Kingdom of the Netherlands

DRR-Team Mission Report – December 2015

Central Luzon, the Philippines

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[20 December 2015

[DRR team Philippines]

DRR-TEAM [Philippines]

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EXECUTIV SUMMARRY

Problem description

In August 2014, the Department of Health Regional Office 3 (RO3) was informed about the first case of arsenicosis (poisoning by arsenic), in Lubao, Pampanga province. Data validation from five barangays in the same city showed 215 residents had consulted with similar dermatological symptoms between 2010 and 2014. This started a large health monitoring and water quality monitoring program in and near Lubao. Arsenic was found with many samples above the Philippine National Standards for Drinking Water for arsenic [> 10 µg/l]. A deep well with a high Arsenic concentration was decommissioned. A small reverse osmosis plant was installed in one area. To date, 93 patients were admitted to the Hospital for diagnostic follow-up and dermatological management.

Work on the arsenic contamination had been a collaborative activity among the Department of Health, Department of Science and Technology, Department of Environment and Natural Resources --National Water Resources Board, University of the Philippines National Poison Management and Control Center, Local Waterworks and Utilities Administration, and the concerned Local Government Units. WHO provided technical support through 2-week visits by 2 consultants in the period 10-20th May 2015.

Bilateral relations between the Netherlands and the Philippines are strong and marked by close cooperation in a variety of areas, economic being a major one. The Netherlands Embassy in Manila has identified water management as one of its sector priorities and has been promoting and supporting Dutch interest in the Philippines in this area. There is complementarity with the DRR-Team activities taking place in Tacloban where a coastal defense master plan is going to be developed in collaboration with the PRA and the DRR-Team activities taking place in the development of a Manila Bay master plan in collaboration with the NEDA.

Dutch Risk Reduction Teams in general aim to reduce the risk of water related disasters. Many countries around the world face severe water threats. Often, these countries are in urgent need of expert advice on how to prevent a disaster or how to recover from a calamity.

The DRR-team visited stakeholders in Manila, collected data and analyzed data prior to the field trip to the affected area in the period 12-14 October 2015, namely the area south and southwest of Pinatubo: Lubao, Porac, Mabalacat and Clark. The objectives of these visits were to:

1. To collect and assess technical information available necessary for decision-making which includes, but not limited, the following:
2. To prepare a ToR for field studies to determine the geology, geochemistry and hydrology of the area and to determine relevant factors which can affect the drinking water quality in the area.
3. To Prepare a ToR for a pilot project aimed at providing clean drinking water to one selected village or area.
4. To propose risk reduction initiatives by application of arsenic removal technologies;
5. To evaluate the pilot project based on identified parameters;
6. To propose a monitor system for drinking water;
7. To propose risk communication strategies at the community level.
8. To determine capability upgrading requirements of personnel on analytical laboratory techniques and GIS mapping/application and
9. To assist in the formulation of a project proposal for the long-term plan and for possible funding assistance. (To elaborate on a roadmap for short-, medium- and long-term interventions to reduce the risks and impacts of the arsenic contamination).

DRR/DoH Mission in DoH office in San Fernando, Pampanga

Annex A gives the names of the DRR team members, as well as those of the Philippine experts who accompanied the team, and those who attended the Wrap-up Meeting on the DoH on the 15th October 2015 in Manila.
On November 9th a workshop took place in Den Haag, the Netherlands were firms with a particular interest in arsenic contamination were invited. The minutes of meeting of this brainstorm session is added in Annex B.

Summary of Findings

The DRR experts received a lot of water quality data from the DoH. And because data was incomplete, contradicting in some cases or difficult to trace, it was decided to take a few samples for analysis in Unesco-IHE lab in the Netherlands. In addition some soil samples were taken and tested with a hand held As tester.

The following was observed (headlines):

- Arsenic is widely present in the visited area. Many arsenic values in drinking water samples are close to the standard or slightly above the standard of 10 μg/l. The problem however seems to concentrate on the city of Lubao (150,000 population) and in particular certain areas in Lubao with values that very locally peak to values up to 300 μg/l;
- These very high values are possibly be attributed to a combination of natural and man-made components (eg industry, deep wells);
- There was a serious difference between the arsenic concentration as measured by Unesco-IHE and the 3 local labs (Unesco-IHE measured much higher values). This may indicate that arsenic concentrations are higher than currently reported;
- The 18 soil samples didn't show any alarming levels in specific areas tested, except the paper mill. Also a (1 no.) rice sample didn't show any arsenic;
- Data sampling is still too limited in the number of components and regional spread, and a good database is lacking;
- The RO plant was out of operation. The treatment results were apparently good but the operation too expensive (electricity, membranes);
- Arsenic concentration is higher in the uncontrolled shallow hand wells compared to LWD owned deep wells;
- The operation of the Lubao water supply company is not optimal. Half the population uses the handwells (with higher As concentration).

Summary of suggested follow-up activities

Item		Cost estimate	Recommendation nr	Duration	Outcome
Further screening of the problem area	Wide spread water quality sampling program with field test kits and smart phones	30,000 euro plus local manpower to be provided my DOH	1	1 month	Much better insight in the footprint of the problem area, and better insight in the arsenic concentration in a wide area, and identification of hot spots
	Medical screening in a wider area , also considering early symptoms	Action DOH	3		
Pilot project for imediate improvement and testing of technologies	Pilot Project (1) – packed treatment plant	Quotation to be obtained	8	3 months preparation and shipment	Testing of better technology to remove arsenic near a pumping station, safe drinking water for a neighbourhood
	Pilot Project (2) – household filters	10,000 euro plus local installation and monitoring costs	8	1 month preparation , trial can last 1 year	Testing of various types household filters, safe drinking water for 100 families
	Inventory of all handpumps in the problem area	Action LWUA, DOH	4	6 months	Safe water
	Sample programme industry near Lubao	Action DENR	14	continuous	Environmental management, improved water quality
Lab & data improvement	Lab analysis improvement	20,000 - 50,000 euro for testing and training	2	1-2 months	Better quality of local labs and better test results
	Improvement of water quality data sampling, testing and data management	Action LWUA	9, 10, 11, 12, 13	continuous	Improved water quality sampling, and data management

Item		Cost estimate	Recom mendat ion nr	Duration	Outcome
	Improvement of water quality data sampling, testing and data management	Action LWUA	9, 10, 11, 12, 13	continuous	Improved water quality sampling, and data management
Technical Assistance programme	Lubao water quality improvement project – TA component	100,000 – 150,000 euro for technical assistance and concept design	6,7,8	3-4 months	A design of an improved water supply system resulting in a more steady flow, positive pipe pressures, less groundwater fluctuations, more control and better water quality
Lubao Water Quality Improvement Project	Lubao water quality improvement project implementation, construction	1-2 million euro	18	12 months	Implementation of the Lubao water quality improvement programme
	Public awareness and training		15, 16		

ABBREVIATIONS

AAS-GF	Atomic Absorption Spectroscopy – graphite furnace
APHA	American Public Health Association
AWWA	American Water Works Association
CRL	RL Environmental Corporation
DOH	Department of Health
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
DRR	Dutch Risk Reduction team
EAMC-NRL	East Avenue Medical Center – National Reference Laboratory
EKN	Embassy of the Netherlands
Lcpd	Liters per capita per day
LOD	Level of Detection
LWUA	Local Water Utilities Administration
LWD	Lubao Water District
NEDA	National Economic Development Authority
mg	milligram
µg/l	microgram per litre
NWP	Netherlands Water Partnership
PNRI	Philippine Nuclear Research Institute
PNSDW	Philippines National Standards for Drinking Water
Ppm	Parts per million
Ppb	Parts per billion
PS	Pumping Station
RO1,2,3	Regional Office
RO	Reverse Osmosis
USEPA	US Environmental Protection Agency
WHO	World Health Organization

CONTENTS

1 INTRODUCTION

1.1 Background and history of the problem

On August 10, 2014, Department of Health Regional Office 3 (RO3) was informed about the case of a 45-year old male patient from a barangay (village) in Lubao, Pampanga province who was admitted at National Poison Management and Control Center of the Philippine General Hospital due to multiple hyperkeratotic papules on the palms and soles and detoxified last June for chronic arsenic exposure. Data validation from five barangays in the same city showed 215 residents had consulted with similar dermatological signs & symptoms for the 2010 to 2014 period.

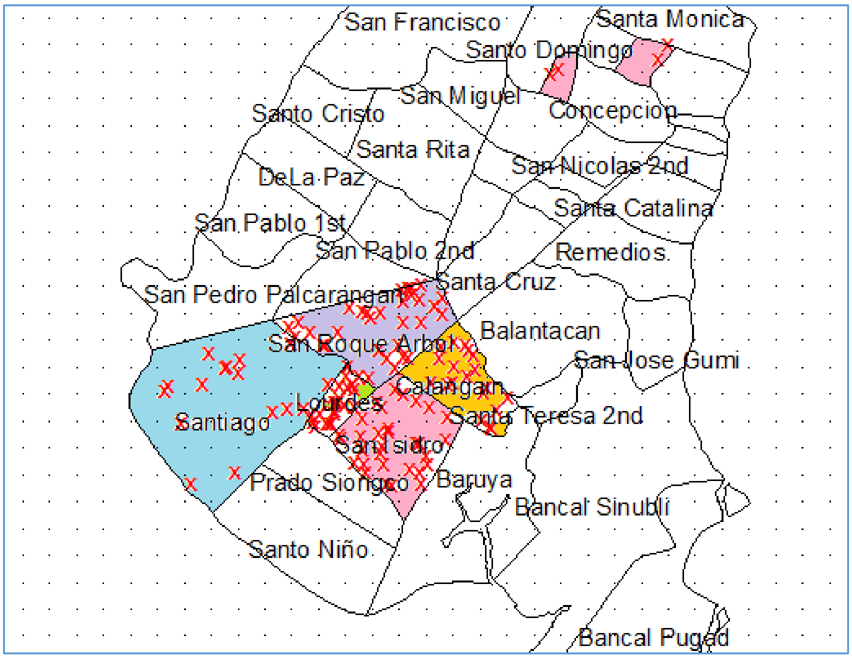

Figure 1.1: Cases of Arsenic Poisoning in the city of Lubao

In view of above findings, health and environmental assessment, environmental monitoring, and health monitoring and management were immediately undertaken. Following were the general findings:

- Initial drinking water tests from households of index cases showed elevated arsenic concentrations; soil samples from 3 sites [residential and school] showed elevated concentrations compared to the USEPA (US Environmental Protection Agency) preliminary remediation goals for chemical contaminants; and, elevated concentrations of arsenic were seen in drinking water from domestic/deep/shallow wells, including pumping stations of the local water district. Recent drinking water monitoring tests conducted by the DOH Regional Office showed 15 of 110 water samples were above the Philippine National

Standards for Drinking Water (PNSDW, Table 1.1) for arsenic [≥ 10 μg/l], while 37 of 110 showed concentrations near PNSDW limit values [5-9 μg/l][1].

- Of 123 residents interviewed and examined, 69 presented with respiratory symptoms, while 47 had neurological complaints. Of the 123 residents, 98 had dermatologic symptoms of skin discoloration, skin rashes, lesions, etc. Dermatological clinical examination showed arsenical keratosis was to be ruled out in 90. On biopsy, 2 were found to have Bowen's disease, and 52 were diagnosed to have hyperkeratosis. Urinary arsenic concentrations were elevated in 40 of 51 patients belonging to the first batch.
- To date, 93 patients were admitted to the East Avenue Medical Center [where the National Reference Laboratory is located] for diagnostic follow-up and dermatological management.

Work on assessment and management of arsenic contamination had been a collaborative activity among the Department of Health, Department of Science and Technology, Environmental Management Bureau-National Water Regulatory Board, University of the Philippines National Poison Management and Control Center, Local Waterworks and Utilities Authority, and the concerned Local Government Units. WHO provided technical support through 2-week visits by 2 consultants in the period 10-20th May 2015.

Table 1.1. The Philippine National Standard for Drinking Water —Inorganic Constituents

Constituent	Maximum level (mg/L)
Antimony	0.005
Arsenic	0.01
Barium	0.7
Boron	0.3
Cadmium	0.003
Chromium	0.05
Cyanide	0.07
Fluoride	1
Lead	0.01
Mercury (total)	0.001
Nitrate as NO_3-	50
Nitrate as NO_2-	3
Selenium	0.01

1.2 Health and Environmental Assessment done by DoH

Drinking water tests conducted in December, 2014 showed that 7 out of 9 drinking water samples from households of index cases have elevated arsenic concentrations (Range: 10-

[1] 1 μg/l = 0.001 mg/l = 1 ppb

600 μg/l) which exceeded the PNSDW set by the DOH at 10 μg/l. Soil samples collected from three selected sites (residential and school) were also elevated when compared with the US Environmental Protection Agency (USEPA) preliminary remediation goals for chemical contaminants (≤0.39 mg/kg). Based on continuing monitoring activities of the Technical Working Group, elevated ([2]) concentrations of arsenic in drinking water were seen in the domestic/deep/shallow wells including pumping stations of the local water district.

On December 4 and 15, 2014, 123 residents from the 5 barangays were interviewed and examined:

1. There were 71 (58%) males and 52 (42%) females, with a mean age of 34.5 years (range 1-83 years): 69 (56%) presented with respiratory symptoms (cough, breathlessness, dyspnea, etc), while 47 (38%) have neurological complaints (dizziness, headache, drowsiness, etc). Peripheral neuropathy was suspected in 8 patients based on an abnormal monofilament test or abnormal neurologic exam findings. Ankle Brachial Index (ABI) were essentially normal.

