.

We planned to develop an effective water management strategy for the community through interview data of residents to understand the community's water usage patterns and perceptions of the current water quality. The interview provided a first-hand insight into how water is used in daily needs, the challenges they face, and the level of trust in the current water treatment system. Additionally, information gathered from interviews and observations could reveal user behavior or patterns that contribute to the contamination of water sources. By gathering feedback directly from residents, a water management plan can be designed to address their specific needs and build trust and confidence in using the water.

Moreover, engaging with the municipality could provide the team with valuable geographical information, including available water sources within or near the village. This information could help to further identify alternative water sources if household water supply becomes insufficient. In addition, as the municipality aims to improve the village's water distribution system, connection with the municipality team could provide valuable insights into the water quality data. Also, the groundwater wells in the village were constructed with financial support from the municipality; they could provide detailed information on the water of that well.

Observing the water management systems at neighboring villages might provide different insights into the current problems and possible solutions, especially on the water filtration system, which can foster trust among the residents. Understanding how the neighboring villages gained trust in their water quality further helped identify aspects that could be adopted and developed for Baan Sai Ngam Moo 13, which will greatly extend good practices in water management systems.

3.2. Investigate the presence and causes of water contamination in water resources and assess potential contamination from the distribution system.

3.2.1. Collect the water data of Baan Sai Ngam Moo 13 and evaluate the current water quality.

Identifying specific contaminants, whether chemical, biological, or physical, provided insights into the root of the problem. Detailed laboratory data from the Public Health Division could provide critical insights into the types and levels of contamination. The information will guide the selection of the most suitable and effective solution to ensure safe and clean water for the community.

The water standard used as criteria in this work should match the context of the village or subdistrict. Utilizing appropriate criteria would provide a correct water quality work and improvement framework.

We expected to identify specific parameters that require improvement or treatment and to design an effective water treatment plan. The information would further benefit the analysis and development of solutions to improve water quality in Baan Sai Ngam Moo 13.

3.2.2. Investigate the hydrogeology characteristics and their impact on groundwater quality in Baan Sai Ngam Moo 13

Hydrogeology plays a significant role in influencing groundwater quality and contamination. Even though both groundwater drilling locations are next to each other, only the first groundwater well is usable. In contrast, the second groundwater well is not clean enough for usage, leading to a loss of confidence among villagers and they decided to close the well. Therefore, hydrogeology could be a key factor contributing to the contamination. Determining the depth and geological characteristics of the groundwater at both locations could be achieved through collaboration with lithology experts to investigate the depth of the mined groundwater at the two locations. The data helps to understand subsurface geology and how it influences water availability, movement, and quality.

Hydrogeological data is critical for understanding the relationship between geology and water resources. Investigating the geological characteristics and exact depths of the underground water sources at both sites can provide valuable data on subsurface conditions. This information can further help identify the relationship between landfills and groundwater contamination and help to analyze how to improve water capacity to serve the community's demand, which would be enough for daily activities.

3.3. Identify recommendations and agencies to assist the sponsor in ensuring long-term sustainability and maintenance of operation

Identifying agencies or organizations that align with the sponsor's mission and contribute resources, expertise, or partnerships ensures the long-term sustainability of operations by offering ongoing support and guidance beyond the project's timeframe. Data collection involved stakeholder consultations to identify specific challenges requiring solutions, complemented by a rapid review of case studies and reports to highlight relevant agency types.

Agencies were identified through targeted searches using databases, online resources, industry networks, and expert input. These were evaluated based on their ability to provide actionable guidance, long-term support, and alignment with the sponsor's goals. Recommendations focused on agencies that could address pressing challenges, provide clear guidance and tools for sustainability development, and serve as long-term partners with our sponsor.

Chapter 4: Result and Analysis

This chapter shows the analyzed results and data collected through interviews and observations with the villagers, village leaders, water caretakers, and the municipality. We divided the findings according to the first two main objectives described in Chapter 3. Data related to the third objective mainly were our recommendations. The villagers experienced poor water management, leading to several health effects, such as itching, rashes, and skin redness. Possible causes could be the overuse of chemicals, lack of routine maintenance of the water production system, or improper wastewater management. Providing guidelines for routine maintenance, proper addition of chemicals, and integrating a village greywater management system would improve the village's tap water and overall.

4.1. Objective 1: study the community's water usage patterns and perceptions by conducting an interview and observation.

We found information on the perception of villagers in Baan Sai Ngam Moo 13 toward village tap water and their water usage patterns. The findings for this objective are:

1. The water usage patterns vary by season, location, and ownership of a personal well.
2. The physical properties of village tap water, such as color and odor, reduce villagers' confidence in it.
3. The social structure in Baan Sai Ngam Moo 13 makes it challenging to address issues and drive progress within the village.
4. Improper greywater and waste management might affect the groundwater quality and environment.

4.1.1. Findings

Finding 1: The water usage patterns vary by season, location, and ownership of a personal well

Interview data from 12 households in Baan Sai Ngam Moo 13 revealed that water supply was insufficient throughout the year, with conditions worsening during the dry season, typically between March and May. The water usage data recorded (**Appendix C**) over a three-month period in 2024–May (hot season), July (rainy season), and November (cool season) showed seasonal consumption at approximately 3.3 million, 2.1 million, and 1.6 million liters, respectively. This demonstrates how water consumption changed across seasons. However, these figures may be inaccurate due to potential meter installations, system changes, or the reverse water flow due to the damage to the tap water meter, leading to possible misrecordings. In addition, households farther from the village water supply system experienced more frequent shortages than those located nearby. However, during the rainy season, the villagers noticed stronger color and odor from the tap water.

Households with private groundwater wells, particularly those near natural water sources like a village pond, reported having ample, clear, and odor-free water even in the dry season. In contrast, households farther from these sources struggled with water shortages, as their wells became insufficient. The presence of a personal well significantly influenced water access, with those relying solely on the village supply facing greater challenges.

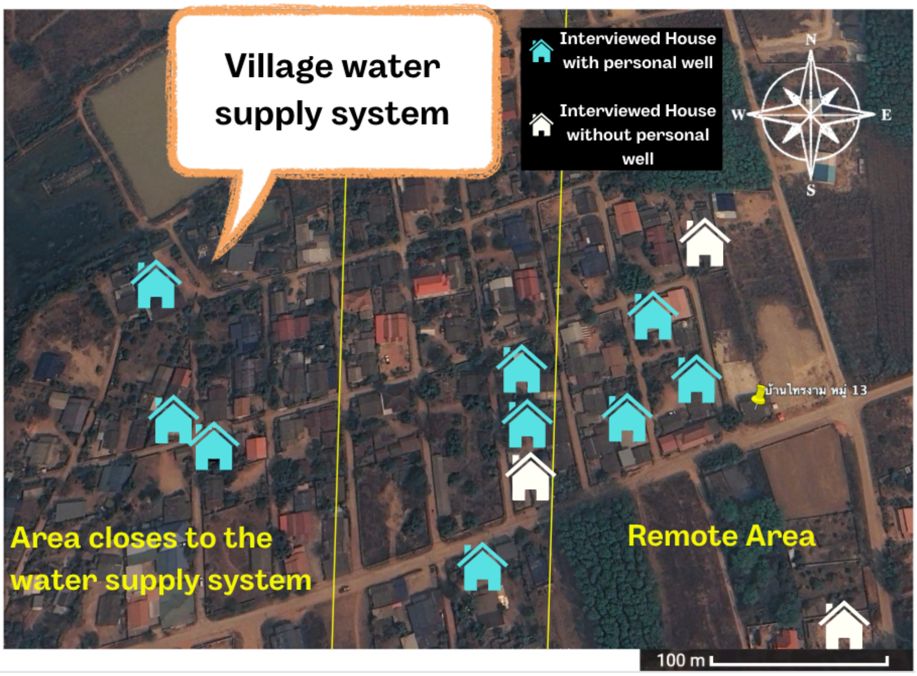

Figure 12. Location of Interviewed Households in Baan Sai Ngam Moo 13
Note. The houses represent the interviewed households during the site visit. The blue house marks are the households that own personal groundwater wells, whereas the white house marks are the households without personal groundwater wells. The map includes the yellow lines that divide the village into areas that are close and far from the village's water supply system (remote area).

Moreover, the village's water caretaker stated that daily water usage was approximately 90,000 liters, based on the frequency of refilling the elevated storage tank up to three times per day. However, each person requires an estimated 120 liters of water per day for daily activities (ตัณฑุลเวศม์, 1989). A village of 2,000 people would need at least 240,000 liters daily. This discrepancy highlighted a significant shortfall in the water supply.

Finding 2: The physical properties of tap water such as color and odor reduce villagers's confidence in using the village's tap water

Interview data from 12 households in Baan Sai Ngam Moo 13 revealed consistent concerns regarding the village's tap water. The primary issues were watercolor (37.5%) and odor (33.3%). Villagers described the water as yellow and cloudy, with a distinctive rusty and earthy smell. **Figure 13** illustrates water samples showing these characteristics. Additionally, many residents reported that the water caused their skin to feel sticky, dry, and rough, with some experiencing skin irritation. These negative effects contributed to a decline in villagers' confidence in using tap water.

Due to these quality concerns, households with personal groundwater wells preferred using their own water sources, which they found to be cleaner and free of unusual odors. This reliance on private wells further highlighted the inadequacy of the village's tap water supply in meeting residents' needs.

Figure 13. Water Samples Collected After Mixing with Alum (Left) and Raw Water (Right)

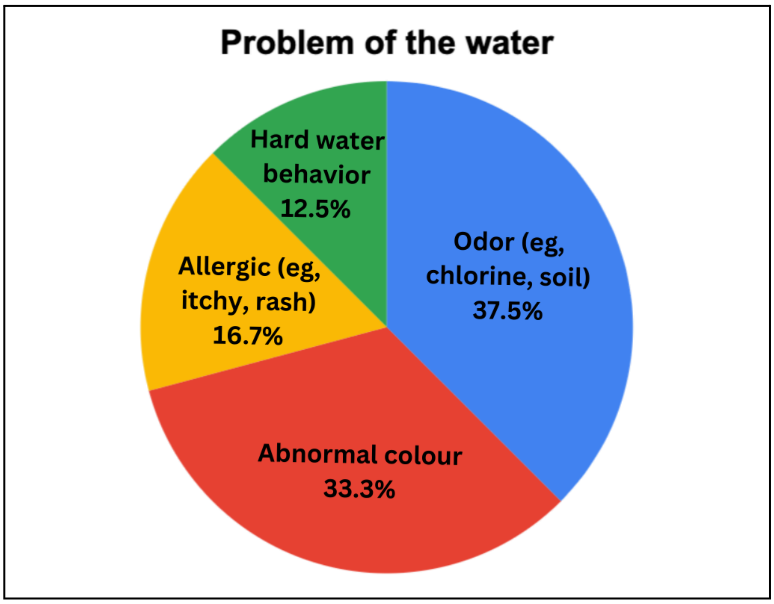

Figure 14. The Concern of Villagers of Baan Sai Ngam Moo 13 Toward Village's Tap Water From Interview

During a site visit, the village's water caretaker expressed concerns about possible contamination of the (Nong Kut) surface water pond, which supplies the village. Villagers have no confidence in the water from Nong Kut, fearing that agricultural runoff from the elevated agricultural zone of Thung Kluai was affecting its quality. These runoffs could introduce soil impurities, organic matter, and chemicals into the water supply. **Figure 15** provides a topographic view of Moo 13, showing the village's location in relation to the nearby agricultural zone.

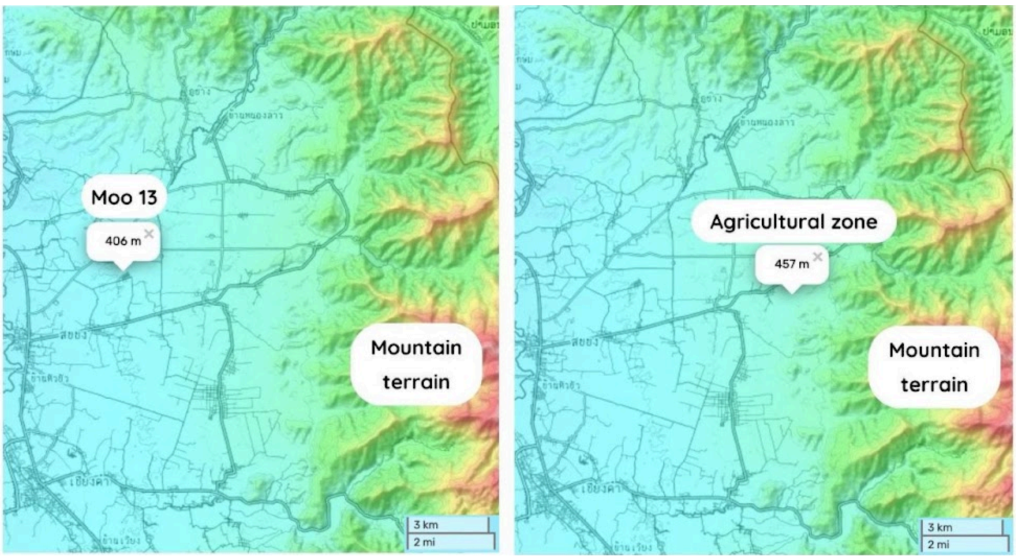

Figure 15. Topography Map of Moo 13 and Nearby Agricultural Zone (Topographic-Map.com)

Finding 3: Social structure in Baan Sai Ngam Moo 13 leads to challenges in addressing issues and driving progress within the village

The Royal Initiative Discovery Institute revealed that the villagers of Baan Sai Ngam Moo 13 belong to the Hmong ethnic group, comprising 13 distinct clans living together. The village operates under a democratic social structure where the head of the village (พ่อหลวง) cannot make decisions independently but must seek approval from the leaders of all 13 clans. Each clan follows the guidance of its leader, meaning that all issues and decisions are voted on separately. As a result, implementing changes requires agreement among all clan leaders before the head of the village can report them to the Royal Initiative Discovery Institute and the municipality. While this system ensures full participation, it also significantly prolongs the decision-making process, making it more time-consuming to address issues and drive progress.

The Municipality Engineering Department noted that villagers in Baan Sai Ngam Moo 13 prioritize road development over water infrastructure. Their main goal is to expand the community and improve road conditions to attract relatives to settle in the village. Since the municipality's annual budget for assisting each village is limited and must be allocated based on villagers' requests, enhancing the tap water system has been more challenging.

Moreover, both the sponsor and the municipality reported a sharp increase in the village's population. The number of households grew from 189 in 2023 to nearly 300 in 2024, an increase of approximately 58.7%. Meanwhile, the number of residents more than doubled from 997 to over 2,000, marking a population increase of more than 100%. This rapid growth is primarily driven by a cultural tradition of inviting cousins to join the village, further straining existing infrastructure and resources.

Finding 4: Improper greywater and waste management might affect the groundwater quality and environment

The households in Moo 13 do not have a proper wastewater treatment system, which leads to the direct disposal of greywater without adequate filtration or treatment. Some households store greywater in a soak pit, while most drain it through pipes into the streets (**Figure 17**). In both cases, the untreated greywater seeps into the soil, posing a risk of groundwater contamination (**Figure 16**).

Figure 16. The Drainage System Connected to the Road Outside of the House at One of the House in Baan Sai Ngam Moo 13

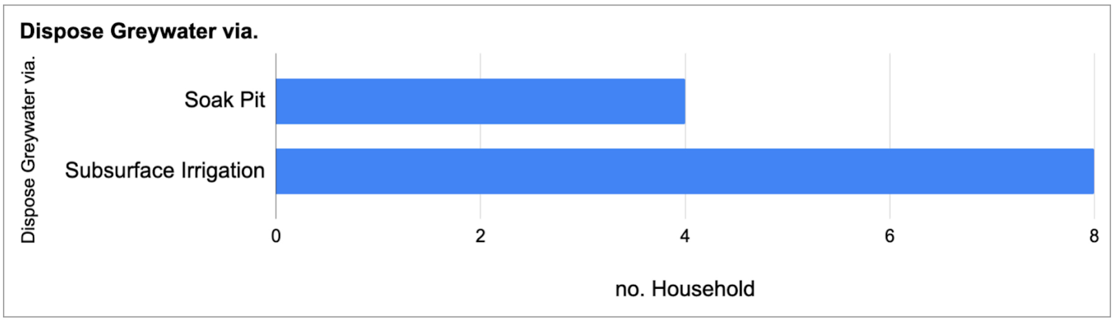

Figure 17. The Method of Greywater Disposal of the Villagers in Baan Sai Ngam Moo 13 From Interview

Note. This bar chart shows the results from the interviews of 12 households in Baan Sai Ngam Moo 13, regarding the methods of greywater disposal, where the majority dispose of greywater through subsurface irrigation. Conducted by Sherlyn Seah

Figure 18 summarises the village water usage cycle as follows: Villagers primarily rely on two water sources: the village's tap water system and personal groundwater wells. The water is used for various household activities and untreated greywater is then disposed of and allowed to seep into the ground. Over time, this cycle can lead to the accumulation of impurities, which can affect the village's primary water sources and pose an extended public health risk.

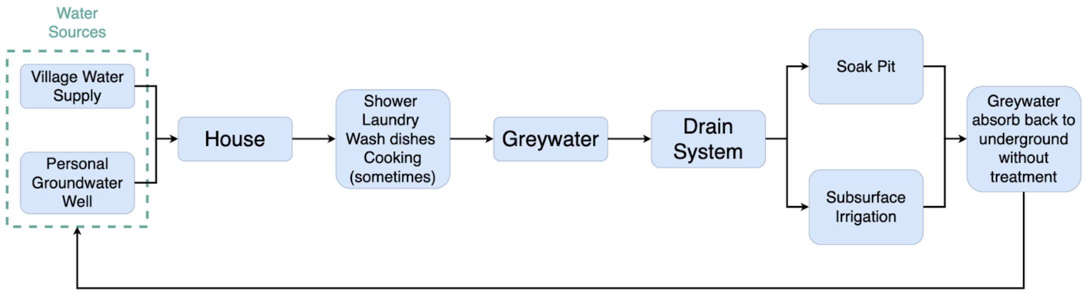

Figure 18. Water Usage Pattern of Villagers in Baan Sai Ngam Moo 13

Note. This flowchart illustrates the water usage pattern cycle of the villagers in Baan Sai Ngam Moo 13.

According to "Greywater irrigation as a source of organic micro-pollutants to shallow groundwater and nearby surface water", the article proved that improperly managed greywater can contaminate groundwater. According to the research, irrigation and seepage of untreated greywater into the soil can lead to contamination of shallow groundwater sources (Turner et al., 2019). This increases the likelihood of villagers' exposure to harmful chemicals, micro-pollutants, and pathogenic microorganisms present in greywater (Turner et al., 2019). Without an effective wastewater management system, groundwater quality in Moo 13 remains vulnerable to long-term contamination, potentially affecting both environmental and human health.

4.2. Objective 2: Investigate the presence and causes of water contamination in water resources and assess potential contamination from the distribution system.

While we worked to achieve this objective, we discovered that many possibilities of water contamination may arise from the village water distribution system. We found no troubleshooting or maintenance plan in place. However, the water caretaker is open-minded and eager to find the best optimization to run the system. The findings for this objective include:

1. The raw water contamination may arise from structural failure of the well.
2. Improper choice of raw water that does not match the treatment process can reduce the system's efficiency.
3. Improper maintenance methods contribute to final water quality.

4.2.1. Findings

Finding 5: Contamination in raw water could be influenced by structural failure in well construction

Observations revealed that the raw water from the second groundwater well in Baan Sai Ngam Moo 13 contained high sand and dirt. The contamination has led villagers to lack confidence in using the well, rely solely on the first groundwater well, and stop using the second one. Villagers suspect that the nearby landfill may cause the contamination. However, the initial raw water testing of the second wells surpassed the groundwater standard. We learned from an interview with the municipality that the turbidity of the water from the second well appeared after two weeks of operation, and more dirt and sand were visible. This information suggested that the contamination occurred not right after the drilling but after the usage. The exact cause of this change remains unknown and requires further investigation to identify potential contributing factors.

Moreover, the groundwater well construction in Baan Sai Ngam Moo 13 follows the Department of Groundwater Resource standard, as shown in **Figure 19** Reviewing the standard well structure suggests that well failure could be attributed to many factors. The well screens allow water to enter the well while blocking sand and other sediments, maintaining structural integrity and preventing collapse. The gravel packs around the well screens serve as a secondary filter, preventing fine particles from clogging the screen while ensuring smooth water flow. (*มาตรฐานการเจาะและการก่อสร้างบ่อน้ำบาดาลตามสภาพพื้นที่*, 2562). Together, these two parts keep sediment out and maintain efficient groundwater extraction. According to "7 Warning Signs Your Water Well Is In Trouble", if the well screen degrades, sand or sediment from the gravel pack around the well screen can enter the well, sand can quickly wear out the pump valves and fill up the bottom of the well with sand (Bulfin, 2021).

Additionally, another possible contributing factor is installing the submersible electric pump too close to the bottom of the well. When the pump operates, it can cause the water level in the well to drop. If the pump is positioned too close to the bottom, it may draw up sand and sediment along with the water (Bulfin, 2021).

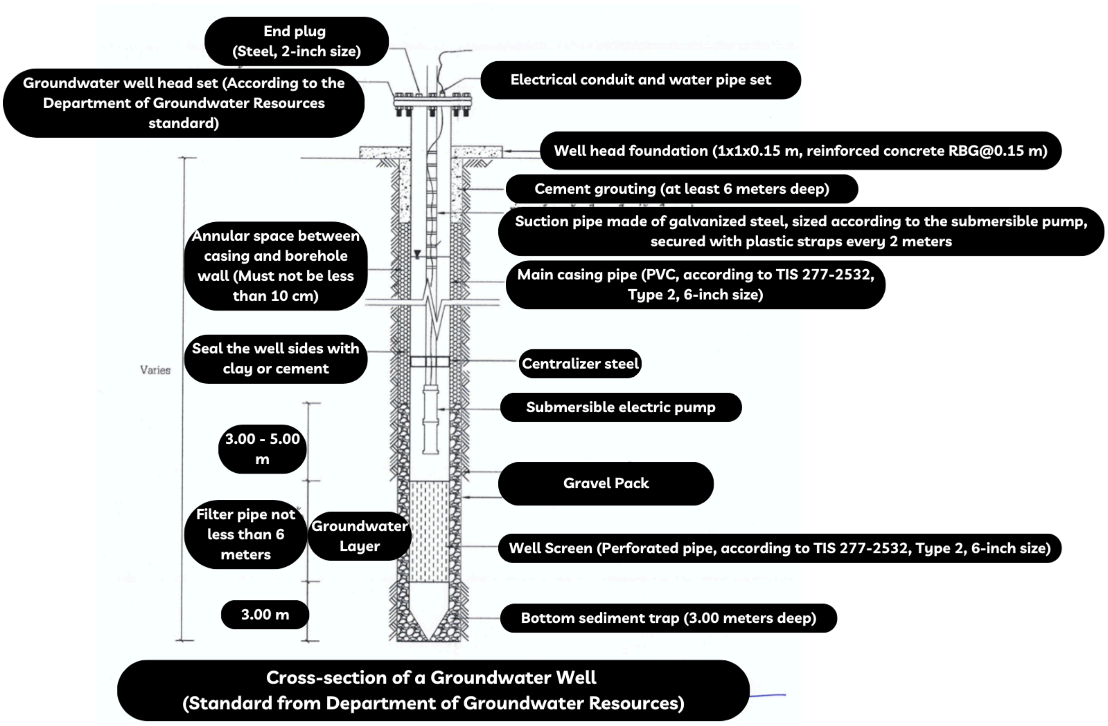

Figure 19. Groundwater Well Standard Structure from the Department of Groundwater Resources (Department of Groundwater Resources, 2019)

The well screen was installed at 73-93 meters and the depth matches the hydrogeology data of the fine sand and clay slit layer (**Table 4).** The groundwater sample collected from the village's second well was brown with suspended fine sand particles, suggesting that the well screen might be damaged at this depth, as it was designed to prevent sediment from entering while allowing water to flow into the well. Jeerapong Laonamsai, Ph.D., an expert in Water Resources Engineering at Chulalongkorn University, suggested that the presence of agriculture and a nearby landfill could affect groundwater parameters but would not cause sand or sediment to flow into the well and the color and odor can be treated through the groundwater treatment system. He also suggested that the contamination in the second groundwater well might be due to damage in the well screen, as it is designed to prevent sediment from entering while allowing water to flow into the well. Moreover, after leaving the raw water sample collected from the second groundwater well for 24 hours, precipitation occurs and the water on the top layers is clear as shown in **Figure 19**. Interview, observation, and additional research suggested that if the well's parts are not functioning or positioned correctly, it could lead to sand and dirt contamination in the water.

Hydrogeology Layer	Depth (m.)
Clayey silt, brownish-yellow	0-18
Fine sand	18-24
Clayey silt, yellowish white	24-30
Clayey silt, brownish white	30-36
Clayey silt, brownish-yellow	36-42
Clayey silt, brownish white	42-48
Clayey silt, yellowish	48-54
Gray sticky clay	54-60
Clayey silt	60-66
Fine sand	66-72
Fine sand	72-78
Clayey silt, white	78-84
Clayey silt, gray	84-96

Table 4. Hydrogeology of the Second Groundwater Well in Baan Sai Ngam Moo 13 (Municipality of Sop Bong, 2023)

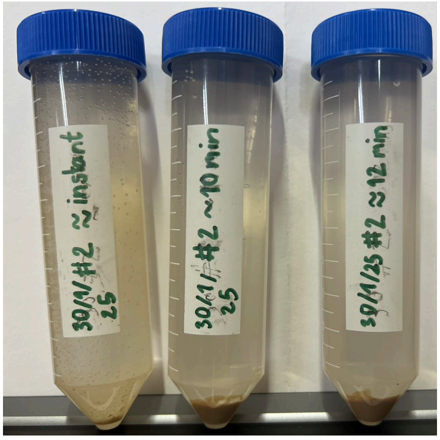

Figure 20. Raw Water Sample Collected from Second Groundwater Well After 24 hours

Finding 6: The unsuitable methods of raw water treatment systems can lead to the reduction of the system's efficiency

From the observation of the tap water station, the village has two treatment systems consisting of surface water treatment and groundwater treatment systems, which differ in treatment methods and specific purposes, as the name states. However, the village treats groundwater using a surface water treatment system, while surface water is processed through the groundwater treatment system.

The surface water treatment system consists of flocculation, coagulation, sedimentation, filtration, clear water storage, and calcium hypochlorite dosing. Raw water is pumped into the flocculation system (rapid mixing) using a hydraulic jump to quickly blend alum and lime solutions, destabilizing suspended particles for aggregation. It then flows into the coagulation system (slow mixing), where circulation channels allow smaller particles to form larger flocs. These flocs then move to the sedimentation tank, where the water flows slowly to enable larger particles to settle while finer ones remain suspended, making the water appear clear. Finally, the water is pumped into the clear water tank, which stores filtered water, balances supply and distribution, serves as a suction source for clean water pumps, and functions as a reaction chamber for calcium hypochlorite disinfection (*คู่มือผู้ควบคุมการผลิตน้ำประปาระบบประปาผิวดิน รูปแบบกรมทรัพยากรน้ำ (5 10 และ 20 ลบ.ม./ชม.),* 2019).

In contrast, the groundwater treatment system consists of aeration, filtration, clear water tank storage, and calcium hypochlorite dosing. Raw water is pumped into the aeration system, allowing contact with air to precipitate dissolved gases. It then flows into the filtration tank, where sand filters remove iron sediment. Finally, the water is pumped to the clear water tank, treated with calcium hypochlorite, and distributed (*คู่มือผู้ควบคุมการผลิตน้ำประปาระบบประปาบาดาล รูปแบบกรมทรัพยากรน้ำ (7 และ 10 ลบ.ม./ชม.)*, 2019).

The above information revealed the different treatment processes of the two types of water supply, which differ in treatment process and designed purposes. Moreover, interviews with the Municipality Engineering Department and Jeerapong Laonamsai (Ph.D.), an expert in Water Resources Engineering at Chulalongkorn University, both suggested that selecting an appropriate treatment system would improve treatment efficiency of Baan Sai Ngam Moo 13's water supply system. Therefore, from the studies, aligning the right water sources with the appropriate treatment systems would significantly optimize treatment efficiency. For this reason, a reverse system in the village could reduce the efficiency of purification methods and allow contaminants to remain in the tap water.

Finding 7: Differences in maintenance methods observed among the villages might lead to variations in water quality

Observing the village tap water well and interviewing the village water caretaker, we found that they do not have a regular maintenance plan. The lack of routine system upkeep has led to the accumulation of debris and allowed external matters to remain in the flocculation system (**Figure 21**). On the other hand, Moo 5 and Moo 10 regularly follow a routine cleaning schedule for their water production system (**Figure 22**), which allows them to produce clean and clear water. This comparison suggests that irregular maintenance of tap water systems can potentially impact water quality, leading to potential contamination risks.

Figure 21. Moo 13's Surface Water Treatment System Contaminated with Leaves and Sediment Accumulated on the Wall (from left to right)

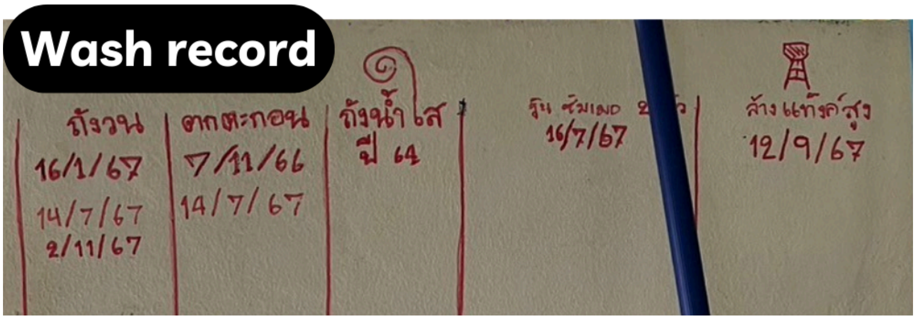

Figure 22. Moo 10's Wash Record

An interview with the caretaker of the tap water station in Moo 13 revealed that excessive chemicals are used to treat groundwater while the raw water quality was rarely inspected. Calcium hypochlorite, a disinfectant, is added visually instead of by precise measurement to match the quality of input water (**Figure 23**). The treatment process also uses alum to remove organic matter and certain heavy metals to clear the water. During the dry season, Moo 13 uses 375 kg of alum each month and 100 kg of alum each month during the rainy season or when the water has become more clear. While in both seasons, Moo 13 uses about 4.30 kg of calcium hypochlorite each month. These numbers are much higher than other villages like Moo 5 and Moo 10. Moo 5 uses only 1 kg of alum and two tablespoons of calcium hypochlorite, while Moo 10 uses 30 kg of alum and none of the calcium hypochlorite per month (**Table 5**).