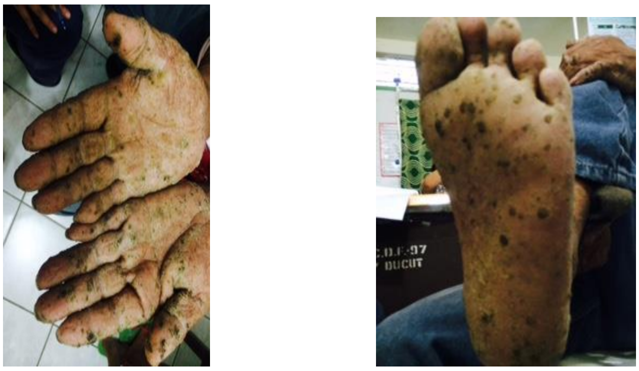

Figure 1.2: Dermatological hyperkeratosis in the palms and soles

2. Dermatologic symptoms in 98 (80%) of the residents examined were skin discoloration, skin rashes, itchiness, lesion, etc. (figure 1.2). At a dermatological clinical examination, arsenical keratosis was ruled out in 90 cases, where the other 86 positive cases were diagnosed as:
    a. Grade I (mild) in 41 cases (48%),
    b. Grade II (moderate) in 28 cases (32%) and
    c. Grade III (severe) in 17 cases (20%).

[2] >10 μg/l

d. On biopsy, 2 residents were found to have Bowen's disease characterized by multiple hyperkeratotic papules on the palms and soles consistent with chronic arsenic poisoning, while 52 residents were diagnosed with hyperkeratosis.

3. Urinary arsenic levels were elevated in 40 out of 51 (78.43%) for the first batch of residents. Urine samples for the second batch will likewise undergo tests for arsenic determination

Environmental Monitoring

Recent drinking water monitoring tests conducted by the DOH Regional Office No.3 showed that 13.6% (15/110) of the samples were above the PNSDW for arsenic while 33.6% (37/110) showed levels almost near the PNSDW limit values (5-9 µg/l). These represent 47.3% (52/110) or almost half of the sampling points that are elevated or needs follow-up monitoring (see Tables 1.2 and 1.3).

Table 1.2 Arsenic levels in 3 municipalities, May, 2015

Municipality	No of sampling sites	No of samples with As (%) above standard	No of samples with As levels between 0-10 µg/l	No of samples below MDL (%)
Lubao	106	14 (13%)	83 (78%)	9 (9%)
Guagua	3	1 (33%)	2 (67 %)	0
Bacolor	1	0	1 (100 %)	0

Table 1.3: Drinking Water Quality Monitoring results for Arsenic, May, 2015

Type of water source	No. of sampling sites	No of samples with As (%) above standard	No of samples with As levels between 0-10 µg/l	No of samples below MDL (%)
Deep Well	88	13 (15%)	67 (76%)	8 (9%)
- HH taps	84	13 (15%)	66 (79%)	5 (6%)
- Water RS	4	0	1 (25%)	3 (75%)
Local WD	13	2 (15%)	11 (85%)	0
- HH taps	10	2 (20%)	8 (80%)	0
- Water RS	0	0	3 (100%)	0
Shallow Well	6	0	5 (83%)	1 (17%)
Total	107	15 (14%)	83 (78%)	9 (8%)

Results of the Department of Science and Technology's (DOST) initial assessment of drinking water quality also showed elevated arsenic concentrations in 7/11 (63.6%) of the pumping stations of the local water district.

Based on the initial findings, the Technical Working Group member agencies concluded that arsenic sources are geogenic (naturally-occurring) due to the interaction of water with As-rich bedrock over long periods of time (PNRI, DOST). Over-pumping of groundwater above the recharge zone is the possible cause of dissolution of arsenic (LWUA). High concentrations of arsenic in the groundwater is highly toxic in its inorganic form. It may contaminate water used for drinking, food preparation and irrigation of food crops.

Health Monitoring and Management

To date, 93 patients were admitted at the East Avenue Medical Center (EAMC) for diagnostic follow-up and dermatological management. The results are good (figure 1.3):

- They were given seafood free, alkaline rich diet for three days before a 24 hour Urinary Arsenic was done. Results showed non-detected concentrations of arsenic in the urine.
- Series of laboratory work-ups such as: CBC, AST, ALT, Protime, BUN, Creatinine, ionized calcium, Mg, Na, K, Cl, uric acid, urinalysis, chest x-ray, whole abdominal ultrasound and urine cytology. ECG, EMG, FBS and HBA1C were done based on the doctor's assessment (table 1.4)
- Pulmonary Function Test (PFT) will be done on out-patient department (OPD) basis. Referral to different subspecialties (Gastrointestinal, Pulmonary, Cardiology, Endocrinology, Nephrology, and Urology) shall likewise be done on OPD follow-up (table 1.5)

Figure 1.3: Dermatological management of Grade III cases show good results

Table 1.4: Result of the whole abdominal ultrasound

Type	No of patients
Parapelvic cyst	1 (2.1%)
Renal cyst	6 (12.8%)
Liver parencgymal disease	9 (19%)
Fatty liver	11 (23%)
Hepatosplenomegaly	6 (12.8%)
Prostatic cyst	2 (6.4%)
Renal microlithiasis	1 (2.1%)
Hepatomegaly	4 (8.5%)
Cholelithiasis	6 (12.8%)
Pelvocaliuereterectasia	1 (2.1%)

No patients examined =47

Table 1.5: Result of urine cytology test

Type	No of patients
Negative for malignant cells	17 (29%)
Benign	12 (21%)
Atypical cells	15 (26%)
Acute inflammatory cells	5 (9%)
Partially degenerated urothelial cells	12 (21%)
Multinucleated giant cells	6 (11%)

No of patients =57

1.3 Netherlands and the Philippines

Bilateral relations between the Netherlands and the Philippines are strong and marked by close cooperation in a variety of areas, economic being a major one. The Netherlands Embassy in Manila has identified water management as one of its sector priorities and has been promoting and supporting Dutch interest in the Philippines in this area. The development relationship between the Netherlands and the Philippines (including support in the areas of poverty reduction and the environment) was completed in 2004. Additionally, there is complementarity with the DRR-Team activities taking place in Tacloban where a coastal defense master plan is going to be developed in collaboration with the PRA and the DRR-Team activities taking place in the development of a Manila Bay master plan in collaboration with the NEDA.

1.4 Dutch Risk Reduction

Dutch Risk Reduction Teams in general aim to reduce the risk of water related disasters. Many countries around the world face severe water threats. Often, these countries are in urgent need of expert advice on how to prevent a disaster or how to recover from a calamity.

For example, when a country has been struck by severe flooding and the first emergency relief workers are gone, the need for advice on how to build a sustainable and safer water future arises. To meet these needs with a swift response, the Dutch government has initiated the Dutch Risk Reduction Team (DRR Team). This team of experts advises governments on how to resolve urgent water issues related to flood risks, water pollution and water supply, to prevent disasters or to rebuild after water related disasters. With climate change and a fast growing world population, water issues are becoming more urgent.

The Netherlands has brought its best water experts together in the Dutch Risk Reduction Team. It consists of high concentration advisors supported by a broad base of technical experts who can provide top quality and tailor made expertise to governments that are confronted with severe and urgent water challenges. The Dutch are experts in adapting to water in a changing world; from delta management to water technology, from urban planning to governance, public private partnerships and financial engineering.

An official request for support from the Dutch Risk Reduction-Team (DRR-Team) was sent to the Dutch Government on May 20th 2015 from the National Government of the Philippines: Department of Health. On July 6th 2015, Dutch Minister Koenders of Foreign Affairs granted the request for this mission. The Secretary of Health of the Philippines, Sec. Janette P. Loreto-Garin recently visited institutes in the Netherlands and Belgium including UNESCO-IHE.

This project concerns a scoping mission to address the water quality in Central Luzon, Philippines in general and, more specific, the arsenic contamination.

1.5 Terms of Reference for this mission

a. Scope

This mission consists of the following parts: 1) Preparation (desk study), 2) Field visits and meetings in the Philippines 3) Expert meeting, 4) Advice and recommendations.

1) Preparation: DRR-Team will collect and assess information available on the environmental profile of the area (Pampanga province) in general, and more specific the extent and magnitude of the arsenic contamination.
2) Field visits and meetings: DRR-Team will visit the contaminated area and organize meetings with stakeholders in the Philippines.
3) Expert meeting: A meeting in The Hague (facilitated by DRR-Team and Netherlands Water Partnership (NWP)) for companies and institutes to share information on Arsenic Removal techniques.

4) Advice and recommendations: The DRR-Team will provide the DOH with a scoping report on the facts and figures found during the mission and give advice and recommendations on short-, medium and long-term measures to address the problem of the arsenic contamination

b. Objectives

1. To collect and assess technical information available necessary for decision-making which includes, but not limited, the following:
    a. An environmental profile,
    b. the extent and magnitude of the arsenic contamination (vertical and lateral extent) from all possible sources (natural and anthropogenic, in water and food (rice and meat),
    c. the prevailing hydrogeological conditions which can effect arsenic concentrations,
    d. the groundwater flow rates and
    e. determination of soil and groundwater quality.
2. To prepare a ToR for field studies to determine the geology, geochemistry and hydrology of the area and to determine relevant factors which can affect the drinking water quality in the area.
3. To Prepare a ToR for a pilot project aimed at providing clean drinking water to one selected village or area.
4. To propose risk reduction initiatives by application of arsenic removal technologies;
5. To evaluate the pilot project based on identified parameters;
6. To propose a monitor system for drinking water;
7. To propose risk communication strategies at the community level.
8. To determine capability upgrading requirements of personnel on analytical laboratory techniques and GIS mapping/application and
9. To assist in the formulation of a project proposal for the long-term plan and for possible funding assistance. (To elaborate on a roadmap for short-, medium- and long-term interventions to reduce the risks and impacts of the arsenic contamination).

a. Activities

1) Preparation

- Kick-Off Meeting with the DOH in close collaboration with the EKN;

- Collecting and assessing the technical information;
- Review of available documentation;

2) Field visits and meetings on the Philippines

3) Expert meeting in The Hague

4) Advice recommendations
   - advice on short-, medium and long-term measures to address the problem of the arsenic contamination including finance of the measures

2 PHYSICAL ENVIRONMENT AND SOCIAL SETTING

2.1 Description of the Project Area

Mount Pinatubo is situated in the Cabusilan Mountains on the island of Luzon, near the tripoint of the Philippine provinces of Zambales, Tarlac, and Pampanga. Before the volcanic activities of 1991, its eruptive history was unknown to most people. It was heavily eroded, inconspicuous and obscured from view. It was covered with dense forest which supported a population of indigenous people, the Aetas, who fled to the mountains during the Spanish conquest of the Philippines (figure 2.1). In total, about 30,000 people lived on the flanks of the volcano in about 25 established barangays and other small settlements like Tarukan village and Maruglu. The dense jungle covering most of the mountain and surrounding peaks supported the hunter-gathering Aeta, while on the surrounding flatter areas, the abundant rainfall of almost 4 metres annually provided by the monsoon climate and the fertile volcanic soils provided good conditions for agriculture.

Figure 2.1: School for Aeta (Indigenous Peoples) near Porac, on the slopes of Pinatubo

Figure 2.2 shows the project area. The volcano is located 87 km northwest of Manila. The USA maintained in 1991 two large military bases in the region: the U.S. Naval Base Subic Bay was 37 km south of Pinatubo, and the extent of Clark Air Base was just 14 km east of the volcano's summit. The volcano's location on Luzon is in close proximity to about 6 million people.

Figure 2.2: Pampanga, Tarlac and Zambales provinces

Angeles City and Clark Freeport Zone

Angeles is a first-class highly urbanized city, bordered by Mabalacat to the north; Mexico to the east; San Fernando to the southeast; Bacolor to the south; and Porac to the southwest and west. The city administers itself autonomously from Pampanga and according to the 2010 census has a population of 326,336.

Clark Freeport Zone is a 4500 ha redevelopment of the former US Clark Air Base. It is located on the northwest side of Angeles City and on the west side of Mabalacat City. CFD has modern infrastructure facilities, fiscal and non-fiscal incentives, professional support services and other amenities to attract high-end business, industry, aviation, and tourism (entertainment and Casinos). The zone employs some 50,000 employees from outside the zone.

Zambales Province

Zambales Province is located west from Pinatubo. Its capital is Iba. The land area is 3,830.83 km^2, and the population is 534,000. The province is noted for its mangoes, which are abundant from January to April.

2.2 Pinatubo Eruption in 1991

Geologically, Pinatubo Volcano is part of a chain of volcanoes on the western coast of Luzon, including Mounts Cuadrado, Negron, Mataba, Pinatubo, Natib, and Mariveles, and the volcanic island of Corregidor in Manila Bay. These volcanoes are formed by magma rising from the subduction along the Manila Trench as the Eurasian Plate subducts under Luzon.

Figure 2.3: Lahar near Pinatubo (in the back ground)

Early sign of unrest at Pinatubo possibly include the summit landslides during the July 1990 Luzon earthquake which had magnitude of 7.2 and an epicentre 80 km north of the volcano. In April 1991, small earthquakes were felt at the foot of the mountain, and after two months, Pinatubo Volcano had small explosions and lava extrusion at its summit. A large eruption on 15 June 1991 created a Plinian ash cloud that reached an altitude of 40 km, injecting 17 megatons of SO_2 into the atmosphere and an estimated 11 km^3 of fresh volcanic ash onto the surface ([3]). Successful predictions and warnings about the volcanic activity led to the evacuation of tens of thousands of people from the surrounding areas and led to the much reduced casualty rate of a few hundred people during the cataclysmic event.