Figure 23. Inconsistent Quantity of Added NaOCl

Comparison between Chemicals Used in Each Village				
	Standard	**Moo 13**	**Moo 5**	**Moo 10**
Types of Alum Used	Aluminum Sulfate or $Al_2(SO_4)_3$. $14H_2O$	Industrial Grade 3rd type of Ammonium Alum (Clear solid No.1) $Al_2(SO_4)_3(NH_4)_2$. $24H_2O$	Industrial Grade 3rd type of Ammonium Alum (Clear solid No.1) $Al_2(SO_4)_3(NH_4)_2$. $24H_2O$	Industrial Grade 3rd type of Ammonium Alum (Clear solid No.1) $Al_2(SO_4)_3(NH_4)_2$. $24H_2O$
Amount of Tap Water Produced (L per day)		60,000-90,000	100,000	115,000
Amount of Alum Used (mg/L per day)	35-50 mg/L	**dry season**: Min. **~136 mg/L** Max. **~204 mg/L** **rainy season**: Min. **~40 mg/L.** Max. **~60 mg/L.**	**~0.33 mg/L**	**~8.5 mg/L**
Types of Chemicals Used for Disinfectant	Calcium or Sodium Hypochlorite, Chlorine gas, Chlorine Dioxide	Dry Calcium Hypochlorite (available Chlorine 65%)	Dry Calcium Hypochlorite (available Chlorine 65%)	None
Amount of Chemical Used for Disinfectant per day	no more than 0.2 mg/L and maximum of 0.5 mg/L	Min. **~1.0 mg/L.** Max. **~1.6 mg/L.**	**~0.0067 mg/L or 6.7 µg/L.**	None

Table 5. Comparison between Chemicals Used in Each Village

Despite excessive chemical usage, the tap water in Moo 13 is cloudy and white, while the other villages' tap water is clear. The observed TDS level in raw water was 26.1 ppm, while tap water had a TDS level of 34.2 ppm, indicating that additional dissolved solids may have been introduced during water treatment and distribution. Thus, the increase in TDS levels may not only result from excessive chemical use but could also result from improper water system maintenance. Free chlorine, such as Cl^- and OCl^-, is not detectable in the tap water system, as shown in **Figure 24**.

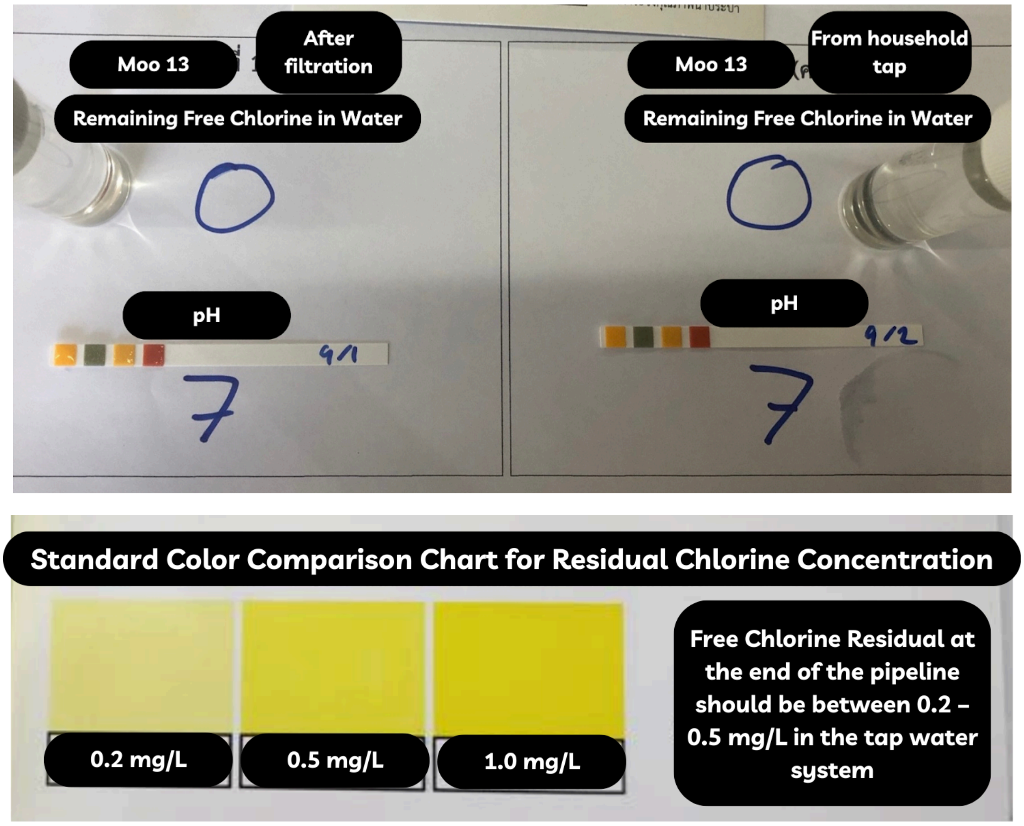

Figure 24. Free Chlorine Residue Test Result of Tap Water System
(Municipality Department of Public Health and Environment, 2023)

Note. The figure illustrates the pH and chlorine residue of tap water collected after filtration and household tap.

Excessive chemical use may be counterproductive. Overusing alum that initially aims to remove floc can promote flocculation by inducing smaller particles to form and resuspend (Topol, 2006). Adding calcium hypochlorite into treated water with excess alum dosage can promote side reactions between free chlorine, which is a stronger disinfection species, and ions or organic substances to form combined chlorine, a weaker disinfection species (Health Canada, 2016). Jeerapong Laonamsai (Ph.D.) mentioned that "groundwater with low TDS does not need to be treated with chemicals like alum since it can promote more particles in the water after treatment.", thus making water more turbid. The turbidity can be reduced using a carbon filter to remove suspended solids, organic substances, odors, color, and turbidity. Therefore, improper use of chemicals initially aimed to improve the water quality could make it less clean and raise more concerns about its safety for daily use.

In addition, pipeline inspections and repairs are infrequent. Tap water quality from the tap water station to the tap water in the household can house bacteria along the pipe (**Figure 25**). Compared with Moo 5 and Moo 10, which have acceptable and regular maintenance schedules for both the tap water systems and the tap water distribution pipeline, the bacteria regrowths are not present in the villages' tap water **(Table 6)**. Positive results of bacteria at household taps indicated the contamination within the tap water distribution pipeline resulting from improper maintenance and inspection.

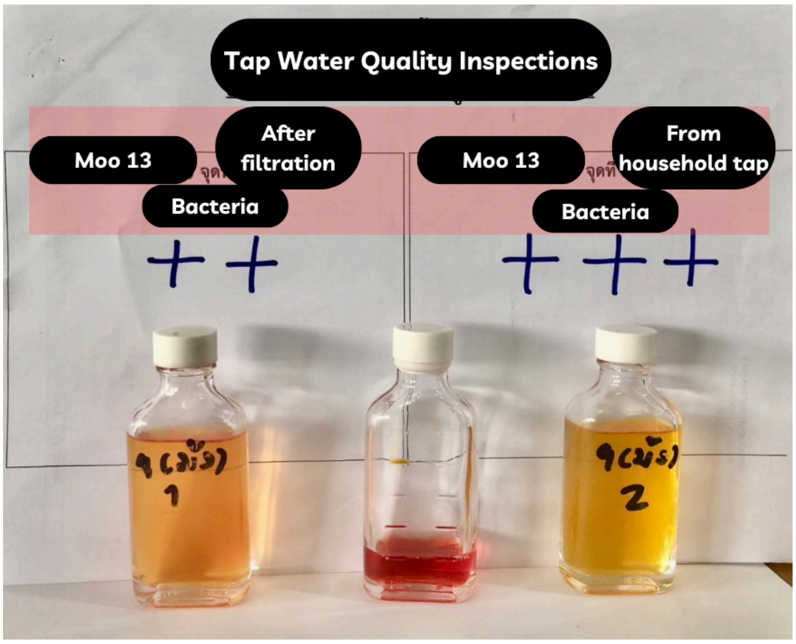

Figure 25. Tap Water Quality Inspection (Bacteria Test) of Baan Sai Ngam Moo 13
Note. The figure shows bacteria levels compare between tap water collected right after filtration and household taps.

Village (Moo)		pH (normally at 6.5-8.5)	Free Chlorine Residual (mg/L)	Bacteria				Analysis	
				-	+	++	+++	Acceptable for use	Acceptable for consumption
5	After Treatment	7	< 0.2			✓		✓	
	Household Tap	7	< 0.2			✓		✓	
10	After Treatment	7	< 0.2			✓		✓	
	Household Tap	7	< 0.2			✓		✓	
13	After Treatment	7	< 0.2			✓		✓	
	Household Tap	7	< 0.2				✓	✓	

Table 6. Data of All Villages Tap Water Quality Inspection (Bacteria Test)
Note. The table illustrates the pH, free chlorine residual, bacteria level, and analysis of tap water of each village in Sop Bong Subdistrict.

Observations and interviews revealed below par in the system management and maintenance of the tap water system of the village. Infrequent system cleaning, wrong amount of chemical usage, and irregular pipeline inspection are some of the causes of poor tap water quality. The situation leaves the village at risk of ongoing water contamination, which could pose serious health risks. Immediate action is needed to address these issues.

Chapter 5: Conclusions and Recommendations

This chapter provides a comprehensive summary of the findings. It also presents recommendations for the sponsor, the Royal Initiative Discovery Institute, based on the study's findings. Additionally, the chapter outlines the limitations of the project that were identified during the progress and offers suggestions for future studies to refine the scope of work. Lastly, concludes with a summary of the overall project.

5.1. Summary of Findings

The water supply in Baan Sai Ngam Moo 13 faces several challenges, leading to insufficient and substandard water for the residents including:

The water usage patterns vary by season, location, and ownership of a personal well

The current daily water supply of 60,000-90,000 liters is significantly below the demand of 240,000 liters for the village population, resulting in water shortages, especially during the dry season. Villagers living farther from the main water supply station experience more water shortage compared to those living closer. Moreover, some of the villagers rely on their personal wells, claiming that their water is clean and clear. However, those who live further from the surface water pond face challenges during the dry season compared to those who are closer.

The physical properties of tap water such as color and odor reduce villager's confidence in using the village's tap water

Villagers are concerned about the tap water's yellow color, rust-like odor, and skin irritation, which weaken their confidence in using the village's tap water. Moreover, the water's turbidity and odor have led households with personal wells to prefer their own well water over the village's tap water. In addition, they have concerns regarding the topography of the surface water pond that could be contaminated from agricultural zones and eventually affect the water sources used to produce tap water.

Social structure in Baan Sai Ngam Moo 13 leads to challenges in addressing issues and driving progress within the village

The village's decision-making process, influenced by the ethnic structure and the requirement for clan consensus, leads to slow progress in addressing water supply issues. Furthermore, a focus on road development over water infrastructure has further hindered the efforts to improve the water system.

Improper greywater and waste management might affect the groundwater quality and environment

The improper greywater management system that discharges the villagers' greywater outside the house increases the risk of groundwater and water source contamination and poses a long-term environmental and health risk.

Contamination in raw water could be influenced by the structural failure in well construction

The contamination in the second groundwater well, which could potentially come from the structural failure would further contribute to water quality issues if used to produce tap water for the community.

The unsuitable method of raw water treatment systems can lead to a reduction in the system's efficiency

Baan Sai Ngam Moo 13 uses two water treatment systems: a surface water supply system for treating groundwater and a groundwater supply system for treating surface water. The surface system involves flocculation, coagulation, sedimentation, and filtration, while the groundwater system uses aeration and filtration. However, the reversal of these systems may reduce the overall efficiency of water treatment as each system is designed to treat a specific type of contaminant in water.

Differences in maintenance methods observed among the villages might lead to variations in water quality

The water quality in Moo 13 can be impacted by irregular maintenance and inconsistent treatment practices. The village's tap water system has improper regular upkeep, leading to debris accumulation. Additionally, the flocculation system is not properly maintained, which could contribute to water contamination. Inconsistent chemical treatment with excessive use of alum without precise measurement can result in the fluctuation of water quality. Infrequent pipeline inspections also allow for bacterial growth, which could influence water safety. Overall, inappropriate maintenance and monitoring processes can potentially pose contamination in the village's tap water.

5.2. Recommendations for Royal Initiative Discovery Institute

Based on the findings, villagers in Baan Sai Ngam Moo 13 face an insufficient tap water supply, which worsens during the dry season. Additionally, the water's physical properties reduce their confidence in using it. To ensure the well-being of the villagers, both water capacity and quality must be considered.

5.2.1. Recommendations for Enhancing Water Sufficiency

Currently, the tap water supply in Baan Sai Ngam Moo 13 relies solely on the first groundwater well, as the second well is contaminated with dirt and sand and is no longer in use. Additionally, the second groundwater well remains under warranty by the private corporation responsible for its construction. However, according to an interview with the Municipality Engineering Department, the corporation has not taken any action to address the issues. For government agencies or other relevant organizations to address the issues, the warranty period must first expire. Therefore, we have structured our recommendations into short-term and long-term solutions.

Recommendation 1: Contact the Department of Groundwater Resources for further inspection of well structure failure to increase the water supply

Based on **Finding 5**, villagers in Baan Sai Ngam Moo 13 lack confidence in using water from the second groundwater well so they do not use it, suspecting that contamination is caused by the nearby landfill. However, in the interview with the Municipality Engineering Department, he suspects that structural damage to the well, rather than the landfill, is the source of contamination.

Further analysis of the initial raw water quality and well structure supports the possibility that structural failure is a contributing factor. Additionally, an expert in Water Resources Engineering at Chulalongkorn University stated that while a landfill can impact groundwater parameters, it would not cause sand and dirt contamination in the well.

Therefore, we recommend the Royal Initiative Discovery Institute to contact in order to collaborate with the Department of Groundwater Resources to conduct a well structure investigation using casing logging or caliper logging after the warranty period. These techniques can assess structural integrity and identify potential damage. As these methods require specialized expertise and equipment, involving the Department of Groundwater Resources would provide more accurate and reliable data. Baan Sai Ngam Moo 13 is located in Phayao and falls under the supervision of the Groundwater Resources Regional Office 1 (Lampang). The contact of the Groundwater Resources Regional Office 1 (Lampang) can be found in **Appendix F**.

This is a long-term recommendation, as investigating structural failure requires significant time and budget allocation. Additionally, if damage is detected, further time and resources will be needed for repairs. Consequently, it will take a considerable period for the second groundwater well to return to full functionality. However, restoring the well will help enhance the water supply in Baan Sai Ngam Moo 13, helping to meet the community's demand.

Recommendation 2: Construction and installation of additional water well, water treatment, and storage system

The obtained information and data analysis from the fieldwork suggested that the installation of an additional groundwater well is required to provide an efficient water supply to the community's needs. Firstly, as stated in **Finding 1**, households that live further away from the village's main water supply faced a significant water shortage and also weaker water pressure reaching them. Having another water distribution system constructed in the area further away from the current one, would expand the coverage for each household to receive a sufficient water supply. Secondly, the rapid expansion of the village's population indicates the need for a new groundwater well system to adequately provide the water as shown in **Finding 3**. Thirdly, the fact that the second groundwater well broke down causes the amount of water produced to not be sufficient to sustain the daily needs, as it only relies on the first well. The claim is supported by the tap water meters that are recorded at each household by the water caretaker in **Finding 1**.

Taking everything into consideration; investing in the construction of the additional groundwater wells can provide the village with a higher tap water production capacity to sustain both the current and future needs of villagers' increases in water usage. Therefore, we recommend the Royal Initiative Discovery Institute to use our research data to support the claim that the installation of additional groundwater wells, treatment, and storage systems is much more important than investing in other objects such as road maintenance. This is because the earlier the construction begins, the faster the benefit in terms of adequate water supply the village would receive. As of now, the water capacity produced is quite low compared to the actual needs. When the population expands, the demand for tap water will eventually rise. Additionally, providing the infrastructure beforehand can serve as a forethought and also solve the long-term problems that may occur in the future.