[3] Self, 1997

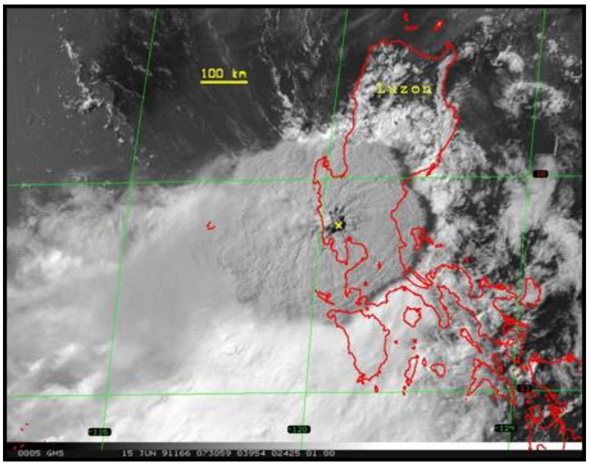

Figure 2.4: Left – Picture of the 15 June 1991 eruption, viewed from Porac, with the Plinian cloud still rising into the atmosphere. Right - Satellite photo of the 15 June 1991 ash cloud [4]

The rising volcanic ash cloud caused electrostatic-induced rainfall which caused wet ash to fall. Then, within hours, Typhoon Yunya (local name Typhoon Diding) formed in the Pacific and traversed Luzon, bringing heavy rain in areas with thick ash deposits. The strong volcanic earthquakes combined with the thick wet ash on the roofs caused many structures to fail, depriving the people of shelters that could protect them from the falling ash and the ensuing typhoon.
The pyroclastic ash of around 750°C flowed down the slopes as fast density currents [5] reaching velocities exceeding 100 km/h.

Figure 2.5: Pyroclastic ash during the eruption

[4] Wolfe & Self, 1997
[5] Bryant, 1991

The pyroclastic materials rested in the large valleys around the volcano and displaced the major rivers that radiated from the peak, creating pyroclastic deposit that reached more than 200m thick in the deep valleys.

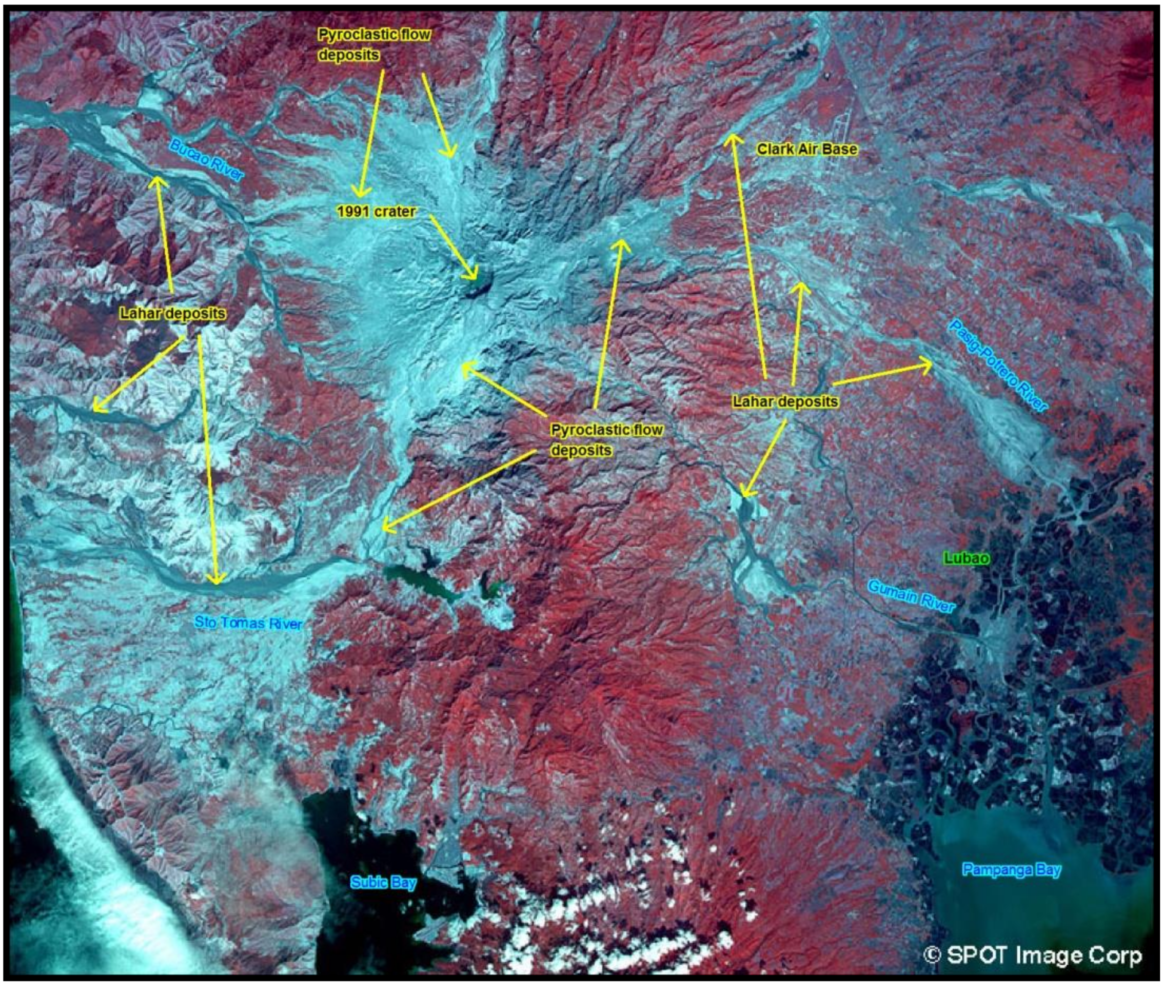

Figure 2.6: SPOT Satellite image[6] of the Pinatubo Volcano deposits taken a few months after the eruption in December 1991. Airfall ash is still visible on some slopes, and the lahars are not yet extensively distributed at this stage.

Within a week, the intensity of ash ejection from the volcano abated leaving behind a large crater at the former summit, thick layers of hot pyroclastic ash in the river channels, and a blanket of airfall ash in the surrounding 4,000 km^2. Dacite pumice of a few meters to a few cm accompanied the ash; 20 cm pumice dropped from the air as far as 18 km from the crater.

The eruption of the volcano occurred in June—the start of the Philippine rainy season. After Typhoon Yunya, other typhoons and monsoon rains followed, making the newly deposited ash to flow down as streams of dense sediment-rich volcanic mudflows or

[6] eos.high.hawaii.edu

lahars. The lahars had the constituency of wet concrete that moved quickly into the surrounding flat floodplains and agricultural areas of Pampanga, and Tarlac on the east, and Zambales on the west. The lahars were more destructive than the initial magmatic episode since they were more mobile—reaching farther downstream, and as far as the coastal areas. The lahars became frequent as the rainy season progressed, enabling even short rain to easily mobilize the ash that was already saturated by earlier rains.

In August 1991 the episodic explosions in the crater ended, and in July 1992, a small lava dome formed on the floor of the new caldera. More lahars came down in the following rainy seasons until 1998 when the last of the lahars were recorded. All throughout this period, dikes were built around major rivers to contain the lahar, many of these dikes were progressively adjusting as the erosive lahars flowed out of their channels and the volume of materials exceeding what was initially expected. The largest communities being protected were located on the east flank of the volcano, in the reaches of the Pasig-Potrero River. A large dike system—the "megadike" was eventually built here, where the rate of sediment accumulation progressively overwhelmed dikes built in the previous periods, leading to the constant outward expansion of the protection system to accommodate the rising volume of the flowing lahars.

Although the 1991 eruption of Pinatubo Volcano—with its volcano explosivity index of 6—is one of the largest in human history, it is the smallest of Pinatubo's eruptions in the past 35,000 years ([7]). The oldest appear to have been the largest, and the size of the eruptions seems to slowly decrease through time.

Figure 2.7: Pinatubo Crater Lake

[7] Delfin, 1997

The 1,485 m high peak lost 260 m of its elevation and was replaced by a 2.5 km diameter caldera that is now occupied by a lake (figure 2.7). The water of this crater lake is partly acidic and its composition was highly influenced by the volcanic emanations but slowly diminished with time (see Table 2.1). The rivers that were covered with thick ash slowly carved new canyons in the pyroclastic materials while the surrounding lahar-filled floodplains have gained some elevation and their distal portions became shallower due to the massive influx of young sediments.

Table 2.1: Chemistry of the new Crater Lake waters includes arsenic[8]

Sample	Type	Date (day month year)	T (°C)	Ref.	Field pH	Lab. pH	Al (mg/kg)[a]	As
1	Crater lake	08.10.1991	40.0	LANL	6.0	4.79	n.d.	0.28
2	Crater lake	19.11.1991	39	PV	5.2	5.21	n.d.	n.d.
3A	Crater lake	18.02.1992	38.5	PV	2.7	n.d.	n.d.	n.d.
3B	Crater lake	18.02.1992	38.5	PV	2.8	n.d.	n.d.	n.d.
3C	Crater lake	18.02.1992	46.5	PV	2.7	n.d.	n.d.	n.d.
4A	Crater lake	04.12.1992	36.7	PV	1.9	n.d.	n.d.	n.d.
4B	Crater lake	04.12.1992	36.7	LANL	1.9	n.d.	n.d.	n.d.
4C	Crater lake	04.12.1992	37	LANL	2.6	n.d.	5.10	0.14
5	Crater lake	30.12.1994	34	LANL	2.4	n.d.	6.73	0.13
6	Crater lake	27.09.1995	33	LANL	1.9	n.d.	6.08	0.11
7A	Crater lake	20.02.1999	32	LANL	n.d.	3.09	2.96	0.17
7B	Crater lake-O	20.02.1999	32	LANL	3.8	3.07	2.74	0.17
8A	Crater lake-O	09.04.1999	30	LANL	3.3	3.3	2.41	0.14
8B	Crater lake-O	09.04.1999	30	LANL	3.3	3.3	2.68	0.14
9A	Crater lake-O	29.01.2000	28	LANL	4.5	3.43	2.76	n.d.
9B	Crater lake-O	29.01.2000	28	LANL	4.5	3.40	2.75	n.d.
10A	Crater lake-M	05.08.2000	n.d.	LANL	n.d.	4.12	1.83	0.009
10B	Crater lake-M	05.08.2000	n.d.	LANL	n.d.	4.06	1.84	0.008
11A	Crater lake-O	26.11.2000	31.4	LANL	5.0	n.d.	1.24	0.050
11B	Crater lake-O	26.11.2000	31.4	LANL	5.0	n.d.	1.53	0.069
12	Crater lake-O	26.11.2000	31.4	LANL	5.0	n.d.	1.15	0.048
25	Crater lake-O	04.02.2001	25.7	LANL	5.5	6.29	0.81	0.089
30	Crater lake-M	01.04.2001	28	LANL	5.5	6.68	0.67	0.12
31	Crater lake-WS	01.04.2001	50	LANL	6.0	7.26	0.48	0.20
32	Crater lake-O	01.04.2001	28	LANL	5.5	6.93	0.56	0.14
19	Crater Lake-SE	03.02.2001	29.0	LANL	5.5	6.28	0.78	0.093
16	Crater SE springs	03.02.2001	97.4	LANL	8.0	8.17	0.034	0.17
17	Crater SE springs	03.02.2001	98.2	LANL	7.5	8.23	0.062	0.19
18	Crater SE springs	03.02.2001	95.8	LANL	7.5	8.55	0.055	0.14
14	Crater SE fumarole	02.02.2001	97.4	LANL		4.99	0.006	0.005
15	Crater SE fumarole	03.02.2001	97.4	LANL	8.0	4.43	0.005	0.001
24	Crater cold spring	04.02.2001	18.5	LANL	6.0	7.22	0.014	0.005
33	Crater cold spring	22.12.2002	20.0	LANL	6.0	7.64	0.010	0.009
21	Lower Maraunot spring	03.02.2001	22.7	LANL	4.0	5.80	0.14	0.007
22	Lower Maraunot spring	03.02.2001	29.0	LANL	4.5	5.81	0.10	0.001
LM90	Lower Maraunot spring	03.04.1990	50	PNOC	n.r.	7.94	n.d.	n.d.
LM82	Lower Maraunot spring	12.10.1982	47	PNOC	n.r.	7.60	n.d.	n.d.
UM	Upper Maraunot spring	12.10.1982	76	PNOC	n.r.	7.75	n.d.	n.d.
UM	Upper Maraunot spring	21.10.1982	69	PNOC	n.r.	7.88	n.d.	n.d.
SP	Solfatara Pool	15.05.1983	58	PNOC	n.r.	1.01	n.d.	n.d.
D	O'Donnell Dangey spring	26.03.1990	39	PNOC	7.99	7.99	n.d.	n.d.
D	O'Donnell Dangey spring	14.05.1983	37	PNOC	7.94	7.94	n.d.	n.d.
27	O'Donnell AFT spring	04.02.2001	38.4	LANL	7.0	7.63	0.007	0.004
28	O'Donnell AFT spring	04.02.2001	66.2	LANL	6.5	7.25	0.005	0.008
29	O'Donnell stream	04.02.2001	24.2	LANL	5.5	7.82	0.010	0.004
13	O'Donnell stream	26.11.2000	23.5	LANL	5.5	6.82	0.024	0.013
26	O'Donnell stream	04.02.2001	21.0	LANL	5.5	7.48	0.009	0.008
D	Dangey spring	26.03.1990	39	PNOC	n.r.	7.99	n.d.	n.d.
D	Dangey spring	14.05.1983	37	PNOC	n.r.	7.94	n.d.	n.d.
M	Mamot spring	24.03.1990	43	PNOC	n.r.	7.99	n.d.	n.d.
M	Mamot spring	13.10.1982	48	PNOC	n.r.	7.77	n.d.	n.d.
PU	Pula spring	14.10.1982	22	PNOC	n.r.	7.18	n.d.	n.d.
PA	Pajo spring	28.10.1982	27	PNOC	n.r.	7.66	n.d.	n.d.
K	Kalawangan spring	23.03.1990	40	PNOC	n.r.	7.64	n.d.	n.d.
C	Cuyucut spring	29.03.1990	47	PNOC	n.r.	8.30	n.d.	n.d.
DS	Dagsa spring	27.03.1990	44	PNOC	n.r.	7.83	n.d.	n.d.
DS	Dagsa spring	14.03.1983	50	PNOC	n.r.	7.90	n.d.	n.d.
A	Asin spring	28.03.1990	54	PNOC	n.r.	8.03	n.d.	n.d.
A	Asin spring	13.05.1983	47	PNOC	n.r.	7.96	n.d.	n.d.
A	Asin spring	13.05.1983	45	PNOC	n.r.	8.21	n.d.	n.d.
N	Nacolcol spring	04.04.1990	49	PNOC	n.r.	7.20	n.d.	n.d.

[8] Stimac et al., 2004

2.3 Description of the Physical Environment

Lubao, Guagua and the adjoining municipalities where arsenic contamination was observed are all set on the distal sections of the Porac-Gumain River, and near the southern edge of the Pasig Potrero River. These municipalities form the south-eastern borders of the province where the land is at the boundary between the dry land represented by the alluvial fan and lahar-filled slopes of Pinatubo, and the wet land where fish ponds and marshlands are common.

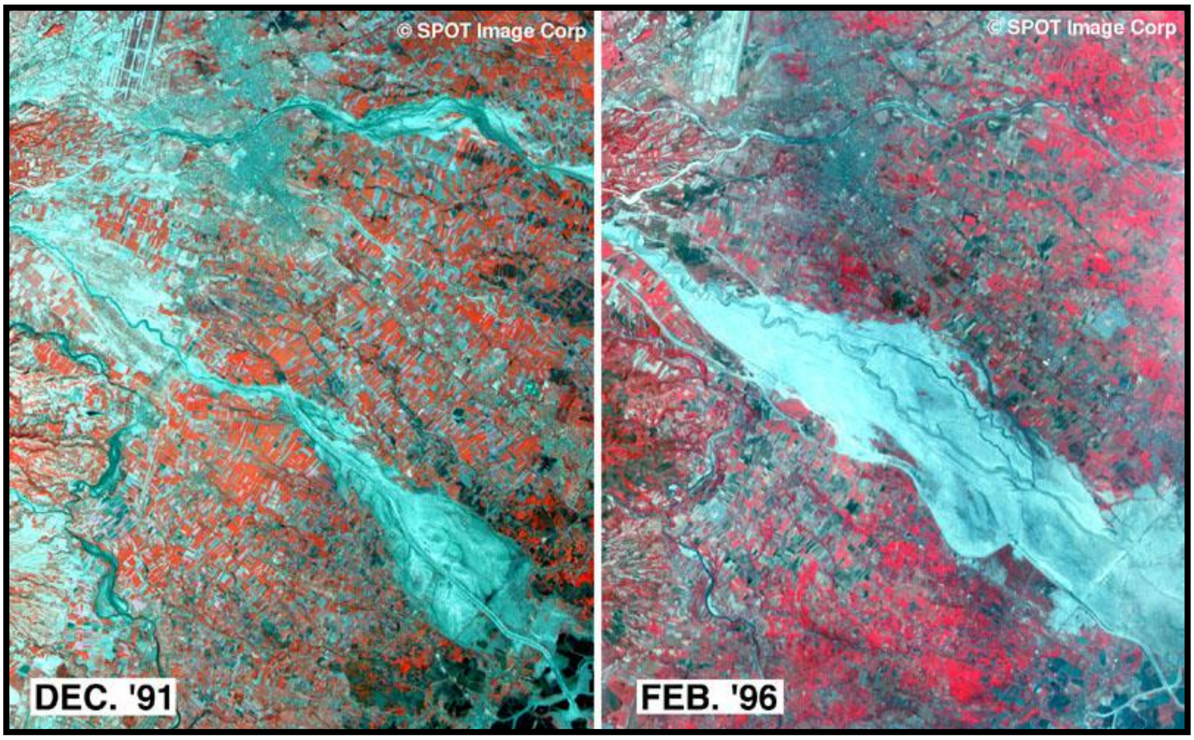

Figure 2.8: Two dates of SPOT satellite image ([9]) showing the growing devastation of the lahars in the Pasig Potrero River. The "megadike" is clearly seen to limit the flow of the lahar in the February 1996 image. Lubao is located on the central south edge of the image.

[9] eos.higp.hawaii.edu

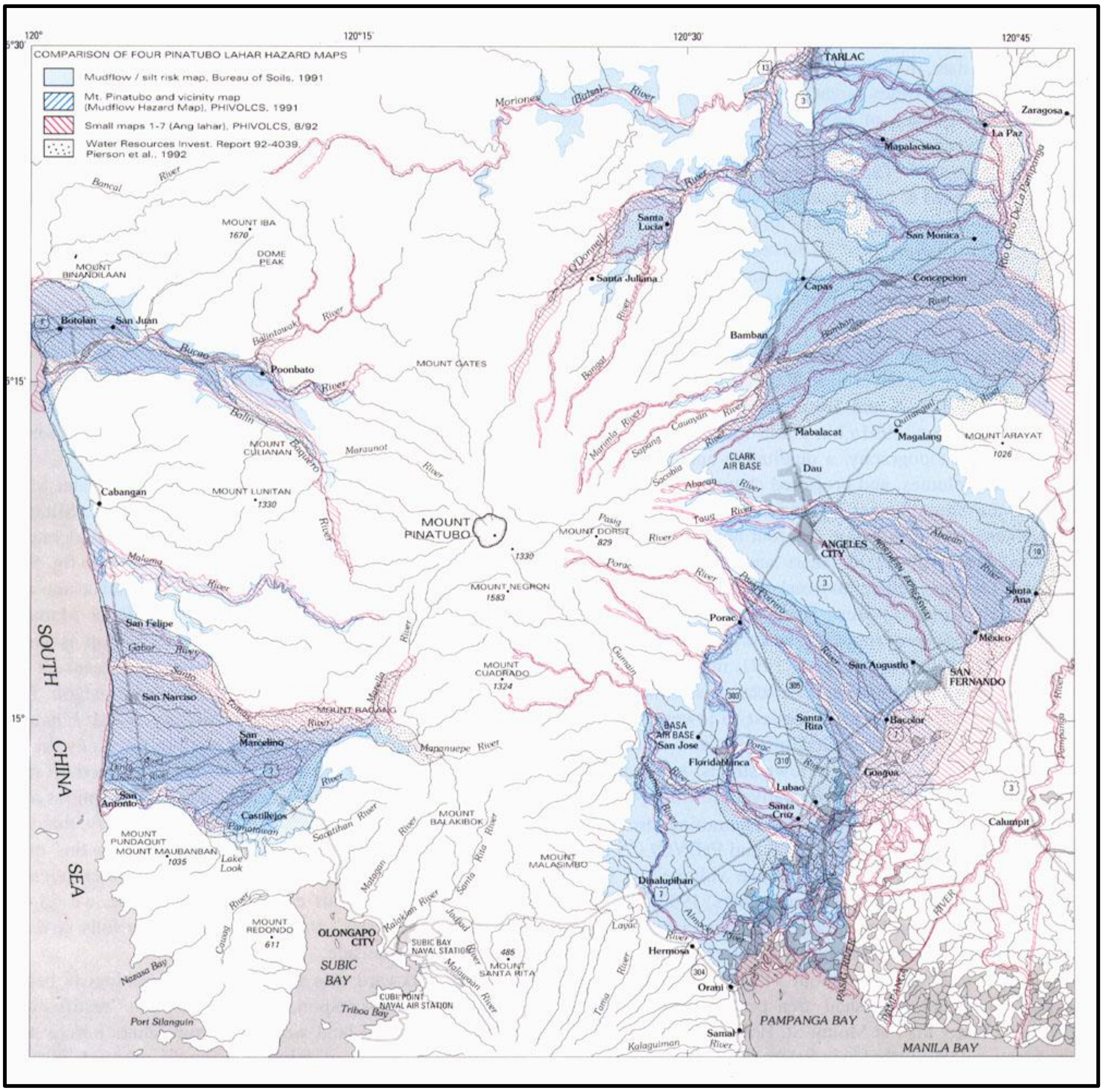

Figure 2.9: Composite lahar hazards map that combine the 1991 and 1992 threats from lahars in various sectors of the volcano ([10]). This map illustrates the resulting distribution of the lahars and remobilized volcanic ashfall deposits around Pinatubo Volcano.

2.4 Lubao Municipality

Lubao is one of twenty-two municipalities of Pampanga province, bound by Guagua on the north, Sexmoan (Sasmuan) on the east, Floridablanca on the west and by Pampanga Bay and Orani of Bataan province on the south. The terrain is generally flat, with elevation ranging from around 12 meters above sea level on the west, and almost at sea level for its southern and eastern portions. The municipality is traversed by two major

[10] Janda, et al., 1997

rivers: the Porac-Gumain and the Kaulaman Rivers. The southern and eastern portions of Lubao are occupied by fishponds and coastal marshlands, with three island barangays along the coast of Pampanga Bay. With an area of around 15,700 hectares, Lubao is composed of forty four barangays (villages), with the urbanized communities in the mid-eastern part which includes the government and commercial center. Around this urbanized core are barangays that had mixed land-use of agricultural, commercial, industrial and residential areas. On the eastern and southern portions of the municipality are the fishpond and fishing communities, while on the north and west, agriculture is the main land use.

The term Lubao alludes to a land of many rivers that served as main channels for commerce and migration. Historical accounts mention these rivers as routes for commercial, missionary and military activity. The vast flat land of Lubao is a major rice source for the country. Other crops such as mongo beans, peanuts, fruits and vegetables are also cultivated along with mango, citrus and ornamental flowers. Having large tracks of marshlands, Lubao is also known for its fishing industry, where brackish fishponds account for 76% of production and the rest for inland or freshwater fishery ([11]).

[11] source lubao.gov.ph

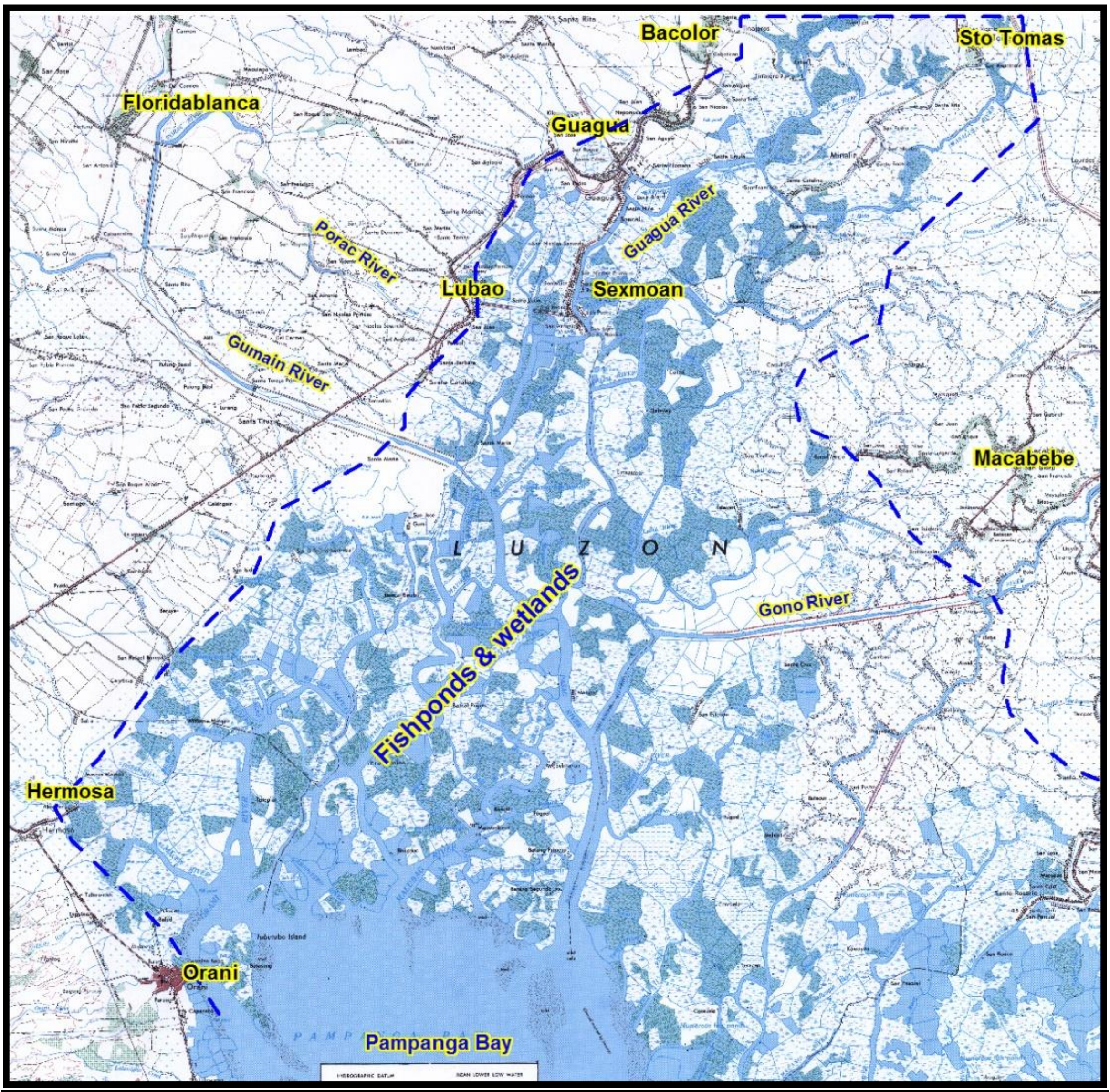

Figure 2.9: Terrain and features around Lubao and adjoining municipalities.
(Base map cropped from 1:50,000 topographic map of NAMRIA)

Most of the Lubao economy is from agriculture with only minor percentage devoted to industrial and commercial activity. The 2010 Census puts the population at around 150,000 people and the population growth as small, likely due to outward migration of its student and young professional population.