Nevertheless, installing the new groundwater well system requires analysis and research first to identify whether the particular area is worth constructing the groundwater well. In this case, we recommend Royal Initiative Discovery Institute contact the Department of Groundwater Resources for an analyst and geophysical fieldwork, as that would be the best solution to do so. Currently, the area that is aimed to be used for the construction of a groundwater well is near the village's pond (Nong Kut). However, due to the limited public area that can be used for well construction, it can become challenging to find a proper location that has a suitable hydrogeology if the location near Nong Kut does not meet the requirements.

Recommendation 3: Installing raw clarifier tank

As mentioned in **Finding 5,** the failure of the village's second well construction shows contamination of sediment and the brown color of the groundwater, which results in the decline of confidence of the villagers toward the water from the second well. These sediments and colors are the main reasons that the village's second groundwater well is permanently closed. The effect of closing the village's second groundwater well is that there is an insufficient amount of water for the villagers in Moo 13 to utilize in daily life, especially during the dry season. To increase the quantity of the village water supply, the infrastructure of the village's second well requires further inspection, as mentioned above. At the same time, we recommend the Royal Initiative Discovery Institute acquire the clarifier tank to instantly enhance the village's water sufficiency.

To increase the village's water supply by utilizing the second groundwater well, we recommend adopting a clarifier tank as part of the water treatment system. Further research conveys that the clarifier tank can be used as a primary sedimentation tank. The primary sedimentation tank is where the separation of suspended organic matter occurs. The clarifier tank will be applied right after the raw water is pumped up. The raw water will flow into the clarifier tank and various mechanisms are happening in the clarifier tank, such as mixing paddles, and a clarifier mechanism with a stirring arm beneath the tank to mix and remove sludge and sediment from the water. After that, the water without sediment will flow out from the top of the tank to go through a further treatment system. The type of clarifier tank that is the most appropriate for Moo 13 is a circular clarifier tank, which prevents precipitate and sediment from remaining on the tank's edges, unlike the square clarifier tank. The recommended clarifier tank for Moo 13 is the clarifier tank with a diameter of 2.5 meters, which is suitable for water with a flow rate of 5 m^3/h. Therefore, we encourage the village to set the maximum flow rate of water at 5 m^3/h for the clarifier tank to work most effectively. Additionally, Ortho FRP is the material suggested for the clarifier tank as it is most acceptable for groundwater with an acceptable price of 150,000 baht. For further information, the contact of Envigear can be found in **Appendix F**. With this ability, the clarifier tank can assist the water treatment system, especially the sedimentation process, and lead to clearer tap water.

Nevertheless, for higher cost efficiency, the alternative suggestion for the clarifier tank is the raw water supply storage tank. The main purpose of the raw water supply storage tank is to store raw water that is pumped up from the groundwater well for various activities and intentions. Despite the main purpose of the raw water supply storage tank, precipitation can occur while the raw water is stored in the tank. This leads to the separation between the sediment and the raw water as the sediment will sink to the bottom of the tank and leave clearer raw water at the top of the tank, which can be used for further treatment process for the village's tap water. The size of the raw water supply storage tank that we recommended the village acquire is 10000 L, to sustain the rate of the water pumped from the groundwater well. The price of this size of raw water supply storage tank is 95,000 baht, which is considered to be lower and more cost-effective compared to the clarifier tank. For additional information, the contact of M-Tech Water Solution can be found in **Appendix F**. Even so, the efficiency of precipitation of the sediment in the raw water supply storage tank is not as effective compared to the clarifier tank, especially the time taken for the precipitation, as it is not the main purpose of the tank itself. However, to solve the urgent problem of insufficient water supply in the village, the raw water supply storage tank can be taken into consideration as an alternative recommendation.

Although, this is a recommendation to enhance the water sufficiently urgently for Baan Sai Ngam Moo 13, as the second groundwater well is still under warranty, which means the municipality does not have the right to fix the possible cause of water contamination, as mentioned. Nonetheless, the clarifier tank and the raw water supply storage tank can be used in the long-term to improve the quality of the water, beside the village's second groundwater well. Moreover, despite the water from the village's second groundwater well raising the quantity of the village's water supply, the quantity of water supply is still below the minimum requirement for each person in the village as the population of the village increases rapidly. Even so, adopting the clarifier tank or the raw water supply storage tank is the most effective and suitable method for Baan Sai Ngam Moo 13 to increase the village's water supply immediately, along with minimizing the period that the Moo 13 villagers have to experience the shortage of water.

5.2.2. Recommendations for Improving the Quality of Tap Water

Currently, the tap water in Baan Sai Ngam Moo 13 exhibits discoloration and odor, reducing villagers' confidence in its use. Analyzing data from interviews, observations, and additional research has revealed multiple factors that may affect tap water quality. Therefore, we have structured our recommendations to address specific areas requiring further investigation and maintenance.

Recommendation 4: Routine maintenance of tap water systems and proper alignment of water treatment systems to the respective water sources

As mentioned in **Finding 7**, the village has inadequate proper maintenance of the tap water system, which could lead to water contamination, as observed in **Finding 2**. We recommend the village's water caretaker implement a comprehensive routine maintenance plan for its tap water system to maintain a consistent and safe water supply. This includes routine cleaning and inspection of filtration units, sedimentation tanks, and storage facilities to prevent bacterial growth, debris buildup, and contamination. To extend the recommendation, the filtration system consisting of sand, gravel, and carbon filters in water supply systems is designed to be cleaned at the appropriate time. The process called backwash, utilizes water pressure from below to lift the filter layers, allowing dirt and accumulated debris to be removed. The decision to backwash the filters could be made based on appropriate considerations, as shown in **Table 7**.

Operating Time per Day (Hours)	Recommended Backwashing Frequency (Times/Day)
4	4
6 - 8	2
10 - 14	1

Table 7. Recommended Frequency for Backwashing the Filters from the Department of Water Resources

Moreover, we recommend the village's water caretaker maintain a logbook for operation and maintenance, along with a fixed schedule for inspections and maintenance to ensure the system remains clean and operates efficiently in treating water. These inspections may be categorized into daily inspections, periodic inspections, and annual inspections. In addition, instead of relying on visual judgment for chemical treatment, we suggest the village use measured amounts of alum and calcium hypochlorite to ensure proper water purification. The logbook guideline can be found in **Appendix G**.

Also, based on **Finding 6**, the right water treatment method must match the specific water source. The primary well and the Nong Kut pond require different filtration and disinfection techniques, hence using appropriate methods for each will improve water quality and efficiency. Activated carbon filters are a potential method for reducing turbidity in raw water, as they can effectively remove impurities through the groundwater treatment system. By trapping suspended particles and contaminants, they help improve tap water quality.

To improve the consistency and accuracy of water treatment, we recommend using a simple measuring tool made from PVC pipe to dispense calcium hypochlorite. This tool is designed to help caretakers easily measure the right amount of chemicals, ensuring that seven scoops provide the optimal dosage for a specific volume of water. By making the chemical application more straightforward and reliable, this approach helps maintain effective water treatment with minimal guesswork.

The village carries out routine checks and maintenance on key infrastructure, such as pipes, pumps, and filtration layers, to keep the system functioning properly is recommended. By following these steps, the village can improve water quality, reduce contamination risks, and maintain a safe and sustainable water supply for its residents.

Recommendation 5: Raw water inspection to adjust the method and chemicals used to treat water

To ensure safe and high-quality tap water, it is recommended to conduct raw water inspections. According to **Finding 7**, Moo 13 has not been monitoring the quality of the raw water and has been treating it without accurately measuring the required chemicals, which may lead to increased contamination in the tap water. Therefore, testing and analysis of water sources will help to identify and suggest changes in water quality which would allow for decisions on whether chemical treatment or modifications to the water quality are necessary.

For this reason, we recommend the Royal Initiative Discovery Institute to assess the raw water sources and specifically identify the important key parameters to the Provincial Waterworks Authorities Office 9. The contact of the Provincial Waterworks Authorities Office 9 can be found in **Appendix F**. Based on the TDS level measured in **Finding 7**, raw water has a TDS concentration of 26.1 mg/L which is well below the maximum permissible level from the World Health Organization standard, thus, TDS removal treatment from chemicals might not required. Therefore, with the TDS level already within the safe limit, there may be an opportunity to optimize the use of alum in the treatment process and focus on the parameters that may require attention. However, the water caretaker can start by using less alum (35-50 mg/L) in the water treatment process and monitoring the tap water quality together with conducting a raw water quality inspection to optimize the the chemical treatment efficiency. Eventually, these methods could assist in improving the efficiency of water treatment and reducing unnecessary chemical use.

By monitoring the key parameters such as pH, turbidity, salinity, TDS, and bacteria level in the raw water, the appropriate chemicals and the quantity required for water treatment can be determined without the excessive use that could further lead to more contamination in the tap water. Implementing this practice could help to enhance the efficiency of the treatment process, minimize the cost of chemicals and resources used and potentially provide safe and clean water for the community's consumption.

Recommendation 6: Design and implement an efficient greywater system to ensure effective drainage

During fieldwork, we found that most of the households do not have a proper greywater management system to treat the greywater. However, the majority of the houses do have a soak pit that holds the greywater for it to seep through underground, while some houses discharge the wastewater directly onto the street water channel. Thus, it results in the contamination of the groundwater source. To ensure the groundwater is free or mostly not involved with these chemicals found in greywater, we recommend the Royal Initiative Discovery Institute and villagers to collaborate in order to design and implement an efficient greywater system. This system will enhance drainage and reduce the risk of greywater contamination, benefiting both the environment and the community. The research in **Appendix J.** suggests a possible solution to tackle these mentioned problems.

Firstly, the idea that we would like to share with the Royal Initiative Discovery Institute is to design an activity or have an announcement that shows the significance of proper disposal of greywater and that involves the cooperation of all the villagers. This is because in order to get the villagers to participate in these changes, requires learning and understanding of why it is important to do so. For instance, providing a lecture on how wastewater impacts the groundwater, adding an activity such as “creating your own” aqua grease trap as shown in **Finding 4**, and perhaps rewarding the most unique design may encourage them to get involved in the activity. The benefit that would get from this is not just about having a grease trap installation but also about educating the villagers to take action more seriously. However, the idea can be tough to get started with, as the difference in social structure stated in **Finding 3** may lead to issues and cooperation of villagers.

Secondly, after the awareness activity has reached the audience, the Royal Initiative Discovery Institute then can provide funds to each house to install the aqua grease trap, preliminary sedimentation tank, and septic tank to specifically treat the wastewater from laundry, shower and kitchen. Aqua grease traps can be purchased or self-made; the tank then connects to the kitchen sink in order to trap grease before releasing the wastewater to the septic tank for treatment. The wastewater from laundry needs to go through a waste filter to remove any cloth residue or plastics before reaching the sedimentation tank, which is placed after the waste filter to collect any suspension of solids that might come with the wastewater. The septic tank then receives the mentioned wastewater for further treatment before releasing the treated wastewater to the public sewer that is further away from the groundwater source used in the village.

Adopting a well-designed greywater system can prevent wastewater buildup, minimize contamination risks, and safeguard both local water supplies and personal wells from greywater pollution, which helps create a cleaner and healthier living environment. Detailed information regarding the wastewater treatment process, such as the type of septic tanks that should be used, can be found at the Pollution Control Department. The closest office within the region is the Environmental and Pollution Control Office 2, Pollution Control Department under the Ministry of Natural

Resources and Environment. The contact of the Environmental and Pollution Control Office 2 can be found in **Appendix F**.

Addressing this issue requires urgent intervention, including the implementation of appropriate greywater treatment systems with the help of lectures and awareness activities to educate villagers on sustainable wastewater disposal practices. Without such measures, the cycle of contamination will persist, posing ongoing risks to the community's water security and health.

5.3. Limitations of This Research

Throughout the work of this project, several limitations were encountered during fieldwork and data collection. First, the interviews conducted with villagers in Baan Sai Ngam Moo 13 did not cover the entire population. Due to time constraints and the large population size, only a selected group of interviewees could be included. Additionally, Baan Sai Ngam Moo 13 is an ethnic (Hmong) village, and many villagers have limited proficiency in Thai, which further restricted the number of interviewees and resulted in a smaller sample size than initially expected.

Second, some villagers did not have answers to some of the prepared interview questions. For example, when asked, *"As a water user, what do you think are the biggest obstacles preventing water from meeting safe water standards?"*, many villagers were unable to provide a response. Even after assuring them that there were no right or wrong answers, they still struggled to answer the question. This limitation reduced the amount of data collected from villagers and made data analysis more challenging.

Lastly, differing perceptions toward the occurred issue among stakeholders interviewed during fieldwork created challenges in data analysis. Additionally, the reliability of information gathered from villagers was not entirely certain. For instance, when asked about the color and odor of the water they experienced, some villagers described the odor as resembling chemicals such as chlorine. However, during fieldwork, we personally smelled the water and did not detect any chlorine odor, which makes these responses remain subjective.

5.4. Recommendations for Future Research

Throughout the course of this project, we identified certain concerns that fell beyond the scope of this project and could not be addressed within the available timeframe. Based on data analysis and identified limitations, we have outlined key recommendations for future research. These recommendations are intended to help define the scope of future studies.

First, interview questions should be carefully designed to ensure that respondents feel comfortable providing their answers. Additionally, given the language barriers encountered during the study, more time should be set aside for conducting interviews to facilitate effective communication. To obtain the expected depth and quality of data, thorough preparation and sufficient time planning should be prioritized in future research.

Moreover, we recommend future research focus on identifying the comprehensive and scientific-based quantity of necessary chemicals used to determine the most effective treatment methods for each water source. By analyzing the specific contaminants present in both the village's wells and the Nong Kut pond, researchers can recommend more precise and efficient filtration techniques. Moreover, we recommend further studies to evaluate the long-term impact of untreated greywater and wastewater disposal on groundwater quality. Investigating alternative and cost-effective water treatment technologies suited for rural communities would also be beneficial in improving overall water safety. Through continuous research, the village can implement scientifically backed improvements to its water management system, ensuring long-term sustainability and public health.

5.5. Conclusion

In conclusion, the data collected indicates that the contamination observed in both the tap water and water from the second groundwater well, which has contributed to the insufficient water supply in Baan Sai Ngam Moo 13, is not directly linked to the nearby landfill or agricultural activities. However, several other factors have been identified as influencing the contamination and related issues.

Given these findings, further investigation is necessary to fully understand the underlying causes of water contamination and insufficiency. Collaborative efforts with government agencies and other relevant organizations will be crucial in addressing these challenges and implementing effective solutions to enhance the village's water supply system.

Additionally, our recommendations align with the community's current operations and future plans by providing strategies to improve water sufficiency and enhance water quality. By adopting these recommendations, Baan Sai Ngam Moo 13 can work towards a more sustainable and reliable water supply, ensuring better access to clean and safe water for its residents.

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Appendix A: Interview Questions

A.1 Interview Questions for Villagers in Baan Sai Ngarm Moo 13

1. Have you experienced any problems with the water supply, such as shortages or contamination?
2. Have you noticed any issues with the water, such as unusual taste, smell, or appearance?
3. Where do you usually get rid of the wastewater (grey water) from households, eg: wastewater from the laundry or kitchen?
4. Are there particular seasons or times of the year when water quality or availability becomes a concern?
5. What are the characteristics of the water during the rainy season?
6. How do you usually manage the shortage?
7. As a person who uses the water, what do you think is the biggest obstacle that prevents that water from meeting the standard of safe water?
8. What improvements would you like to see in the water distribution system?