Climate in Lubao is Type "C" of Corona's classification, with distinct dry and wet seasons. The dry season occurs from May to October when rain is nil and the temperatures are from 29 to 34ºC, while the wet season peaks from July to September with an average monthly rainfall of 35.3 cm (figure 2.10).

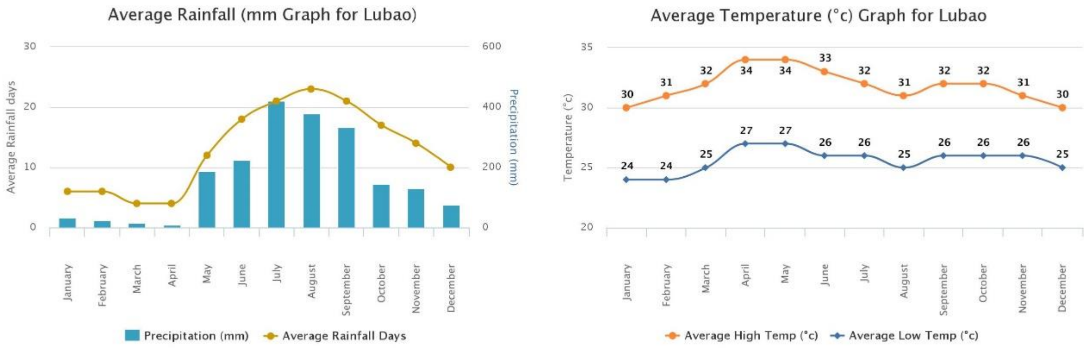

Figure 2.10: Rainfall and temperature in Lubao (PAGASA)

2.5 Volcanic ash and the river systems in Lubao and surroundings

Mount Pinatubo's ash is composed of dacite rocks in the form of mineral crystals, glass and rock fragments. As these materials are carried by river and lahar flows, these are mixed with other sediments and organic materials and deposited in the area of Lubao as distal river sediments and soil. The ash is composed of sand-sized particles of biotite-hornblende, quartz, plagioclase and fragments of pumice. Minor amounts of old volcanic rocks are observed as more mafic, being darker and richer in ferromagnesian and lithic fragments. Petrographic analysis showed plagioclase crystals (35%), quartz grains (25%) and fine-grained rock fragments (20%). Table 2.2 shows the typical chemical analysis of Pinatubo's ash ([12]).

Table 2.2: Rock Chemistry of the 1991 pyroclastic materials ([12]).

	June 12 tephra		**June 15 dacite (phenocryst rich)**		**June 15 dacite (phenocryst poor)**					
	7-1-91-1A scoria		**EW910615-1**		**PH 13d (near plagioclase)**		**PH 13d (near hornblende, cummingtonite, augite)**		**PH 13d (misc, matrix)**	
	Avg. SD (*n*=12)		Avg. SD (*n*=24)		Avg. SD (*n*=23)		Avg. SD (*n*=17)		Avg. SD (*n*=6)	
SO_2	70.39	1.18	76.73	0.76	69.37	1.92	75.38	1.50	72.65	1.37
Al_2O_2	14.96	.70	12.55	.23	14.87	1.21	12.68	.45	13.55	1.11
FeO	2.41	.14	.74	.04	2.56	.53	1.26	.43	1.67	.72
MgO	.72	.16	.10	.02	1.51	.81	.49	.37	.75	.53
CaO	2.57	.16	1.20	.04	3.60	.71	1.54	.45	2.35	.91
Na_2O	2.81	.56	3.66	.62	3.47	.75	3.97	.28	3.74	.75
K_2O	3.18	.17	3.07	.20	2.36	.27	3.01	.16	2.75	.23
TiO_2	.31	.05	.06	.03	.26	.06	.11	.08	.16	.10
Total	97.35	.97	98.11	1.03	98.00	1.32	98.44	1.08	97.62	2.07

[12] Pallister, et al., 1997

The soil in Lubao is reflective of both the volcanic and river sources of the materials. Soil classified as La Paz fine sand and the Angeles coarse sand are likely derived from the lahars and volcanic materials eroded from Pinatubo, while the La Paz silt and hydrosol reflects materials delivered by the rivers. The silt loam and fine sand are used for rice, sugarcane and vegetables, while the coarse sand is quarried. The hydrosol which mark the southern and eastern areas are covered by fishponds and the mangroves and nipa palm swamps.

Porac - Gumain River is one of the major drainages on the slope of Pinatubo Volcano. This river did not have major pyroclastic nor lahar deposits since its headwaters are protected from the crater by a ridge. Being detached from the main river channels that drain the volcano, Porac-Gumain River has the least volume of pyroclastic ash in its channels. However, the river's watershed received large amounts of airfall deposits as illustrated in Table 2.3.

Table 2.3: The ash deposits in the various rivers around Pinatubo (DPWH, 2000)

Drainage system	Drainage area (km^2)	Estimated volume of pyroclastic deposits (km^3)
O' Donnell	360	300-1,000
Sacobia-Bamban	230	600-900
Abacan	80	100-200
Pasig-Potrero	110	300-500
Porac Gumain	310	30-100
Santo Tomas	310	1,000-1,300
Bucao	660	2,500-3,100
Total	2,060	4,800-7,100

Although the Porac-Gumain River is detached from the large pyroclastic and lahar deposits, its share of volcanic materials is enhanced as Sacobia-Bamban and Pasig-Potrero Rivers join together with the Porac-Gumain River in the lower elevations.

The Porac-Gumain-Caulaman Rivers is characterized by a network of irrigation systems that serves the farms of Lubao and nearby municipalities. The river also drains Floridablanca and joins the drainages of Guagua River and the lower reaches of the Pasig-Potrero River.

Social Impact of Ash Deposits

About 30,000 people lived on the flanks of Pinatubo Volcano before the eruption, some gathered food and materials from the forests and while others cultivated the gentle and fertile volcanic landscape. Residents on the volcano's slopes include the Aetas—an indigenous group or people of shorter stock and darker skin. As aboriginal people living in the area for the past thousand years, they survive by hunting and gathering from the forests and brushlands, living in small isolated communities. Likewise, other settlers from the lowlands worked the slopes, growing grain and bananas, and raising farm animals on the fertile land.

About 847 people were killed by the 1991 eruption, many by roofs collapsing from the wet ash. Of these, about 200 Aetas and a few other local residents were trapped by pyroclastic flows on the middle slopes. The warnings and evacuation orders given days before the eruption saved tens of thousands of lives, and are acknowledged as a great success for volcanology and eruption prediction. The lahars that followed caused more casualties, and people living in evacuation and relocation sites were affected by damaged sanitation and healthcare facilities. About 2.1 million people were directly affected by the eruption with at least 8,000 houses completely destroyed, more than 73,000 houses damaged, along with damaged road and communication systems.
As the lahars abated and the renewed explosive eruption became unlikely, people started to reoccupy the slopes affected by the eruption. A few Aeta relocation sites have become large organized communities, and some families—both Aetas and lowlanders—have started to move again into the upper slopes. In 2010, an estimated 500,000 people live within 40 km of the mountain, while population centres such as Angeles City, Porac and the Clark Freeport Zone have regrown and regained their economic and social functions. Outside the dikes, communities have started to rebuild, while inside the dikes the sand is being quarried for aggregate materials and the land is slowly being cultivated for rice and crops. In the distant parts of the drainages, flooding and siltation still affect the edges where the river systems became shallow and clogged by sediments.

Figure 2.11: Lahar covering human settlements in 1991 is nowadays used as construction material

2.6 Pampanga Delta

The main river system in the project area is Pampanga River. With a catchment area of over 10,000 km^2, and a length of 260km this is the 3rd largest river of the Philippines. Its orginates in the Sierra Madre and runs a south and southwesterly course to Pampanga Delta, which is draining into Manila Bay. This area is submerged during the rainy season but is relatively dry during summer.

The Pampanga Delta is a swampy lowland with fish farms, rice fields and frequent flooding during typhoons. The delta is situated at 0-9m above sea level.

Lubao is positioned right at the banks of the wetlands, and a part of the city is actually inside the wetlands. A lot of runoff water from Pinatubo ends up near Lubao, either through groundwater or as river run-off.

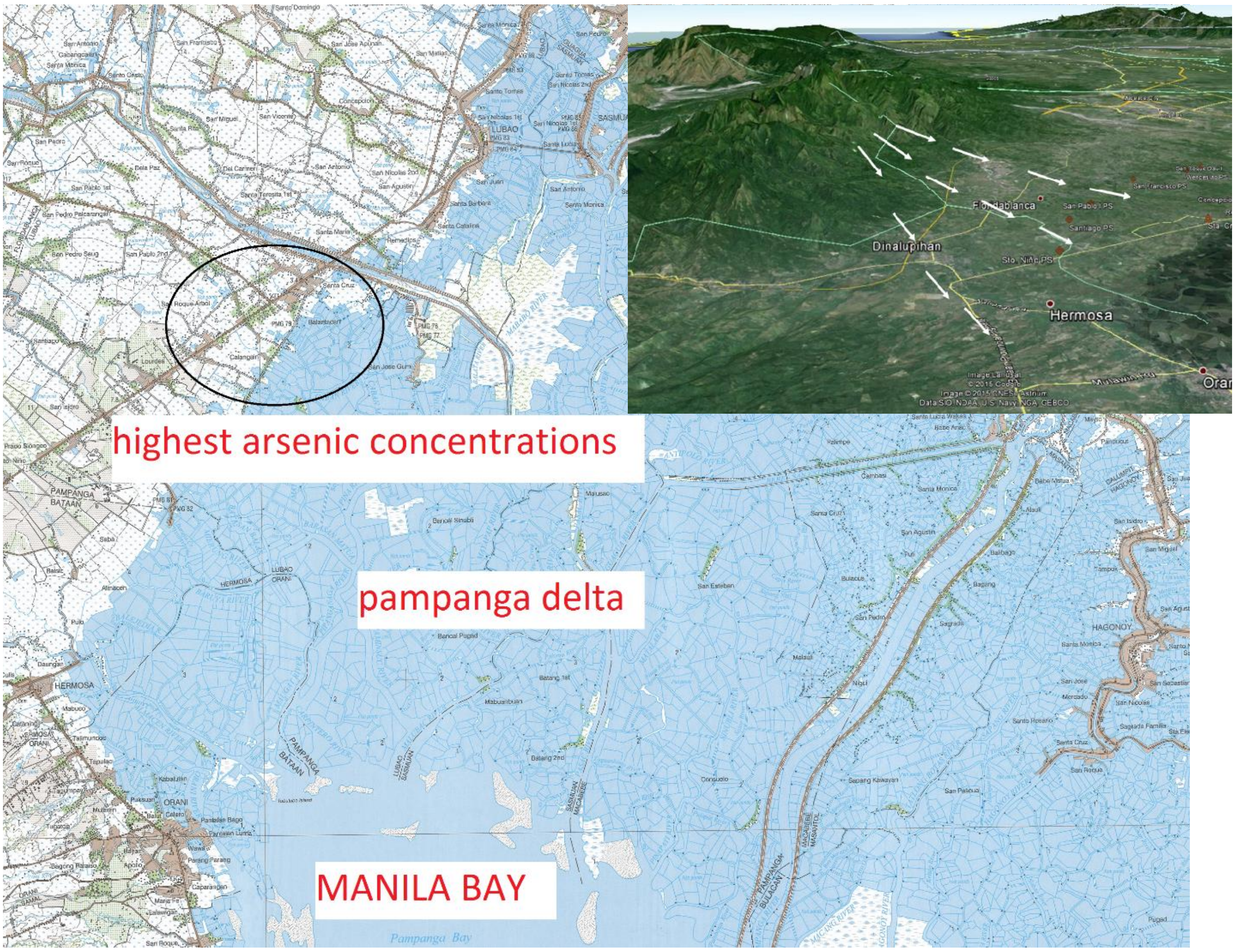

Figure 2.12: Pampanga Delta, with Lubao and the contaminated area encircled

3 DATA ANALYSIS

3.1 Water Sampling Efforts in 2014-2015

Arsenic concentration in drinking water in the study area was not routinely measured before 2014 when the Arsenicosis cases were detected. Several drinking water monitoring campaigns were conducted since then (December 2014, March, April, May, June, July 2015) with focus on arsenic concentration in different drinking water sources used in the Lubao municipality. Samples were analysed by a number of certified laboratories in the Philippines.

In October 2014 the water from the tap in the house of the index case was sampled by DOH and it was found to have elevated As concentrations. In December 2014 seven out of eight samples taken by DOH from hand pumps and taps from Lubao showed concentrations exceeding the Philippine National Standard for Drinking Water (PNSDW) of 10 µg/l. On December 29, 2014 LWUA resampled all pumping stations in Lubao Water District.