A.2 Interview Questions for Baan Sai Ngam Moo 13's Water Caretaker

1. What does the surface water treatment system consist of?
2. How much of each chemical is being used?
3. Why can't the village pond be used anymore?
4. Please describe the water from Nong Kut.
5. Which season has the least water-related issues?
6. Please explain the water treatment process for well 1 before use.

A.3 Interview_Questions for Municipality Engineering Department

1. How do the village's groundwater wells differ from the shallow wells in individual households?
2. Why does Baan Sai Ngam Moo 13 install water pumps deeper in groundwater wells compared to other villages?
3. What are the reasons for the lower water availability in Baan Sai Ngam Moo 13 compared to other villages?
4. What is the estimated budget for drilling a single groundwater well?
5. Why were the first and second groundwater wells in Baan Sai Ngam Moo 13 drilled close to each other?
6. Why does the village water system operator in Baan Sai Ngam Moo 13 add the current amount of chemicals and alum to the water supply?

7. When do you plan to drill a third groundwater well?
8. Why do villagers drill their own shallow wells at home and use the water without filtration?
9. What are the reasons why Baan Sai Ngam Moo 13 does not have a wastewater disposal system?
10. Is it possible that water contamination originates from the upstream water source?
11. When water shortages occur in Baan Sai Ngam Moo 13, how does the municipality provide water support to residents?
12. From your perspective, what do you think is the cause of the second groundwater well becoming unusable?
13. After the construction, did the initial water quality for both wells meet the standard, or was there contamination from the beginning?

Appendix B: Interview Transcript

B.1 Villagers in Baan Sai Ngarm Moo 13

ปัญหาของการใช้น้ำมีอะไรบ้าง เพียงพอไหม ไม่สะอาดอย่างไร?

House 1: "น้ำไม่พอใช้ น้ำสกปรก ถ้าไม่ใส่สารคอรีนน้ำก็จะขุ่นไม่สะอาด น้ำมีกลิ่นสนิมปนกับคอรีนจากความคิดของลุงนะ"

House 2: "ไม่ค่อยสะอาด ไม่พอใช้"

House 3: "ไม่ค่อยพอใช้"

House 4: "ไม่ค่อยสะอาด น้ำมาไม่พอใช้"

House 5: "น้ำไม่พอใช้และคุณภาพไม่โอเค"

House 6: "น้ำประปาสกปรกมีกลิ่นบ้างและมีสีขุ่น มีบ่อน้ำตื้นของตัวเองซึ่งสะอาดกว่า"

House 7: "น้ำไม่ใสมีสีขุ่น และน้ำไม่พอใช้"

House 8: "น้ำไม่สะอาดและไม่พอใช้"

House 9: "น้ำไม่พอใช้ มีกลิ่น"

House 10: "คนที่บ้านเยอะใช้ไม่พอ น้ำมีกลิ่นเหม็น"

House 11: "ใช้แต่น้ำบ่อไม่ใช้ประปาเลย ใช้น้ำบ่ออย่างเดียว"

House 12: "ไม่พอใช้เดือน3-4 ไม่ค่อยได้อาบน้ำในช่วงหน้าแล้ง"

จากการใช้น้ำในชีวิตประจำวัน รู้สึกถึงปัญหาของน้ำที่ใช้อยู่ไหม เช่นกลิ่นหรือสีที่ผิดปกติ?

House 1: "มีกลิ่น คันเวลาอาบ"

House 2: "มีกลิ่นคลอรีน สีเหลืองขุ่น มีสารส้มเยอะจะเปรี้ยวๆ น้ำจะมีคราบน้ำมัน เหนียวตัวหน่อย"

House 3: “มีสีขาวๆ ขุ่นบางทีก็เหลือง กลิ่นไม่ค่อยมี กลิ่นมีเป็นบางช่วง กลิ่นคลอรีน ถ้าน้ำประปาไม่ค่อยใช้ ที่นี่มีบ่อน้ำตื้น น้ำที่ขึ้นมาเป็นน้ำใส”

House 4: “มีกลิ่น มีสีขุ่นๆ บางครั้งใช้แล้วคัน”

House 5: “น้ำไม่ใส ขุ่นๆ สีขาวๆ มีกลิ่นคลอรีนใช้แล้วไม่คัน แต่มีสี ใช้น้ำประปาอย่างเดียว ไม่ได้เจาะบ่อน้ำตื้นเพิ่ม”

House 6: “น้ำบ่อบาดาลที่บ้านมีความ ฝืดๆ แต่น้ำประปา มีความขุ่นๆ แต่เดี๋ยวนี้ไม่มีกลิ่นละ ก็มีกลิ่นบ้าง แต่ทำกับข้าวใช้น้ำจากบ่อน้ำตื้นดีกว่า ไม่ค่อยอยู่บ้าน ไปขายไก่อยู่ นนทบุรี พอปีใหม่คนอยู่ครบน้ำไม่พอเลย น้ำช่วงนี้กลิ่นไม่ค่อยมี แต่ก่อนมีกลิ่นเยอะกว่านี้ แบบกลิ่นบ่อปลาเลย และมีตะกอนด้วย”

House 7: “น้ำมีกลิ่นบางที กลิ่น มาเป็นช่วงๆ พอใช้แล้วไม่ได้คัน แต่มันฝืดๆ เวลาอาบน้ำเสด ที่บ้านมีการใช้น้ำประปา แต่ก็มีเจาะบ่อน้ำตื้นเองด้วยแบ่งใช้กับอีกบ้าน”

House 8: “น้ำมีสนิม โคลน หิน ใช้แล้วคัน มีเจาะบ่อน้ำตื้นเองแต่ไม่ค่อยพอ ใช้ช่วงหน้าแล้ง ต้องให้พ่อหลวงไปประสานกับเทศบาล และเอาน้ำมาเติมแทงค์มาใส่ให้เพื่อใช้น้ำซักผ้า และกินด้วย”

House 9: “น้ำสีเหลือง ขาวขุ่นๆ กลิ่นคลอรีน สารส้มจะเหม็นๆ ได้เจาะบ่อไว้เองด้วย บ่อที่เจาะไว้เองจะดีกว่า ใสกว่า ส่วนใหญ่ไม่ค่อยใช้ แม่จะเป็นคนใช้น้ำประปาและบอกว่าจะมีคันๆบ้าง”

House 10: “มีบ่อน้ำตื้นเป็นของตัวเอง แต่ก็ต้องใช้น้ำประปาด้วย มีสีขาวขุ่นๆ มีกลิ่น มีตะกอน เหม็นคาว น้ำประปาไม่ค่อยพอใช้ อยู่กัน 2 บ้าน แชร์บ่อบาดาลกัน ได้ยินมาว่าใช้น้ำประปาอาบ หน้าเป็นตุ่ม บ้านนี้เลยใช้น้ำจากบ่อน้ำตื้นอย่างเดียว”

House 11: “บ่อบาดาลที่เจาะเองไม่มีสีหรือกลิ่น”

House 12: “น้ำมีสีเหลืองๆ มีกลิ่นดิน คาวๆ เหมือนน้ำในคลอง มีดินติดมาด้วยบางครั้ง”

ปกติแล้วทิ้งน้ำเสีย เช่น น้ำจากห้องครัว, น้ำซักผ้าที่ไหน?

House 1: “มีบ่อเก็บน้ำเสียโดยเฉพาะ มีอยู่ 4 บ่อซึม มีท่อปูน 4 ท่อเพื่อใช้ เป็นบ่อซึมและทิ้งน้ำเสีย”

House 2: “บ้านนี้ไม่มีท่อน้ำทิ้ง อยากให้มีร่องน้ำทิ้ง จะได้สะดวกหน่อย”

House 3: “ขุดบ่อซึมเอาไว้ใช้ทิ้งน้ำเสีย”

House 4: “ขุดบ่อซึมไว้ใช้ทิ้งน้ำเสีย”

House 5: “มีบ่อซึมไว้ทิ้งน้ำเสีย”

House 6: “มีบ่อซึมไว้ทิ้งน้ำเสียอยู่สำหรับห้องครัว แต่น้ำซักผ้าและน้ำที่ใช้อาบน้ำ จะไหลตามท่อไปข้างนอกบ้าน แต่ถ้าอาบน้ำติดและซักผ้าติดๆกันกันน้ำมันจะระบายออกไม่ทันเลยพยายามจะไม่ทิ้งน้ำซักผ้าลงไป”

House 7: “น้ำซักผ้าจะไหลตามท่อออกไปที่ร่องข้างบ้าน น้ำจากห้องครัวก็เททิ้งหลังบ้าน”

House 8: “ขุดบ่อซึมไว้ทิ้งน้ำเสีย ขุดเป็นบ่อและใช้ท่อวงซีเมนต์ใส่ลงไป ความยาวท่อประมาณเมตรปลาย แต่ก็น้ำก็ซึมลงดินอยู่ดี”

House 9: “มีขุดบ่อซึม โดยการวางท่อซีเมนต์ลงดินและมีฝาปิด บ่อนี้ใช้เพื่อเทน้ำเสีย”

House 10: “ขุดบ่อซึมไว้ทิ้งน้ำใช้ วางท่อลงดินแล้วมีฝาปิด น้ำใช้จะไหลตามท่อในบ้านมาลงที่บ่อซึม”

House 11: “ปล่อยน้ำลงท่อน้ำทิ้งออกไปนอกบ้านไปตามร่องน้ำ”

House 12: “มีท่อต่อออกไปเพื่อระบายน้ำเสีย ซึ่งท่อต่อไปที่บ่อซึม”

มีฤดูหรือช่วงไหนที่มีปัญหาเกี่ยวกับการใช้น้ำ เช่น น้ำไม่พอใช้, สกปรกกว่าปกติ, มีกลิ่นหรือสีผิดปกติจากช่วงอื่น?

House 1: “ช่วงหน้าร้อน จะแล้งมากน้ำจะน้อยกว่าช่วงปกติ”

House 2:	“ถ้าไม่พอ จะมีรถลากเพื่อไปเอาน้ำจากที่อื่นมา มีจากบ้านหล่ายหมู่ 9 บ้าง จากบ้านคนเมืองบ้าง แต่ว่าช่วงหน้าแล้งน้ำจะไม่พอ มีความขุ่น ถ้าดูดจากหนองกูดมาช่วงหน้าแล้ง จะมีสีเหลืองๆ”
House 3:	“น้ำมีสีบ้างไม่มีสีบ้าง มาเป็นช่วงๆ”
House 4:	“เมษาถึงพฤษภา เป็นช่วงหน้าแล้ง น้ำไม่พอใช้”
House 5:	“ช่วงแล้ง น้ำไม่พอใช้ มีสีและกลิ่น คุณภาพน้ำเหมือนๆกันทั้งปี แต่ช่วงหน้าแล้งน้ำขาด บางทีขาดเป็นวันเลย น้ำไหลไม่ต่อเนื่อง มาบ้างไม่มาบ้าง”
House 6:	“ช่วง มีนา-เมษา มีน้ำน้อยมาก ไหลไม่ทั่วถึง พอจะใช้น้ำต้องเปิดค้างไว้ก่อน มีกลิ่นโคลน และมีตะกอน”
House 7:	“ช่วงน้ำไม่พอก็จะมียืมจากเพื่อนบ้านบ้าง ช่วงหน้าแล้งน้ำจะมีตะกอนติดมาด้วย”
House 8:	“ช่วงหน้าฝนและแล้ง มีความต่างกันนิดนึง คิดว่าช่วงหน้าแล้งน้ำมันมาจากข้างล่างอย่างเดียว ไม่มีการปนเปื้อนจากฝน จึงรู้สึกสะอาดกว่า”
House 9:	“ช่วงปกตินานๆทีจะใช้ไม่ได้ ช่วงหน้าแล้ง บ่อน้ำตื้นก็ยังใช้พอ จริงๆในหมู่บ้านสำหรับบ้านที่มีฐานะจะใช้น้ำจากบ่อน้ำตื้น แต่ว่าบ้านที่ไม่มีงบและไม่มีบ่อน้ำตื้นก็จะใช้น้ำประปาอย่างเดียว”
House 10:	“น้ำแห้ง น้ำขาด”
House 11:	“ช่วงหน้าร้อนน้ำจะหายไปเยอะ ก็ต้องรอหน่อย”
House 12:	“ช่วงแล้งน้ำจะมีสีเหลืองๆ ที่บ้านไม่ใช้ประปาเลย ต้องเอาถังมาพักน้ำไว้ก่อน หน้าแล้งน้ำไม่พออาบ เวลาน้ำขาด ก็จะขาดเปนวันเลย บางครั้งช่วง 10โมงน้ำถึงค่อยมา ค่าน้ำ 300-400 ใช้น้ำประปาทำกับข้าว แต่ต้องต้มก่อน แต่ก็มีซื้อมาจากบ้านหล่ายหมู่ 9 เหมือนกัน เวลาใช้อาบน้ำก็ไม่ค่อยคัน แต่ช่วงหน้าร้อนจะรู้สึกคัน ไม่กล้าใช้น้ำแปรงฟันเพราะคาว ไม่กล้าเอาน้ำมาสระผม อยากจะมีบ่อของตัวเอง

นะ แต่เคยขุดบ่อไปแล้ว 2 รอบ และขุดลึกไป 10 กว่าเมตรแต่ไม่พบน้ำ”

ในช่วงฤดูฝนน้ำมีลักษณะอย่างไร?

House 1: -

House 2: “หน้าฝนและหน้าแล้ง น้ำไม่ได้ต่างกัน ปกติจะมีการปล่อยน้ำมาจากทางนาตำบลทุ่งกล้วยมาลงหนองกูด คิดว่ามียาฆ่าแมลงตามมาด้วย เพราะน้ำจะไหลตามร่องมา แต่ว่าร่องที่น้ำไหลมานี่เพิ่งมาปิดปีนี้เอง น้ำกรองไม่ค่อยสะอาดรู้สึกว่ามีเกล็ดปลาเล็กติดมาด้วย”

House 3: -

House 4: “น้ำมีความขุ่นน้อย แต่ว่าไม่ค่อยสะอาด”

House 5: -

House 6: -

House 7: -

House 8: “ช่วงหน้าฝนรู้สึกว่าน้ำแปลกๆ มีกลิ่นมากกว่าหน้าร้อน”

House 9: “ช่วงหน้าฝนน้ำจะใช้ไม่ได้เลย ช่วงหน้าฝนจะมีความแตกต่างจากหน้าร้อน”

House 10: -

House 11: -

House 12: “น้ำจากบ่อที่ขุดเองถึงจะมาช่วงหน้าฝน มีกลิ่นคาวๆ ปนกลิ่นสนิมด้วย ถังกรองน้ำมีตะกอนและสนิมเกาะ มีสีขาวๆเกาะ คิดว่าน่าจะเป็นเศษฝุ่นกับขี้ดิน”

ถ้าน้ำไม่พอใช้ปกติทำอย่างไร?

House 1: “ถ้าน้ำไม่พอใช้ก็จะมีไปอาบน้ำที่บ้านของเพื่อนบ้านด้วย”

House 2: -

House 3: “ซื้อน้ำเพิ่มมาใช้ ถ้าน้ำไม่พอจะซักผ้าด้วยมือเยอะกว่าใช้เครื่อง เพื่อพยายามประหยัดให้ได้มากที่สุด”

House 4: “ถ้าน้ำไม่พอก็ไปหาเพิ่มจากหมู่บ้านข้างๆ”

House 5: “ถ้าน้ำไม่พอก็จะเอารถออกไปซื้อน้ำจากที่อื่นมาใช้”

House 6: -

House 7: “แชร์น้ำใช้กันกับบ้านอื่นๆ”

House 8: “ถามเพื่อนบ้านในเขตหมู่บ้านไทรงามว่ามีน้ำใช้มั้ย ถ้าเกิดมีก็จะไปขอ”

House 9: -

House 10: “ใช้ถังพักน้ำตุนน้ำเก็บไว้ แต่ว่าถังประมาณ 20 ลิตร เลยไม่พอ คนอยู่กันเยอะด้วย”

House 11: -

House 12: -

ในฐานะคนที่ใช้น้ำ คุณคิดว่าอุปสรรคที่ใหญ่ที่สุดที่ทำให้น้ำไม่สามารถมีคุณภาพได้ตามมาตรฐานน้ำที่ปลอดภัยคืออะไร?