Table 3.1: Summary of arsenic concentrations (ug/L or ppb) found in samples taken at pumping stations in Lubao in 2014 and 2015

	As (ppb)							
	CRL	CRL	NRL	ITDI	CRL		CRL	
Pumping Station	29-12-14	10-02-15	Split Sampling Conducted on March 2015			08-04-15	10-04-15	
PS 1 - San Nicolas I	3	1	6	4	3	2	4	
PS 2 - Sta. Cruz	6	4	10	9	6	5	6	
PS 3 - Sto. Tomas	7	3	10	5	7	6	5	
PS 4 - Sto. Niño	2	1	9	3	2	3	2	
PS 5 - Remedios	7	6	9	6	4	6	6	
PS 6 - San Roque Dau I	4	3	5	2	4	4	3	
PS 7 - Concepcion	5	2	5	8	4	4		
PS 8 - San Pablo I	7	4	9	8	4	4	5	
PS 9 - Wenceslao	4	3	5	4	3	4	2	
PS10 - San Jose Gumi	10	9	17	17	10	10		RO p
Santiago	300							Deco
San Francisco	6	5	10	4	5	4	4	
Sta. Cruz Bypass								
Sta. Rita								

*ITDI – commissioned a DOST accredited laboratory

On 17 March 2015 LWUA reiterated in a Memorandum Circular that all water districts are required to submit monthly reports on physical and chemical water quality analysis, including arsenic. We analysed available reports from 290 pumping stations in Central

Luzon in October 2015. Table 3.1 shows arsenic concentration in samples taken in December 2014, and February, March and April 2015. Water samples were taken from different pumping stations of the Lubao water supply system. Results obtained show extremely high arsenic concentration in the sample taken at the pumping station Santiago. In addition, most of samples taken from the pumping station San Jose Gumi were found to have arsenic levels equal or higher than the maximal acceptable concentration 10 ppb. Samples taken from other pumping stations in the Lubao water supply system did not exceed the maximal acceptable arsenic concentration of 10 ppb; however, several samples taken from a number of pumping stations were either very close or even equal to the maximal acceptable arsenic concentration.

The pumping station with the highest arsenic concentration, namely PS Santiago, was decommissioned. Additional 110 samples were taken from hand pumps and taps in Lubao, and were analysed for arsenic presence. 15 samples (14 %) showed elevated arsenic concentrations (up to 300 µg/l). At the same time DOST reanalysed water from the 11 operational pumping stations in Lubao and found only 4 pumping stations complying with the PNSDW. **Error! Reference source not found.**3.1 shows the results from arsenic concentrations found in samples taken from both hand pumps and pumping stations. The arsenic content in the water from the public water supply wells from LWUA, shown on Figure 3.1 with small dots, is currently unknown.

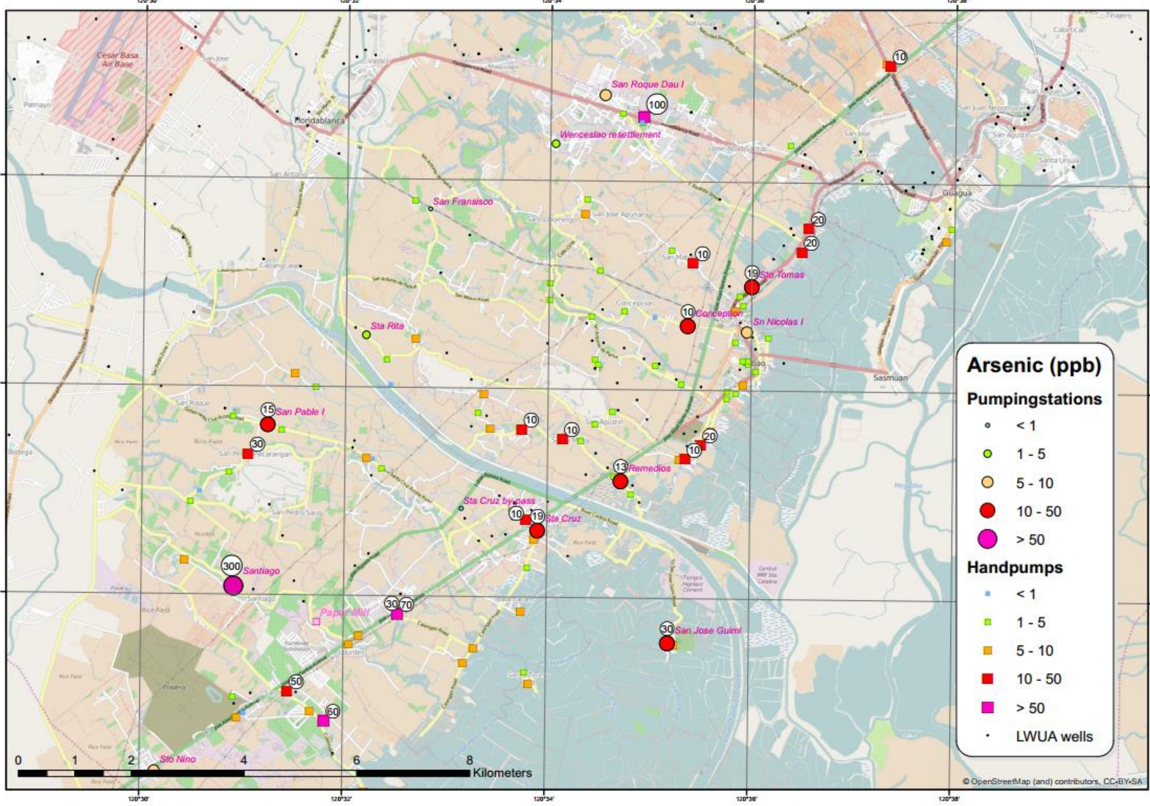

Figure 3.1: Arsenic concentration at some locations in Lubao

The arsenic concentration at the San Jose Gumi pumping station was found to be as high as 30 µg/l and LWD installed a portable RO plant at the pumping station in June 2015.

In June 2015 the Lubao Water District (LWD) took 14 samples from pumping stations and 29 from hand pumps. Five hand pumps (17%) showed elevated arsenic concentrations (up to 70 µg/l). The arsenic concentration in all pumping stations was below the PNSDW concentration.

Arsenic was detectable in all samples taken from the public water supply system.

Extremely high arsenic concentrations (≥300 µg/l) were found in samples from the pumping station in Santiago. Water samples taken from the public water supply in the area served by PS Santiago as expected have shown extremely high arsenic concentrations Authorities made good decision to immediately decommission this source of drinking water production.

Arsenic concentrations in a same deep well were also found to fluctuate significantly in time and as a function of pumping capacity.

Drinking water quality in other municipalities in Pampanga and other provinces

During the DDR team field visit in addition to the Lubao municipality, short visits were made to the Mabalacat Water District (MWD), the Porac municipality (that takes care about water supply) and Clark Development Corporation. During the visit a few groundwater quality analyses were made available to the DDR team.

__Water Quality in Porac Municipality__

Three types of water are at present used for drinking water supply in the Porac municipality: District water (public water supply system), Individual or communal shallow wells with hand pumps, and springs. According to information provided by the Porac municipality arsenic presence is not an issue of concern. During the short visit to the municipality two water quality analyses were made available for the DDR team. The analyses of district water have shown arsenic concentration of 9 µg/l. Similarly arsenic concentration of the refilling station was found to be 9.2 µg/l. Iron and manganese concentrations were low in both samples. Regular monitoring of the arsenic concentration in district water is highly recommended given the fact that the arsenic concentrations reported were just below the maximal acceptable concentration.
Three samples taken by the DDR team from district water, community well and the spring in the Caminas village have shown low arsenic concentrations (≤ 3 µg/l).

Figure 3.2: The team near Porac, with Pinatubo crater in the background

__Water Quality in Mabalacat municipalities__

MWD provides drinking water to 37.400 house connections in the Mabalacat municipalities, with in total approximately 230.000 inhabitants. The total number of household in the municipality is approximately 42.396. Capacity of the water supply system is 30.000 m3/day, and approximately 95% of people are connected to water supply system. According to information provided by MWD non-revenue water is 10-15%.

Groundwater from 34 deep wells (200-300 m) is used as the only source for drinking water production of the public water supply system. Shallow groundwater (individual wells with hand pumps) is used for drinking purposes by 20-30% of the population in the municipality. Five out of 34 production wells have treatment: one consisting of pre-chlorination and rapid sand filtration, and 4 comprising pre-chlorination followed by ultra-filtration.

Analyses of drinking water quality of the district water is made by certified commercial laboratories. Quick screen of the water quality analyses of district water, that were made available during the visit, have shown that arsenic concentrations are below the standard. Several samples have shown strongly elevated manganese (≤0.67 mg/l) and iron (≤3.7 mg/l). Results from 27 water samples from the Mabalacat District Water Supply System (Pampanga) that were made available to DDR team, show arsenic concentration below 10 µg/l, with 5 wells that, however, have arsenic concentrations between 5 and 9 µg/l.

Local industry (the paper mill factory) has 8 own wells. Farmers also make very intensive use groundwater from (deep) wells (≤100m), and possibly less deep wells).

Based on the water quality data provided by MWD it seems that arsenic presence is not of direct concern for district (public supply) water quality of the Mabalacat municipality. At the same time strongly elevated iron and manganese concentrations are likely responsible for aesthetic and operational problems. Further on very high manganese concentrations (> 0.4 mg/l) that are found in a number of samples are of direct health concern. It is consequently strongly recommended to provide treatment facilities for wells of the district water supply system characterised by elevated iron and/or manganese concentrations.

Water Quality in Clark Development Corporation

Drinking water supply in the Clark Development Corporation is based on 28 wells (100 to 450 ft deep). In addition 7 new wells are at present under development. Result from the Water Baseline Study (1997) show that approximately 10 wells had (slightly) elevated arsenic concentration (≤19 µg/l). In addition, detectable levels of pesticides are found in

some wells. Groundwater treatment based on GAC filtration is provided for selected wells. No recent water quality data were available for the DDR team.
Data available show that possible arsenic presence in groundwater used for drinking water production for the area of the Clark Development Corporation should be of concern given the observed elevated concentrations in some wells and high ambitions for further development of the area.

Drinking water quality in other public water supply systems
Several water quality data sets for other public water supply systems in Pampanga and other provinces were also made available to the DDR team. Results available show that arsenic concentration in none of the large number of samples analysed exceeded the maximal acceptable arsenic standard.

In Angeles City, Masantol, and Sta. Rita (all Pampanga), Norzagaray (Bulacan) and Talugtug (Nueva Ecija) arsenic concentration in large number of samples taken from different pumping stations showed identical arsenic concentration of 9 μg/l, just below the maximal acceptable concentration. Such uniform arsenic concentration, specifically for different wells in the same water supply system is rather uncommon. In addition it is known that arsenic concentration in a well can fluctuate in time. Consequently, additional careful monitoring of water quality from wells with arsenic concentration close to the maximal acceptable arsenic concentration is strongly recommended.
Arsenic concentration in samples taken in several municipalities including Bacolor, Florida blanca, Macabebe, and Candaba (all Pampanga), St Maria (Bulacan), Hermosa and Orion (both in Bataan), San Marcelino and Subic (both Zambales), Guimba, Licab, Munoz, San Jose City, Santa Rosa and Palayan City (all Nueva Ecija) were found to be very low (≤2 μg/l). Arsenic concentrations in samples taken in the General Tinio water supply system (Nueva Ecija) were also found to be relatively low (≤5 μg/l).
Results of arsenic analyses of water samples taken in water supply systems Camiling (Tarlac), Cabiao, Gapan, Gen. Mamerto Trinidad, Peñaranda, and San Antonio (all Nueva Ecija) show identical arsenic concentration of 5 μg/l, that likely represent the detection limit of the analytical method applied.
Water sample taken at different pumping stations in Guagua (Pampanga) had variable arsenic concentrations, with 5 out of 11 samples show arsenic level equal to, of just below the maximal acceptable concentration. Similarly 15 samples taken in St Fernando (Pampanga) and Dinalupihan (Bataan) had arsenic concentration ≤8 μg/l.
Available results for arsenic presence in public water supply systems in different municipalities and provinces strongly suggest that arsenic presence in groundwater used

for drinking water supply is a serious issue for several municipalities. In addition to routine water quality monitoring, based on legal requirements, well organized and intensive water quality monitoring campaigns are essential in public water supply systems where arsenic concentrations close to or equal to the maximal acceptable concentrations were detected. Arsenic analyses should be done by laboratories with extensive experience in metal (arsenic) analyses and that apply analytical techniques suitable for low concentration range.

In addition to arsenic high to very high manganese concentration were identified in large number of samples originating from different public water supply companies in several provinces. It should be mentioned that he maximal acceptable manganese concentration of 0.4 mg/l established in the national drinking water regulations should be re-considered and likely strongly reduced having in mind operational and aesthetic problems associated with presence of arsenic in public water supply systems.

3.2 Additional soil and water quality tests during the DRR mission

3.2.1 Additional Soil Samples taken by the DRR team

In order to determine the scope of Arsenic contamination, a few soil and other solid samples were gathered during the mission. The intention during this sampling was to define if there are any detectable levels of contamination in the soil and if these can be related to any of the observations in water contamination or medical cases earlier documented. It should be noted that the sampling activity is neither structured nor exhaustive, since the areas visited are few, and the time involved for sampling is short.

Testing of the soil samples

The soil samples have been tested using a desk-mounted Niton XL3t. The instrument uses a high-performance thermoelectrically cooled detector (XRF analyser. During the tests for the soil samples from Pampanga, the materials were taken to the laboratory in Metro Manila and tested on a bench-mounted instrument.