House 1: “เครื่องกรองไม่ค่อยดีเท่าไหร่ ถ้าเกิดมีนกมาบิน หรือหนูมาเดินใกล้ๆ มันก็จะเปื้อนได้ อยากให้มีที่บังเครื่องกรองแบบดีๆ จะได้กันสิ่งแปลกปลอม และก็ทุกๆ 1-2 เดือนอยากให้มีการทำความสะอาดตลอด เวลาลูกที่บ้านอาบน้ำรู้สึกเหมือนมีกลิ่นคลอรีน มีผื่นขึ้นตามตัว”

House 2: “คิดว่าที่น้ำไม่สะอาดน่าจะมาจากที่กรองน้ำที่ไม่น่าดี”

House 3: “ไม่แน่ใจเหมือนกัน”

House 4: “ไม่ทราบว่าน้ำเป็นแบบนี้เกิดจากอะไร”

House 5: “ไม่แน่ใจเหมือนกัน”

House 6: “คิดว่าน้ำไม่สะอาดมาจากต้นทาง คิดว่าอาจปนเปื้อนจากบ่อน้ำใกล้ๆที่ประปา”

House 7: “ไม่แน่ใจเหมือนกัน”

House 8: “ปัญหาน่าจะมาจากคลอรีนและสารส้ม”

House 9: “ไม่แน่ใจเหมือนกัน”

House 10: “ไม่แน่ใจเหมือนกัน”

House 11: “ไม่แน่ใจเหมือนกัน”

House 12: “ไม่แน่ใจเหมือนกัน”

มีข้อเสนอแนะในการปรับปรุงอย่างไรบ้าง?

House 1: “มีโครงการเจาะบ่อาดาลสัก 3 อันก็ได้ น้ำจะได้พอใช้”

House 2: “เพิ่งมาเช่าอยู่บ้านนี้ได้2เดือน แต่อยู่ที่นี่มานานแล้ว แต่แค่ย้ายที่มาก็มีปัญหาเหมือนกัน บ้านนี้ไม่มีบ่อบาดาลเอง ใช้แค่ประปา อยากมีบ่อนะ แต่ยังไม่พร้อม”

House 3: “ขุดแล้วมีเครื่องสูบสูบขึ้นมาใช้เลยไม่มีการกรองก่อนใช้ อยากให้แก้ให้น้ำพอใช้ ประชากรเยอะขึ้นน้ำไม่พอใช้น้ำประปาใช้อยู่ สลับกับบ่อบาดาล ค่าน้ำประมาณ 200-300 ต่อเดือน อยู่ประมาณ 5-6 คน”

House 4: “ใช้น้ำประปากับบ่อน้ำตื้น มีขุดบ่อเอง มีบ่อน้ำทิ้งขุดโดยบริษัทรับจ้าง ต่อท่อมาจากในบ้าน ไม่แน่ใจเรื่องการบำบัดน้ำ เพราะเพิ่งมีและยังไม่เต็มบ่อ แต่รู้สึกจะเป็นบ่อธรรมดาที่ ซึมผ่านดินอยู่ดี ก็อาจจะปนเปื้อนได้”

House 5: -

House 6: “บ่อน้ำตื้น ขุดลึกจนไม่มีอากาศ สร้างนานละ ตั้งแต่ปี 53 ตั้งแต่อยู่ใหม่ๆก่อนประปา ตอนนั้นน้ำยังพออยู่ พอคนมาเยอะ น้ำก็เริ่มไม่พอ ขุดบ่อน้ำตื้นไป2ครั้งแล้ว ขุดลึกจนแทบไม่มีอากาศหายใจ มีผ้ากั้น

เพราะเคยมีหนูไปตายข้างใน ทุกวันนี้ช่วงไหนน้ำประปาดีก็ใช้ ใช้ประปาอาบตัวจะลื่น เลยใช้น้ำจากบ่อน้ำตื้นมาราดอีกทีหนึ่ง อยากให้สามารถใช้ทำกับข้าวได้อย่างสะบายใจ อยากให้พัฒนาให้ดีขึ้น จะได้ใช้อย่างมีความสุข จ่ายเงิน อยากได้น้ำที่ดีจริงๆ บางทีก็ใช้น้ำดื่มทำกับข้าวเลย มีบ่อน้ำทิ้งใส่ท่อลึกลงไปประมาณ 4 ท่อวง ลงดินก็จะซึมเหมือนเดิม ไม่ต่างกับทิ้งบนดิน แต่ค่าใช้จ่ายสูง"

House 7: "อยากให้ประปามีกรองที่ดี ไม่มีสีกลิ่น เพราะใช้น้ำทำกับข้าว บางทีจำเป็นก็ต้องดื่มเลย มีรสชาติเหม็นๆ บางทีก็ไม่ได้ต้ม บางทีก็ซื้อน้ำลังน้ำขวดจากชุมชนร้านค้า ไม่ใช่น้ำขวด มีบ่อน้ำตื้น ก็ขุดลงไปแล้วใช้เครื่องดูด ช่วงหน้าแล้งก็ไม่ค่อยพอใช้เหมือนกัน แบบเดียวกับบ้านข้างๆ (บ้านที่ 6)"

House 8: "เห็นบ่อน้ำตื้นใสดีเลยใช้ ใช้ประปามารถน้ำต้นไม้ แต่ไม่ใช้ในบ้าน แต่ก็อยากจะใช้น้ำประปา"

House 9: -

House 10: -

House 11: -

House 12: "ที่นี่ไม่มีบ่อบาดาล เพราะแห้งเจาะแล้วน้ำไม่ออก บางคืนไม่ได้อาบน้ำเลย คิดว่าน้ำไม่สะอาดน่าจะเพราะติดกับคลองน้ำ อยากให้มีถังน้ำสำรอง"

B.2 Baan Sai Ngam Moo 13's Water Caretaker

ตัวกรองน้ำประกอบไปด้วยอะไรบ้าง?

"ที่กรองตรงที่ขึ้นไปยืนมี ทราย ถ่าน หินเล็ก และหินใหญ่"

พี่ใช้สารแต่ละอย่างจำนวนเท่าไร?

"ก็จะตักคลอรีนสองครั้งโดยใช้ท่อพีวีซีตักต่อวันมาผสมน้ำ วันนึงใช้คลอรีนผสมน้ำ 1 ถังกับใช้สารส้ม 25 กิโล ชาวบ้านบอกว่ามีกลิ่นคลอรีนเยอะ สารส้มถ้าใช้เยอะน้ำก็จะเหนียวพอใช้อาบก็จะคัน แต่ว่าถ้าเกิดใช้สารส้มน้อย น้ำก็จะไม่สะอาด จำนวนของสารเคมีที่ใช้ก็จะขึ้นอยู่กับสีและกลิ่นที่ชาวบ้านบอกมา"

ทำไมถึงใช้สระน้ำหมู่บ้านไม่ได้แล้ว?
“สระน้ำใหญ่ชาวบ้านเอาขยะมาทิ้งมั่วเลยสกปรก”

ช่วยเล่าให้ฟังหน่อยค่ะว่าน้ำจากหนองกูดเป็นอย่างไร?
“น้ำจากบ่อหนองกูด ผ่านแค่ทรายแล้วก็เข้าที่พักเลย ไม่มีระบบตกตะกอน แต่ว่าน้ำจากหนองกูดจะมีสีเหลืองๆ มีกลิ่นโคลน แต่ว่าเดี๋ยวในอนาคตน้ำจากหนองกูดก็จะผ่านที่ตกตะกอนด้วย แต่ว่าน้ำบ่อ 2 หน้าฝนก็แย่ตลอด ผู้รับเหมาคิดว่ามาจากดินถล่มรึเปล่า ผมก็ไม่แน่ใจว่าดินถล่มหมายถึงยังไง”

ฤดูไหนที่ปัญหาเรื่องน้ำน้อยที่สุด?
“ช่วงหน้าฝนน้ำจะเยอะ และน้ำจะใสกว่า หน้าฝนก็จะมีน้ำท่วมด้วย แต่ว่าประมาณ 2-3 ชั่วโมง น้ำก็จะลด แต่จะท่วมทางด้านหมู่ 9 มากกว่า

ช่วยอธิบายการกรองน้ำของบ่อ 1 ก่อนใช้ได้ไหมคะ?
“น้ำขุดจากบ่อขึ้นมา เจอสารส้มก่อน ผ่านการตกตะกอน และผ่านตัวกรองทราย, ถ่าน, หินเล็กและใหญ่ หลังจากนี้ถึงเจอคลอรีน ต่อท่อมาเจอกันและไปพักที่บ่อพักน้ำก่อนขึ้นไปบนแทงค์”

B.3 Municipality Engineering Department

ตามปกติบ่อบาดาลของหมู่บ้านกับบ่อน้ำตื้นในบ้านของชาวบ้านแตกต่างกันอย่างไร?
“การเจาะบ่อบาดาลประปา จะต้องเจาะให้ถึงชั้นน้ำอยู่ที่ 40 เมตรลงไป ปกติแล้วระยะจะอยู่ที่ 40-100 เมตร แต่เทศบาลจะกำหนดให้มากกว่า 70 เมตร ขึ้นอยู่กับปริมาณน้ำ แต่บ่อที่ชาวบ้านเจาะใช้เองในบ้านจะมีความลึกได้ไม่เกิน 20 เมตร ตามกฎหมายกำหนดไว้”

ทำไมบ้านไทรงาม หมู่ 13 ใส่ปั๊มสูบน้ำลงไปในบ่อบาดาลลึกกว่าหมู่อื่น?
“เพราะน้ำในบ่อบาดาลของหมู่ 13 น้อยกว่า จะเจอระดับน้ำที่ใช้ได้ก็ต้องเจาะลงไปลึก จึงจะต่อปั๊มสูบน้ำลงไปในบ่อบาดาลได้”

สาเหตุที่บ้านไทรงาม หมู่ 13 มีน้ำน้อยกว่าหมู่บ้านอื่น?
“บ้านไทรงามมีพื้นที่เป็นหินแข็ง ชั้นหินแตกต่างกันในแต่ละพื้นที่ หมู่ 13 ติดชายภูเขาเลยเป็นหินแข็ง แต่หมู่ 10 เลยไปทางฝั่งตะวันออก หินเลยจะเป็นคนละแบบ”

การเจาะบ่อบาดาล 1 บ่อใช้งบประมาณเท่าไร?
“ใช้ประมาณ 400,000 กว่าบาทต่อบ่อสำหรับบ่อบาดาลที่ใช้ทำประปาหมู่บ้าน แต่บ่อน้ำตื้นที่ชาวบ้านเจาะเองราคาแล้วแต่ที่ชาวบ้านตกลงกับช่าง ส่วนใหญ่จะประมาณ 20,000-30,000 บาท”

อะไรคือสาเหตุที่เจาะบ่อบาดาลบ่อ 1 และบ่อ 2 ในบ้านไทรงาม หมู่ 13 ใกล้กัน?
“เหตุผลที่เจาะใกล้กัน เพราะเป็นพื้นที่สาธารณะ เป็นพื้นที่สำหรับสร้างประปาอยู่แล้ว และพื้นที่สาธารณะในหมู่บ้านก็มีจำกัด และแหล่งน้ำแรกที่ใช่ทำประปาคือสระด้านหลังประปาหมู่บ้านปัจจุบัน”

เพราะอะไรคนดูแลประปาหมู่บ้านของ บ้านไทรงาม หมู่ 13 ถึงใส่สารเคมีและสารส้มในปริมาณที่ใส่อยู่ในปัจจุบัน?
“เทศบาลแนะนำให้ใส่สารตามที่กรมอนามัยวางมาตฐานไว้ ช่วงแรกๆน้ำก็จะสะอาดกว่าตอนนี้ แต่เหมือนหลังๆไม่ค่อยมีการดูแล เลยมีการใส่เพิ่ม แล้วตอนแรกเหมือนจะมีเครื่องใส่สารตามค่าน้ำ แต่ว่าน่าจะพังเลยใส่กันเองเหมือนในตอนนี้”

คิดว่าจะเจาะบ่อบาดาลที่ 3 เมื่อไร?
“หมู่ 13 จะมีการทำถนนก่อนประปา ในส่วนของเรื่องประปา จะต้องใช้งบ 3.5 ล้านเพื่อสร้างประปาที่ใหม่ ชาวบ้านดูจะอยากได้ถนนเป็นหลักมากกว่า สาเหตุที่ใช้เวลานานเป็นเพราะว่าหมู่บ้านมีหลายแซ่ แล้วต้องใช้เวลานานกว่าเคสจะถึงเทศบาล เพราะต้องผ่านพ่อหลวงอีก แล้วชาวบ้านดูจะทำงานแยกๆกันเป็นแซ่มากกว่า สิ่งที่เทศบาลอยากจะทำก่อนคือเรื่องน้ำ แต่เพราะชาวบ้านเรียกร้องมาอยากให้ทำถนนก่อน ก็อาจจะต้องยึดความต้องการของชาวบ้านเป็นหลักก่อน”

ทำไมคนในหมู่บ้านถึงเจาะบ่อน้ำตื้นใช้เองในบ้านและไม่มีการกรองน้ำจากบ่อน้ำตื้นก่อนใช้?
“ชาวบ้านคงเอาระบบน้ำประปาภูเขามาปรับมาใช้กับประปาหมู่บ้าน บางบ้านใช้เลย เปิดทิ้งไว้ ไม่กรอง”

สาเหตุอะไรที่ บ้านไทรงาม หมู่ 13 ไม่มีระบบทิ้งน้ำเสีย?
“บางบ้านถูกสร้างมานานแล้ว แต่บ้านใหม่ๆที่สร้างก็มีกฏหมายให้มีระบบทิ้งน้ำเสีย ตอนที่เขายื่นแบบสร้างบ้านมามันก็มีนะ แต่ตอนสร้างจริงๆก็ไม่มีระบบทิ้งน้ำเสีย”

เป็นไปได้ไหมที่น้ำสกปรกเกิดจากการไหลจากต้นทางของน้ำ?

“การไหลของน้ำมาจากทิศทางของทุ่งกล้วย ซึ่งมีการเกษตรมาจนถึงหนองกูด หนองกูดเลยเหมือนเป็นบ่อพัก แต่ไม่น่าเกี่ยวกับสิ่งแปลกปลอมที่มากับน้ำ น่าจะเกี่ยวกับการกรองมากกว่า หลักๆอยู่ที่การบำรุงรักษา ที่เขาไม่ค่อยทำกัน”

เวลาที่น้ำในบ้านไทรงาม หมู่ 13 ขาดแคลน ทางเทศบาลได้สำรองน้ำให้กับชาวบ้านอย่างไร?

“สูบน้ำ 40,000 ลิตรต่อวันใส่รถส่งน้ำ ไปเติมให้ในหมู่บ้านทุกวันในช่วงหน้าแล้ง เติมที่ถังสาธารณะของชาวบ้าน”

จากมุมมองส่วนตัวคิดว่าอะไรคือสาเหตุที่ทำให้บ่อบาดาล บ่อ 2 ใช้ไม่ได้?