The detection limit for the Arsenic tests of soil samples is around 4.5 ppm (depending on the bulk overall composition of the sample being tested) while the RMS error for the tests varied from 2 to 3.5 ppm (depending on the value of the results).

Some of the samples collected are from the lahars deposited after the Pinatubo eruption. The lahar deposit near Porac River was selected, since this site provided a view and accessible reach to the top, middle and bottom layers of the lahar deposit.
Likewise, some samples of soil were taken from various locations where medical cases of Arsenic poisoning was documented. The soils samples collected in these sites were either on the soil where the local water hand pump are located, since these pumps served as the primary source of drinking water of the residents until they were instructed to source safe water from the community water system or from bottled purified water.
Soil samples were also collected in two water pump stations, one of which is the Santiago water pump station of the Lubao Water District. The operation of this pump station was quickly discontinued after the water from its system was determined to have high Arsenic levels. Soil samples were gathered from inside the decommissioned station, and also from the rice farm outside the fence of the station. A few stalks of mature rice grains were also collected from this site for chemical analysis.
Samples were also taken from the Gumi Pumping Station where a reverse osmosis water treatment facility is in operation. At this site, four samples were gathered, two soil samples from the pump house grounds, one from the domestic sludge flowing near the pumps, and the fourth sample is the soil from the RO hose which returns the discharge water into the ground.
A sediment sample was also from the banks of the Porac-Gumain River. This sample represents the recent silt deposit located just above the water line and thus represents the most recent sediment deposition by the river.
The last set of sediments are from the paper mill which is the only operating industrial facility in the area close (1.5km) to the decommissioned Santiago pumping station. This paper mill uses scrap paper collected from various sources including Manila and imported scrap paper, recycles the materials and produces rolled brown paper. The paper mill uses coal to fire its boilers, and recycles its process water with replenishment coming from a groundwater well. Water was sampled from its groundwater pump, and solid samples were taken from the coal ash pile. A sample was also taken from the sludge that forms as the wastewater is left to settle in a canal within the compound.

Figure 3.2: Paper Mill Lubao (wastewater canal and uncontrolled waste dump both contain arsenic) at 1.5km from the closed Santiago PS

The results of the chemical analysis for the solid materials collected during the mission are shown in Table 3.2 and plotted as map in Figure 3.3. It is notable that soil samples that have significant levels of Arsenic were taken from inside the Santiago yard where the decommissioned pump is located, the samples from the Gumi pump where the reverse osmosis water treatment is done, and the soils sample at San Roque Arbol where some of the medical cases are reported. Interestingly, the sediment sample from Porac-Gumain River also showed some elevated concentrations of Arsenic, while the sludge in the paper mill showed insignificant arsenic levels. Ash from burned coal at the paper mill showed elevated Arsenic, which is expected from such materials.

Somewhat relieving is the result that the rice sample showed negative results for Arsenic, despite the three readings were done for three separate specimen of the rice grains. This suggests that the Arsenic concentration in rice grown near the decommissioned Santiago pumping station is below the detection level of the instrument which is 4.5ppm.

Table 3.2: Result of soil, sludge and rice grain samples that were collected from various sites in the Lubao and adjoining areas by the DRR team

Latitude	Longitude	GPS Way-point	Description	Arsenic level (ppm)
15.104427	120.549108	516	Lahar Top	<LOD
15.104428	120.549108	516	Lahar Middle	<LOD
15.104426	120.549108	516	Lahar Bottom	<LOD
14.901493	120.515075	520	Santiago rice	<LOD
14.901494	120.515075	520	Soil inside pumpyard	11
14.901492	120.515075	520	Soil riceland	<LOD
14.886081	120.522769	525	Soil Handpump	<LOD
14.898912	120.543328	526	Soil Med Index	<LOD
14.899654	120.545261	527	Soil MedCase	<LOD
14.899892	120.544971	528	Soil MedCase	<LOD
14.893002	120.586923	529	Gumi soil	<LOD
14.893001	120.586923	529	Gumi sludge	6
14.893003	120.586923	529	Gumi hose	4.3
14.893004	120.586923	530	Gumi soil	<LOD
14.915333	120.569883	531	Sediment Porac-Gumain River	6
14.898513	120.544083	532	Soil San Roque Arbol	12
14.897538	120.531690	534	Paper Mill ash	5.3
14.896469	120.530615	535	Paper Mill sludge	<LOD

<LOD =below instrument's detection level of 4.5 ppm

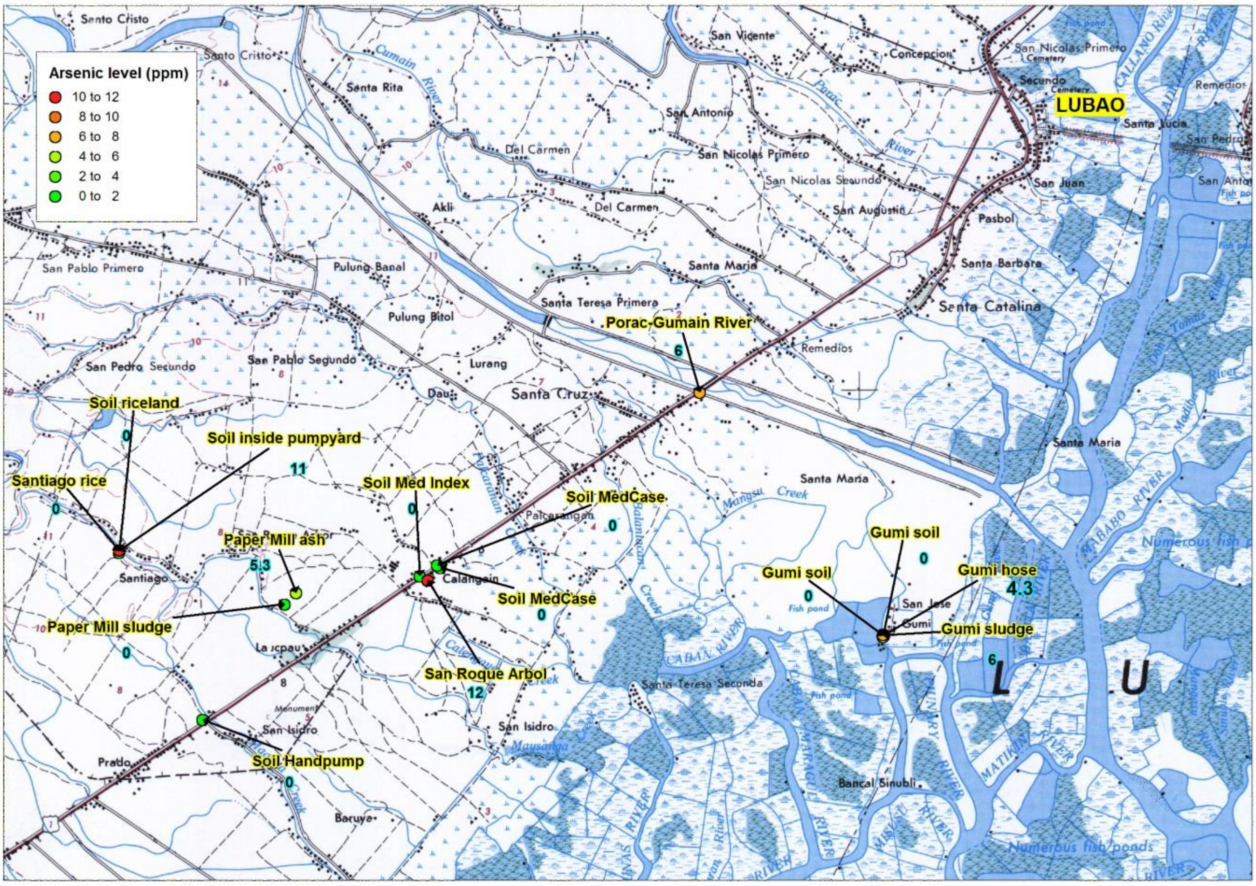

Figure 3.3: Result of Arsenic analysis for soil, sludge and rice grains gathered during the mission. Description of samples highlighted in yellow, while arsenic values are highlighted in blue.

Conclusion of soil sampling

The results of the preliminary soil sampling done during the mission suggest that Arsenic contamination in the soil is not uniform and is likely low in the natural conditions of the ground. Of the 14 soil samples collected, 10 of the samples had insignificant Arsenic levels. The four soil samples that showed elevated Arsenic values were those collected inside the Santiago pump yard, the soil under the Gumi RO hose and the sediment from the Porac-Gumain River. Somehow, human activity (e.g., RO water treatment, pumping of As-contaminated groundwater) may have resulted elevated concentration of Arsenic in soil. For the Porac-Gumain River sample, it is possible that the river's siltation in the distal part may lead the river to concentrate Arsenic coming from both natural and artificial sources by silt accumulation.

In most of the soil samples gathered from residential areas, the Arsenic concentration is low. The only soil sample that shows elevated Arsenic concentration was taken from San Roque Arbol.

3.2.2 Additional water samples taken by the DRR team

A field visit covered a number of municipalities including Mabalacat, Porac and Lubao, with focus on the area affected by arsenic presence was made October 11 to 13, 2015. In addition to public water supply companies, a number of families were visited that make use of individual (shallow) wells. In a number of household visited, clear symptoms of arsenicosis (keratosis and/or change of skin pigmentation could be observed). Though it was not a part of the official scope of the assignment, in total 18 water samples of water from individual (figure 3.4) and community wells (figure 3.5), public water supply system that makes use of deep groundwater (figure 3.6), surface (river) water (figure 3.7) and waste water from the paper mill factory were collected and analysed for presence of arsenic, iron and manganese. The purpose of the sampling campaign was to screen arsenic, iron and manganese concentration in different type water sources in the affected area. In a parallel a number of some of samples taken were brought for analyses to local laboratories, to allow comparison of specifically arsenic concentrations determined by different laboratories using different analytical techniques.

Figure 3.4: Individual wells included in the survey

Figure 3.5: Community wells in Porac and Gumi included in the study

Figure 3.6: Drinking water from public water supply system included in the survey

Figure 3.7: Location at which river water samples were taken

An overview of sampling points and arsenic, iron and manganese concentrations found is given in table 3.3. Water quality analyses were conducted at the UNESCO-IHE laboratory. Arsenic was determined with AAS-GF, while iron and manganese were determined with AAS.

Table 3.3: Arsenic, iron and manganese concentration found in samples taken during field visit October 11-13, 2015.

			WQ paramer			
Sample No.	Sampling date	Sample description	As (µg/l)	Fe (mg/l)	Mn (mg/l)	Notes
0	October 12, 2015	the river Pasig-Potrero	6	<0.05	<0.02	sample taken in 500ml water bottle containeda a lot of solid matter; dissolved compounds
0A	October 12, 2015	the river Pasig-Potrero	6	2.11	0.26	Total
1	October 12, 2015	Porac: tap public water supply	2	0.17	<0.02	chlorine smel
2	October 12, 2015	Porac: a comunity well with a hand pump in the vicinity of municipality not used for drinking	3	0.08	0.82	
3	October 12, 2015	Porac: Spring in Caminas	<2	<0.05	<0.02	
4	October 13, 2015	Lubao: PS St Cruz, raw groundwater	16	<0.05	0.19	
5	October 14, 2015	Lubao: St Isidro, public water supply system, tap in a household	11	<0.05	<0.02	
6	October 14, 2015	Lubao: St Isidro, old indivudual well with a hand pump	4	<0.05	0.16	
7	October 14, 2015	Lubao: St Isidro, 5th family visite, a deep well with	4	0.82	0.88	well depth 140 Ft
8	October 13, 2015	Lubao: family in Santiago, an individual well with HP, 125 ft deep	200	0.17	0.13	two patiens with arsenicosis
10	October 14, 2015	Lubao: Monguinto family, St Roque, individual well with hand pump	58	0.12	1.27	
11	October 14, 2015	Lubao: sample taken at the tap of Water Supply company of Lubao (origin: PS St Nikolas)	8	<0.05	0.37	
12	October 14, 2015	Gumi- Comunal well with HP, 54 m deep	16	<0.05	0.11	
13	October 14, 2015	Gumi PS: raw groundwater at PS gumi (RO unit out of operation)	27	0.15	0.66	
14	October 14, 2015	Lubao: the river Porac Cumain, below the bridge	5	0.45	0.09	
15	October 14, 2015	Lubao: Gregorio Emanuel household (visited after the sampling of the river water); sample from the individual well with a hand pump	<2	<0.05	0.11	
16	October 14, 2015	Lubao: Gregorio Emanuel household visited after the sampling of the river water; sample taken from the tap water (locally also called district water).	33	0.05	0.81	
17	October 14, 2015	Well with a hand pump on the outer fence (on the main road) of the paper mill factory.	115	<0.05	0.42	
18	October 14, 2015	Waste water paper mill factory in Lubao	31	0.67	0.30	Dissolved fraction only
18A	October 14, 2015	Waste water paper mill factory in Lubao	29	3.21	1.30	Total

Arsenic was found in all samples taken during the visit including (a) shallow individual wells; (b) community wells; (c) deep wells of the district water supply system; (d) surface (river) water and (e) waste water from the paper mill factory. Concentrations above the maximal acceptable level for drinking water were found in approximately a half of the samples taken.

High to extremely high arsenic concentrations (58 µg/l, 115 µg/l and 200 µg/l) were found in only 3 samples, 2 taken from individual shallow wells and 1 taken from the community (public) well with hand pump located close to the paper mill factory (depth of the well unknown).