“บ่อที่ 2 ของไทรงามเหมือนบ่อจะล้ม ข้างๆที่เจาะดินเลยเข้าไปได้ อาจจะเป็นเพราะพื้นดินที่ทรุด ระหว่างก่อสร้าง น้ำเลยไหลลงไปในบ่อและปนเปื้อน เคยเรียกประกันมาแล้วแต่เขาก็ทำอะไรไม่ได้ เคยเรียกคนมาเป่าท่อแล้ว แต่ก็เป่าไม่สุด เลยไปไม่ถึงปลายบ่อ 2 ก็เลยปิดไปเลย เพราะยังแก้ไขไม่ได้ เพราะต้องรอให้หมดประกันก่อนเทศบาลถึงจะเข้าไปดูหรือแก้ไขบ่อได้ วันแรกที่ใช้หลังการขุดเสร็จน้ำมีความใส และใช้ได้ แต่เปิดใช้เยอะหลังจากสร้างเสร็จทันที บ่อเลยอาจจะทรุดในช่วงแรกๆ เพราะเป็นบ่อใหม่ ไม่ควรเปิดใช้เยอะขนาดนั้น ถ้าเปิดปั๊มทั้งวันจะสามารถทำให้ปั๊มทรุดลงได้ ต้องเปิดสลับๆ ในช่วงแรกๆนะ แต่หลังๆก็เปิดนานๆได้ ตอนนี้ทำได้แค่รอให้หมดประกันก่อน ถ้าหากหมดประกันแล้วบริษัทเขาไม่มาแก้ไขก็จะสามารถริบเงินประกันได้”

ในครั้งแรกที่บ่อบาดาลขุดเจาะเสร็จ คุณภาพน้ำปกติทั้ง 2 บ่อ หรือมีการปนเปื้อนมาตั้งแต่แรก?

“ทั้ง 2 บ่อเจาะมาตอนแรกใช้ได้ปกติ แต่คุณภาพมาแย่ลงในตอนหลัง”

Appendix C: Water and Chemical Usage in Moo 13, Moo 5, and Moo 10

Moo 13:

Month	Water Usage Amount (L)
May 2024	~3,290,000
July 2024	~2,114,000
November 2024	~1,582,000

Table 8. Water Usage Amount in Each Month in Baan Sai Ngam Moo 13

Note. These data are the recordings based on the amount shown on the water meter for each house. These numbers may be inaccurate due to potential meter installations, system changes, or the reverse water flow due to the damage to the tap water meter, leading to possible misrecordings.

Moo 5:

อยากทราบว่าที่หมู่ 5 ใช้สารส้มและคลอรีนเพื่อบำบัดน้ำในปริมาณเท่าไร?

Head of the village	“ที่หมู่ 5 ใช้คลอรีนครั้งละ 2 ช้อนโต๊ะ ใส่เดือนละหนึ่งครั้ง ส่วนสารส้มใช้ประมาณ 2 กิโลในทุกๆ 2 เดือน ถ้าเกิดใส่สารส้มมาก น้ำจะกระด้าง ลื่นตัว ใช้สารส้มเพื่อดับกลิ่น แต่ถ้าเกิดใช้มากจะมีผลต่อพืช” “วันนึงใช้น้ำ 4 แทงค์ต่อวัน แทงค์นึงจุได้ 25,000 ลิตร”

Moo 10:

อยากทราบว่าที่หมู่ 10 ใช้สารส้มและคลอรีนเพื่อบำบัดน้ำในปริมาณเท่าไร?

Head of the village	“ใช้สารส้ม 30 กิโล หรือ 1 กระสอบ ต่อ 1 เดือน เป็นสารส้มชนิดเบอร์ 1 เพราะละลายน้ำช้าดีมาก ที่ใช้ 1 กิโล ต่อวันเพราะมีตัวกรอง ทราย, กรวด และ แมงกานีสอยู่แล้ว สามารถกรองได้ดีในระดับนึงแล้ว ที่ หมู่ 13 หอน้ำน่าจะเป็นของกรมทรัพฯ แต่ของหมู่ 10 เป็นของกรมอนามัย ของหมู่ 10 จุดได้ 80,000 ลิตร แต่ว่าความจุจะขึ้นอยู่กับลูกลอย ที่ตั้งไว้ ”

Appendix D: Calculations for Amount of Alum and Calcium Hypochlorite Used in the Villages

The calculation for the amount of alum and calcium hypochlorite used in Moo 13, Moo 5, and Moo 10 **(Finding 7)**
* Note: The calculations are based on the amount of concentration per the amount of water produced. Factors such as the rate of chemicals being fed into the system, volatility, and impurities are not considered.

Alum:

Moo 13

- Each day the village produces approximately 60,000–90,000L of water.
- The village uses a bag of solid blocks of alum that weighs 25 kg with 98% w/w of pure alum.

1. Calculation of pure alum

$$25\ kg \times \frac{98\ g\ of\ pure\ alum}{100\ g\ mass\ of\ solid} = 24.5\ kg\ of\ pure\ alum$$

2. Calculation of pure alum used in dry season

2.1 In the dry season, the village uses 1 bag of alum every 2 days. Hence, it totaled to ~ 12.25 kg of pure alum used per day.

2.2 For the concentration of pure alum used at the upper limit at approximately 60,000L of water produced per day:

$$Max.\ concentration = \frac{12.25\ kg}{60{,}000\ L} = 204\ mg/L$$

2.3 For the concentration of pure alum used at the lower limit at approximately 90,000L of water produced per day:

$$Min.\ concentration = \frac{12.25\ kg}{90{,}000\ L} = 136\ mg/L$$

3. Calculation of pure alum used in the rainy season

3.1 In the rainy season, the village uses 1 bag of alum every week. Hence, it totaled to ~ 3.57 kg of pure alum used per day.

3.2 For the concentration of pure alum used at the upper limit of approximately 60,000L of water produced per day:

$$Max.\ concentration = \frac{3.57\ kg}{60{,}000\ L} = 60\ mg/L$$

3.3 For the concentration of pure alum used at the lower limit at approximately 90,000L of water produced per day:

$$Min.\ concentration = \frac{3.57\ kg}{90{,}000\ L} = 40\ mg/L$$

Moo 5

- Each day the village produces approximately 100,000L of water.
- The village uses 1 kg of alum (98% w/w of pure alum) per month.

1. Calculation of pure alum

$$1\ kg \times \frac{98\ g\ of\ pure\ alum}{100\ g\ mass\ of\ solid} = 0.98\ kg\ of\ pure\ alum$$

2. Calculation of pure alum used

   2.1 Each day the village uses approximately 0.98 kg / 30 days = 0.03267 kg/day of pure alum

   2.2 For the concentration of pure alum used at approximately 100,000L water produced per day:

$$Concentration = \frac{0.03267\ kg}{100{,}000\ L} = 0.33\ mg/L$$

Moo 10

- Each day the village produces approximately 115,000L of water.
- The village uses a bag of solid blocks of alum that weighs 30 kg with 98% w/w of pure alum.

1. Calculation of pure alum

$$1\ kg \times \frac{98\ g\ of\ pure\ alum}{100\ g\ mass\ of\ solid} = 0.98\ kg\ of\ pure\ alum$$

2. Calculation of pure alum used

   2.1 Each day the village uses approximately 0.98 kg of pure alum

   2.2 For the concentration of pure alum used at approximately 115,000L water produced per day:

$$Concentration = \frac{0.98\ kg}{115{,}000\ L} = 8.5\ mg/L$$

Calcium Hypochlorite:

Moo 13

- Each day the village produces approximately 60,000–90,000L of water.
- The village uses solid powder of $Ca(OCl)_2$ with 65% of available Cl.

1. Calculated volume of the container used (use only the highlighted part)

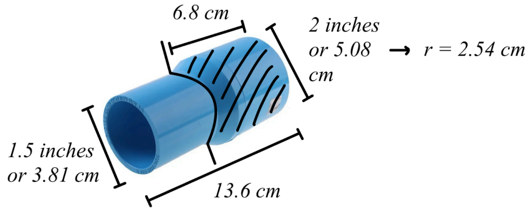


Figure 26. Dimension of PVC Pipe Used by the Water Station Caretaker

The volume of the highlighted part of PVC tube using $V = \pi r^2 h$ formula

$V = \pi \times (2.54 \text{ cm})^2 \times 6.80 \text{ cm}$

$V = 137.8 \text{ cm}^3$

2. Mass of $Ca(OCl)_2$ used
   - The bulk density of $Ca(OCl)_2$ is approximately 1.04 g/cm^3 (retrived from https://www.mwa.co.th สารเคมีที่ใช้ในกระบวนการผลิตน้ำประปาและการคำนวณ)

   $V = (1.04 \text{ g/cm}^3) \times 137.8 \text{ cm}^3 = 143.3 \text{ g } Ca(OCl)_2$

3. Concentration of chlorine dosage from $Ca(OCl)_2$ used

$$143.3\ g \times \frac{65\ g\ of\ Cl}{100\ g\ calcium\ hypochlorite} = 93.15\ g\ Cl$$

4. Calculation of pure chlorine dosage used

   4.1 For the concentration of pure chlorine dosage at the upper limit at approximately 60,030L of water produced per day (30L is the amount of water used to dissolve the solid):

$$Max.\ concentration = \frac{93.15\ g}{60{,}030\ L} = 1.6\ mg/L$$

   4.2 For the concentration of pure chlorine dosage at the lower limit at approximately 90,030L of water produced per day (30L is the amount of water used to dissolve the solid):

$$\text{Min. concentration} = \frac{93.15\ g}{90{,}030\ L} = 1.0\ mg/L$$

Moo 5

- Each day the village produces approximately 100,000L of water.
- The village uses the solid powder of $Ca(OCl)_2$ with 65% of available Cl.

1. Calculated volume of the tablespoon(tbsp.) used to measure the solid $Ca(OCl)_2$
   - 1 tbsp. is equivalent to 14.78 cm^3 (retrieved from https://www.inchcalculator.com/)

2. Mass of $Ca(OCl)_2$ used
   - The village uses 2 tbsp. of $Ca(OCl)_2$ per month to treat the water. Thus, 29.57 cm^3 of powdered $Ca(OCl)_2$ is used

2.1 Amount used per day

V = 29.57 cm^3 / 30 days = 0.9858 cm^3/day

2.2 Mass of $Ca(OCl)_2$

- The bulk density of $Ca(OCl)_2$ is approximately 1.04 g/cm^3 (retrived from https://www.mwa.co.th สารเคมีที่ใช้ในกระบวนการผลิตน้ำประปาและการคำนวณ)

Mass of $Ca(OCl)_2$ used per day = 0.9858 cm^3 x 1.04 g/cm^3 = 1.025 g

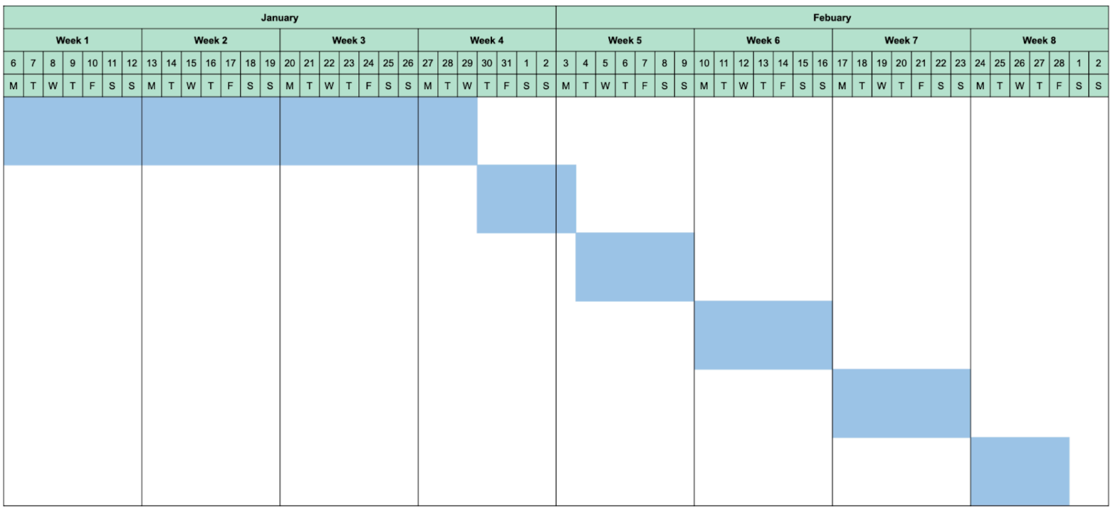
$$1.025\ g \times \frac{65\ g\ of\ Cl}{100\ g\ calcium\ hypochlorite} = 0.666\ g\ Cl$$

2.3 Concentration of pure chlorine dosage used in 100,000L of water

$$\text{Concentration} = \frac{0.666\ g\ Cl}{100{,}000\ L} = 0.0067\ mg/L\ or\ 6.7\ \mu g/L$$

Appendix E: Timeline

Task	Status	Start date	End date
Project initiation: - Team meetings - Reviewing prior research and setting objectives - Preparing for fieldwork	In progress	1/6/2025	1/29/2025
Investigation Period 1: - Visit Baan Sai Ngam Moo 13 - Preliminary interviews with community members - Investigate the area for contamination sources and infrastructure conditions - Sample collection from current water sources for lab testing	Not started	1/30/2025	2/3/2025
Data analysis: - Analyze collected samples data from fieldwork - Begin drafting solutions and improvements	Not started	2/4/2025	2/9/2025
Further research: - Continue drafting solution and improvent - Reasearch more information for solution	Not started	2/10/2025	2/16/2025
Final analysis and solution planning: - Finalize analysis - Develop recommendations for water supply improvement - Data summarization	Not started	2/17/2025	2/23/2025
Final Deliverable: - Present findings and proposed solutions - Collect final feedback - Submit project report	Not started	2/24/2025	2/28/2025



Appendix F: Contact Information for Recommended Agencies

The Groundwater Resources Regional Office 1 (Lampang) can be contacted via:
Address: 430 Moo 2, Phahonyothin Road, Sala Subdistrict, Ko Kha District, Lampang Province, 52130, Thailand
Phone: 054-282-356 to 7, 091-859-2233
Fax: 054-282-356 to 7
Email: saraban.bgr001@gmail.com

Environmental and Pollution Control Office 2 can be contacted via:
Address: 13 Pa Kham 1 Road, Hua Wiang Subdistrict, Mueang District, Lampang Province, 52000, Thailand
Phone: 054-227201
Fax: 054-227207
Email: epo02@pcd.go.th

Provincial Waterworks Authorities Office 9 can be contacted via:
Address: 1120 Kraisorasit Road, Wiang Subdistrict, Mueang District, Chiang Rai Province, 57000, Thailand
Phone: 053-711655
Fax: 053-713008
Email: 5511032@pwa.co.th

Envigear Co., Ltd. (Clarifier Tank Company) can be contacted via:
Address: 72/185, Moo 4, Khlong Phra Udom, Pak Kret, Nonthaburi 11120, Thailand
Phone: 097-101-9873 (Sales engineer), 082-224-2535 (Engineer Head)
Email: sales@envigear.com

M-Tech Water Solution Co., Ltd (Raw Water Supply Storage Tank) can be contacted via:
Address: 268/13, Moo 2, Om Noi Subdistrict, Krathum Baen District, Samut Sakhon 74110, Thailand
Phone: 092-4392509, 034-446877 (Sales)
Fax: 034-446877
Email: Sales@m-techwatersolution.com

Appendix G: Village Water Supply System Maintenance Logbook

Link to the Logbook: สมุดประวัติการใช้งานและบำรุงรักษา

Daily Record:

บันทึกประจำวัน เดือน.......................... ปี..........................				
วันที่	ระยะเวลาทำการ		ปริมาณสารเคมี (กรัม)	
	เปิด	ปิด	สารส้ม	คลอรีน

Record of Maintenance:

บันทึกการบำรุงรักษา									
ล้างทรายย้อน วันที่เปลี่ยน..................................		ถังสร้างตะกอน		ถังตกตะกอน		ถังกรองน้ำ		ถังน้ำใส	
วันที่ล้าง	วันครบกำหนด	วันที่ล้าง	วันครบกำหนด	วันที่ล้าง	วันครบกำหนด	วันที่ล้าง	วันครบกำหนด	วันที่ล้าง	วันครบกำหนด

Appendix H: Amount of Calcium Hypochlorite (Measuring Tool PVC pipe) and Alum Required to Treat Raw Water Calculation

1. **Amount of calcium hypochlorite required to treat raw water:**

- Calcium hypochlorite (65% available chlorine)
- 90,000 L raw water
- The residual chlorine in the tap water distribution system must not be less than 0.2 mg/L and a maximum of 0.5 mg/L

* Note: Calcium hypochlorite can decompose, and some of the released chlorine reacts with organic substances in the water. As a result, the effective chlorine concentration for treating raw water may be around 0.3 mg/L.

Calculation of calcium hypochlorite required:

$$Chlorine\ dose = Dosage \times Volume$$

$$Chlorine\ dose = 0.3\ mg/L \times 90{,}000\ L = 27{,}000\ mg = 27\ g$$

$$Mass\ of\ calcium\ hypochlorite\ required = \frac{Required\ chlorine\ dose}{Purity\ fraction}$$

$$Mass\ of\ calcium\ hypochlorite\ required = \frac{27\ g}{0.65} = 41.54\ g$$

Measuring Tool dimension:

- Name/Size: 18 mm
- Outer diameter: 22.0 mm
- Wall thickness (Class 8.5): 2.0 mm
- Inner diameter = 18.0 mm

* Note: cut into the length of 5.00 cm for ease of use

The cross-sectional area of a hollow cylinder:

$$A = \frac{\pi}{4}\left(D_{outer}^2 - D_{inner}^2\right)$$

$$A = \frac{\pi}{4}\left(22^2 - 18^2\right) = 125.66\ mm^2$$

The volume of a 5 cm. pipe section:

$$V_{section} = A \ x \ length$$

$$V_{section} = 125.66 \ mm^2 \ x \ 50.0 \ mm$$

$$V_{section} = 6{,}283 \ mm^3 = 6.283 \ cm^3$$

Mass of calcium hypochlorite per pipe section:

$$mass \ per \ section = volume \ x \ density$$

$$mass \ per \ section = 6.283 \ cm^3 \ x \ 1.04 \ g/cm^3 = 6.534 \ g$$

Number of scoops needed:

$$scoops = \frac{41.54}{6.534} \approx 6.357 \approx 7 \ scoops$$

* Note: 7 scoops contain 45.74 g of calcium hypochlorite, resulting in a chlorine concentration of 0.508 mg/L, assuming no decomposition. However, even if decomposition occurs, the approximate chlorine concentration would remain within the safe range and still effectively eliminate bacteria from the water distribution system.

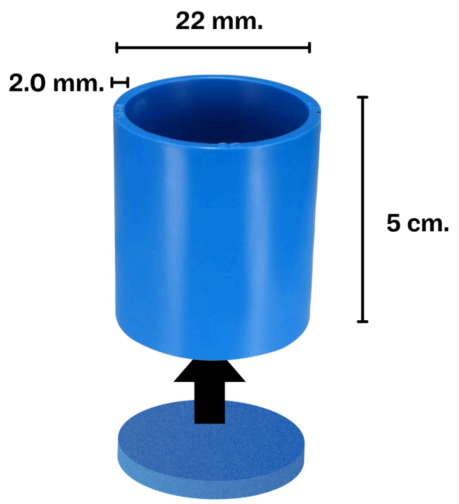


Figure 27. Dimensions of Recommended PVC Pipe

2. **Amount of alum required to treat raw water:**

- 98% Industrial Grade 3rd type of Ammonium Alum (Clear solid No.1) $Al_2(SO_4)3(NH_4)2.24H_2O$
- 90,000 L raw water
- Standard concentration of alum used: 35-50 mg/L

Calculation of alum required:

$$\textit{Mass of alum} = \textit{Dosage x Volume}$$

$$\textit{Mass of ammonium alum required} = \frac{\textit{Alum mass}}{\textit{Purity fraction}}$$

$$\textit{For 35 mg/L} = \textit{0.035 g/L x 90,000 L} = \frac{\textit{3,150 g}}{0.98} = \textit{3.21 kg}$$

$$\textit{For 50 mg/L} = \textit{0.050 g/L x 90,000 L} = \frac{\textit{4,500 g}}{0.98} = \textit{4.59 kg}$$

Appendix I: A Collaborative Expert Profile

1. Professor Dr. Santi Pailoplee
   Department of Geology, Chulalongkorn University
   Earthquake Geology, Seismic Hazard Analysis, Statistical Seismology
   Email: Pailoplee.S@hotmail.com
   Homepage Website: https://www.mitrearth.org/

2. Ph.D. Jeerapong Laonamsai
   Department of Water Resources Engineering, Chulalongkorn University
   Email: Jeerapong.La@chula.ac.th

3. Mr. Kraison Sangkajan
   Senior Geologist, Conservation and Restoration Division
   Department of Groundwater Resources, Region 1, Lampang
   Email: saraban.bgr001@gmail.com

Appendix J: Standard Procedures of Greywater and Wastewater Management

There are two methods of managing greywater and wastewater from households. The first method is effective for communities or villages that do not have a centralized wastewater treatment system, meaning each household should have a personal wastewater treatment system. This primary wastewater treatment should consist of a grease trap, a septic tank, and a small-scale wastewater treatment system to manage the water quality before draining off. Another method is best for community groups that have combined wastewater treatment systems for a cluster of buildings. The primary wastewater treatment includes grease traps and septic tanks in individual households; the wastewater flows to the community wastewater collection pipe to be treated at the cluster-based treatment system before draining into public water sources (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

The most common method of wastewater treatment in households is to collect wastewater from all household activities, including the kitchen, bathroom, toilet, and laundry by channeling it into a single wastewater treatment system using one pipe, which may not be possible for every household, depending on the layout and design of the house. Nevertheless, households unable to adopt the method can gather wastewater for treatment at multiple points. Wastewater from various activities must be collected and channeled into different wastewater treatment systems regarding its location in the house (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

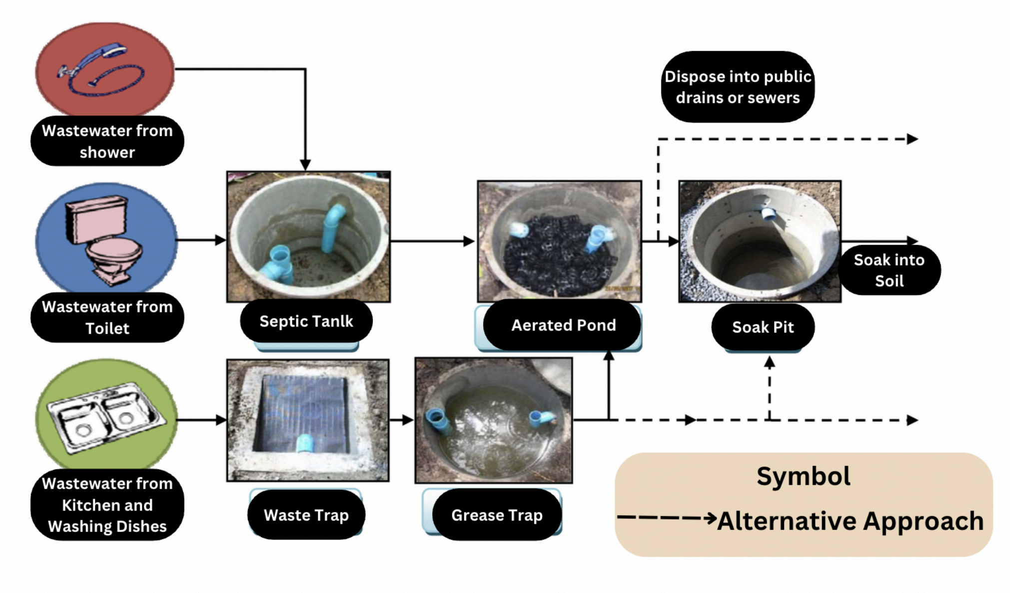


Figure 28. Collecting Wastewater for Treatment at a Single Point (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020)

The wastewater treatment system process can be varied depending on the type of wastewater, consisting of wastewater from the kitchen, bathing and laundry, and toilet. In order to treat the wastewater from the kitchen, the wastewater must pass through a screen or basket to discard food scraps before passing through an aqua grease trap to collect the grease and oils from the kitchen. Not only does it help the pipe to be clogged-free, but it also prevents the grease from entering the sewerage or seeping into the ground. Different types of grease traps share the same system; they only differ in the material used (**Figure 29**). The wastewater from the kitchen sink comes through the inlet, which needs to pass through the food scrap filter. The water then gets stored in the tank, while the grease layer will eventually float on top of the water due to the lower density. The water outlet must be lower than the inlet ones to let the wastewater separated from the grease flow out. **Figure 30.** demonstrates the steps for the homemade aqua grease trap. If there is a large quantity of food waste or fat residue, the wastewater may go through a septic tank for further treatment. The septic tank is a pit installed underground for storing waste and wastewater (**Figure 31**). The purpose of the septic tank is to treat organic substances, preventing grease and settleable solids from flowing out the next treatment process. The septic tank is a sealed pit that relies on anaerobic bacteria to decompose the organic matter in the wastewater and produce gases, water, and sludge. Therefore, the flow of the water in the septic tank is designed to pass through baffles or pipes to slow down the velocity of the water to prevent the sludge from being distributed and short-circuited. The tank also required a gas vent pipe to release the gas produced (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020). These are the fundamental processes of treating wastewater from the kitchen before entering the wastewater disposal system.

Figure 29. Aqua Grease Trap Ready-to-use, Concrete-built, and Homemade from Left to Right (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020)

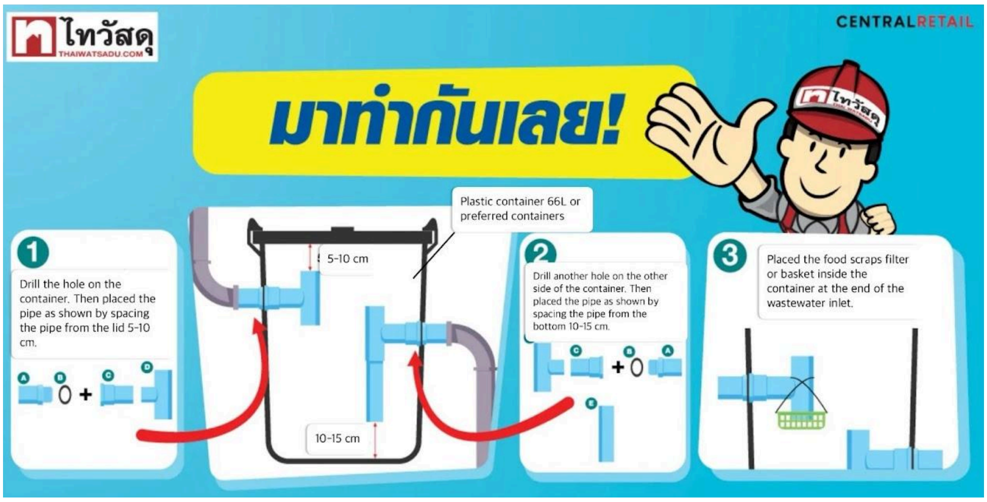


Figure 30. Self-made Aqua Grease Trap (Thaiwatsadu.com)

Figure 31. Septic Tank without Partition Wall and with Partition Wall (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020)

Treating wastewater from the toilet starts directly with the septic tank, where solids, such as feces, toilet paper and other impurities are settled on the bottom while fats float to the top. The anaerobic bacteria in the septic tank decomposed organic matter, with similar processes mentioned in the treatment of wastewater from the kitchen. Then the water passes through either an aerated or anaerobic treatment tank. This tank contains a filtering medium (media layer) to which microorganisms used to cling themselves. The wastewater flows into the bottom of the tank and then rises through the media layer, eventually flowing through the pipe to the top. As the water passes through the media layer, anaerobic microorganisms decompose organic matter in the wastewater, convert it into gas and water, and reduce BOD in wastewater. In order to increase the effectiveness of an anaerobic treatment tank, the distribution of microorganisms must be evenly throughout the tank. The treated wastewater then flows to the polishing unit, which separates any suspended microbial sludge for further water quality adjusting before discharged (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020). Similarly, wastewater from bathing and laundry flows through the septic tank to remove organic substances and filter through an anaerobic tank (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

Figure 32. Anaerobic Treatment Tank (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020)

There are several methods of wastewater disposal from households; the method can vary depending on diverse factors, including the types of soil within the area of the wastewater treatment system, the distance between the wastewater treatment system and the natural water source, or the public drainage system. Disposal of wastewater from households can be divided into two main methods, which are soak system and disposal system to public water sources (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

The soak system includes the soak pit and the soak bed system. The soak pit system is the method that is most suitable for households that mainly rely on the soil's absorption process. The soak pit is installed underground within the area of the treatment system. This type of wastewater disposal is commonly used for households or small buildings with limited drainage areas and far from drinking water sources. The process starts by allowing the wastewater to flow from the wastewater treatment system into the soak pit, which is then released into the surrounding soil underground through compact holes drilled around the pit. The soil particles can assist in filtering out suspended solids remaining in the wastewater; at the same time, the remaining organic compounds in the wastewater can be broken down by microorganisms in the soil. However, with a large quantity of wastewater and sufficient land area available, it is highly more suitable to use a soak bed compared to the soak pit. The soak bed required perforated pipes installed underground, to distribute the wastewater and allow the soil to absorb the wastewater. Nevertheless, it is necessary to test the soil's permeability characteristics to ensure its ability to absorb the wastewater. It needs to be certain that the bottom of the pit is at least 0.6 to 1.0 meters above the highest groundwater level (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

Disposal of wastewater to public water sources can be directly drained into natural water bodies or using the drainage system. This method is suitable for households located in urban areas that have limited space and households located close to public drainage pipes or natural water sources. In addition, this method is ideal for households located in an area where the soil cannot allow fast wastewater percolation. To effectively dispose of wastewater in public water sources, the elevation of the drainage pipe and the potential environmental impact must be taken into consideration. However, for direct wastewater disposal into natural water sources, the quality of the wastewater is required to meet the standard set for effluent before being discharged (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020).

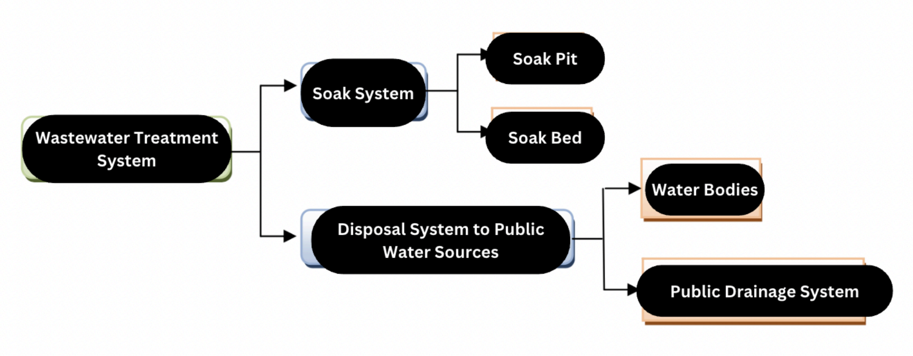


Figure 33. Wastewater Disposal System from Households (*คู่มือการจัดการน้ำเสียสำหรับบ้านเรือน*, 2020)