In general arsenic concentrations in private (shallow) wells and community (public) wells (of unknown depth) were found to vary in very wide range (from <2 µg/l - 200 µg/l).

Four out of 5 drinking water samples taken from the public water supply system in the Lubao municipality have shown arsenic concentrations above the maximal acceptable

concentration, with measured concentration range 11-33 µg/l. The fifth sample has shown arsenic concentration of 8 µg/l, just below the maximal acceptable concentration.
Arsenic concentrations in surface (river) water samples were found to be slightly elevated (5-6 µg/l), however, still under the maximal acceptable concentration.
Arsenic concentration in the waste water sample taken at the paper mill factory was approximately 30 µg/l, with arsenic present mainly in dissolved form.
All 3 samples taken in the Porac municipality (public water supply system, public hand pump and the spring) show rather low arsenic concentration (≤3 µg/l).
Iron concentrations in most of drinking water samples were found to be relatively low (from <0.05 mg/l to 0.17 mg/L), with an exception of a sample from an individual well in San Isidro that showed iron concentration of 0.82 mg/l. Somewhat elevated iron concentrations were found in the river water samples (2.1 mg/l and 0.45 mg/l), and waste water from the paper mill factory (3.2 mg/l). Elevated iron concentration are of no direct health concern, however, presence of iron in drinking water will cause aesthetic problems (colouring of laundry and sanitary ware) and could also interfere with acceptability of such drinking water.
High to very high manganese concentrations (≤1.3 mg/l) were found in more than the half of the samples taken. Elevated concentrations were found in all types of water samples. Presence of elevated manganese concentrations in drinking water, specifically at higher concentrations (≥0.4 mg/l), is of direct health concern. Manganese present in drinking water even at low concentrations will cause aesthetic problems for consumers, and introduce problems in the water distribution system (black water incidents, need for frequent flushing of distribution system).

Figure 3.8: DRR team taking a soil sample from the 7m thick ash and lahar deposits near Porac-Gumain River

3.3 Comparison of the Measured Results from Different Laboratories

3.3.1 Inter lab test

To ensure the comparability of the lab results, especially for arsenic analysis, from the three regional laboratories (EAMC-NRL, CRL, MACH Union) TWG initiated an inter-laboratory comparison test. All these labs have national quality certificates. It is consequently a logical assumption that values of arsenic measured and reported are reliable. Split samples were taken in May 2015 by DOH, LWUA and DOST from 11 pumping stations and 13 hand pumps and sent to the three labs. Results of analyses of these samples from the 3 different labs show however a significant difference of arsenic concentrations for identical samples.

Two of the labs are using graphite furnace atomic absorption spectrophotometry (GFAAS) supervised by the National Reference Laboratory and APHA standards, the third lab is using AAS with USEPA standards. NRL and CRL have different detection limits, 0.002 mg/L and 0.001 mg/L respectively (table 3.4).

Table 3.4: Inter laboratory comparison results

Location	Year Operated	May, 2015 Inter-Laboratory Comparison Result (mg/L)		
		DOH	LWUA	DOST
		EAMC-NRL	CRL	MACH ONE
WATER DISTRICT-PUMPING STATION				
Sn Jose Gumi	2011 (154m)	**0.017**	0.010	0.010
Sta. Cruz	1993 (183m)	**0.011**	0.006	0.006
Sto. Tomas	2001 (180m)	0.010	0.006	0.008
Sn Francisco	2012 (150 m)	0.010	0.005	0.007
Remedios	2006 (176)	0.009	0.004	0.006
Sn Pablo	2009 (131)	0.009	0.004	0.006
Sn Nicolas	1963 (160)	0.006	0.003	0.004
Concepcion	2009 (149)	0.005	0.004	0.005
Wenceslao, Phase I	2010 (120 m)	0.005	0.003	0.003
San Roque, Dau I	2007 (184 m)	0.005	0.004	0.002
Sto. Nino	2004 (179)	0.003	0.002	0.003
Santiago	2011 (125)			

The observed difference could be attributed to:

(a) different analytical methods used for arsenic analyses by different laboratories. (b) very low arsenic concentration range in all samples included in the study that is per definition difficult to measure accurately, and,

(c) precision of analytical methods applied; e.g. the analytical method applied by one of laboratories visited during the short mission (3500-As, APHA/AWWA/ WEF Standard methods 2012), has relative standard deviation of results of 10%.

3.3.2 Comparison UNESCO-IHE and local labs

The first screening of the results of arsenic concentration in samples taken during the DDR team field visit analysed by the Unesco-IHE laboratory and a local laboratory seems to show a significant difference. Differences between results of the Unesco-IHE laboratory and CRL are more pronounced. Arsenic concentrations determined by the Unesco-IHE laboratory are considerably higher. Table 3.5 shows the comparison.

It is consequently strongly recommended to properly compare arsenic analyses conducted by local laboratory with a selected well establish laboratory with an extensive experience in arsenic analyses.

Further on, use of proper test kit for arsenic analyses is recommended for wider screening arsenic of arsenic concentration. Use of an appropriate test kit can be strongly increase number of samples that can be analysed while keeping the costs relatively low. Unesco-IHE has very good experience with the Arsenator test kit that is relatively cheap and simple to use.

Table 3.5: Comparison of water tests between UNESCO-IHE and local labs showing large differences

			WQ paramer			NRL			CRL	Chempro	
Sample No.	Sampling date	Sample description	As (µg/l)	Fe (mg/l)	Mn (mg/l)	As (µg/l)	Fe (mg/l)	Mn (mg/l)	As (µg/l)	As (µg/l)	Mn (mg/l)
0	October 12, 2015	the river Pasig-Potrero	6	<0.05	<0.02					<50	0.84
0A	October 12, 2015	the river Pasig-Potrero	6	2.11	0.26					<50	<0.002
1	October 12, 2015	Porac: tap public water supply	2	0.17	<0.02	<10	0.15	0.79			
2	October 12, 2015	Porac: a comunity well with a hand pump in the vicinity of municipality not used for drinking	3	0.08	0.82						
3	October 12, 2015	Porac: Spring in Caminas	<2	<0.05	<0.02	<10	0.07	<0.4			
4	October 13, 2015	Lubao: PS St Cruz, raw groundwater	16	<0.05	0.19	10	<1.0	0.23			
		Handpump: Santiago				160	0.2	0.18	50		
		New pump near house				<10	0.27	0.21	<1		
		Medical cases				5.1	0.1	<0.4	<1		
5	October 14, 2015	Lubao: St Isidro, public water supply system, tap in a household	11	<0.05	<0.02						
6	October 14, 2015	Lubao: St Isidro, old indivudual well with a hand pump	4	<0.05	0.16						
7	October 14, 2015	Lubao: St Isidro, 5th family visite, a deep well with	4	0.82	0.88						
8	October 13, 2015	Lubao: family in Santiago, an individual well with HP, 125 ft deep	200	0.17	0.13						
10	October 14, 2015	Lubao: Monguinto family, St Roque, individual well with hand pump	58	0.12	1.27				<1		
11	October 14, 2015	Lubao: sample taken at the tap of Water Supply company of Lubao (origin: PS St Nikolas)	8	<0.05	0.37	3.8	0.59	1.4			
		Gumi PS and RO				18	0.13	0.08	3		
12	October 14, 2015	Gumi- Comunal well with HP, 54 m deep	16	<0.05	0.11						
13	October 14, 2015	Gumi PS: raw groundwater at PS gumi (RO unit out of operation)	27	0.15	0.66						
14	October 14, 2015	Lubao: the river Porac Cumain, below the bridge	5	0.45	0.09				<10		
15	October 14, 2015	Lubao: Gregorio Emanuel household (visited after the sampling of the river water); sample from the individual well with a hand pump	<2	<0.05	0.11	<10	0.7	0.76	<1		
16	October 14, 2015	Lubao: Gregorio Emanuel household visited after the sampling of the river water; sample taken from the tap water (locally also called district water).	33	0.05	0.81	19	0.1	0.38	7		
		gate of paper mill				64	0.52	0.29	20		
17	October 14, 2015	Well with a hand pump on the outer fence (on the main road) of the paper mill factory.	115	<0.05	0.42	110	0.39	0.68	30		

3.4 Summary of water quality analysis

Conclusions Lubao

- Based on samples from hand pumps taken in Lubao by DOH, LWUA and DOST in 2014 and 2015, that were analysed by local certified laboratories, elevated concentrations of arsenic (up to 100 µg/l) were found in 14% of water samples;
- The arsenic concentrations in samples taken at pumping stations of the district water supply system were found to fluctuate, but in general levels found were below the PNSDW standard; some samples, however, have shown arsenic levels slightly above the maximal acceptable concentration;
- Generally, the shallow groundwater shows higher arsenic concentrations than the deep groundwater;
- Spatial distribution of the arsenic concentrations shows an irregular pattern, but is more present in the South Eastern part of town;

- The analysis show high temporal variability in the same well;
- Extremely high arsenic concentrations with levels of up to 300 µg/l, were found in water samples taken at PS Santiago;
- Water samples from the PS San Jose Gumi showed high concentrations of Arsenic (30 µg/l), and an RO plant was installed there. The plant operated well for a certain period but was out of operation due to technical problems during the DDR team visit ;
- The analyses of field water samples collected during the DDRT team visit confirm presence of elevated concentrations of arsenic in both shallow and deep groundwater;
- Soil samples showed a high Arsenic concentrations at the same locations where high arsenic concentrations were found in the water (PS San Jose Gumi, PS Santiago);
- A soil sample taken from the banks of the Porac-Gumain River (Lahar fields) showed a slightly elevated arsenic concentration;
- Elevated to very high manganese concentrations (≤1.3 mg/l) are common in groundwater samples in different municipalities in Pampanga. Presence of elevated manganese concentrations could be of health concern (at concentrations ≥0.4 mg/l), and will cause aesthetic and operational problems.

Conclusions Porac

- Analyses of a few field water samples taken at hand pumps and public taps showed low arsenic concentration (<3 µg/l);
- Results of a number of earlier conducted analyses, however, show arsenic concentration in drinking water just below the maximal acceptable PNSDW concentration. Regular monitoring of the arsenic concentration in district water were arsenic concentration close to the maximal acceptable concentration is therefore strongly recommended.

Conclusions Mabalacat

- Based on available analyses arsenic concentrations in 34 deep wells, are below the PNSDW standard but high to very high concentrations of Fe and Mg were noticed.

Conclusions field tests

- There are significant differences of arsenic level in water samples analysed by the UNESCO-IHE and local laboratories. Arsenic values analysed by the UNESCO-IHE laboratory were found to be significantly higher. This conclusion is, however, based on just a handful of samples analysed, but results obtained strongly suggest that arsenic concentrations determined by some of certified local laboratories likely underestimate actual arsenic levels.

- Arsenic contamination in the soil is not uniform and is likely low in the natural conditions of the ground.
- Of the 14 soil samples collected, 10 of the samples had insignificant Arsenic concentrations.
- Locally, human activities (e.g., uncontrolled discharge of RO concentrate, pumping of As-contaminated groundwater) possibly contributed to elevated concentrations of arsenic.
- The only soil sample from a residential area with significantly elevated arsenic was taken from San Roque Arbol, while all other samples have shown low arsenic levels.

4 WATER SUPPLY LUBAO

Lubao Water District (LWD) is the water service provider in the area that operates a level III water supply system that covers 39 of 44 barangays of the municipality. Households not connected to the LWD utilize shallow wells to meet their domestic requirements. However, it is also common in the area that households utilize shallow wells with hand pumps in combination with the piped water supplied by LWD.

The number of residents served is 67,805 (October 2015) with an average domestic water demand of 177 lpcd. The water consumption of different type of consumers (connections) is shown in table 4.1 (October 2015). The residents not served make use of shallow wells with hand pumps. The number of hand pumps in Lubao is estimated at 17,000.

Table 4.1: Water demand Lubao

Classification	Number of connections	Demand per connection (m^3 per month)	Total demand per month (m^3)
Residential ½”	14,708	25	367,700
Residential 1”	4	183	732
Commercial ½”	49	70	50
Commercial 1”	3	490	1,470
Semi commercial A	74	26	1,924
Semi commercial B	260	14	3,640
Semi commercial C	40	14	560
Government ½”	117	54	6,318
Government 1”	2	604	1,208
	15,257		**383,602**

Figure 4.1: Lubao Water Supply

4.1 Pumping Stations

Lubao Water District produces about 4.6 million m^3/year of drinking water using at present 11 pumping stations. Every pumping station has one single deep well equipped with a Grundfos submersible pump (20 to 30 HP). The average production per well is approximately 14 l/s. The wells are between 120 and 184 m deep and have screens in a multi-layer sedimentary aquifer system. The screened sections are all below 70 meter. An exception is pumping station Santiago, where the top screen is positioned at 59 meter. Some characteristics of the 12 pumping stations are shown in Table 4.2.

The static water level ranges from 5.90 to 0.30 m below the surface (near artesian conditions) and the drawdown during pumping ranges from 2 to 8 meter. Nevertheless, the pumps are installed between the screened sections at large depth. The submersible pumps feed directly into the distribution network, without a buffer tank (except a few small elevated tanks). Water supply is discontinue (e.g. there is pressure in pipes only during supply hours). This makes the system susceptible to contamination from the surface when the system is not pressurized (e.g. during the night). Moreover, high variation in pumping regime, required to compensate for hourly fluctuation in water consumption), and causes the ground water level to fluctuate, which increases the risk on clogging, scaling and oxidation. In addition very high pumping flows from wells, that are require to cover peak hourly demand, could contribute to higher arsenic levels in drinking water (e.g. reduction of groundwater table that results in abstraction of groundwater from layers with higher arsenic concentration, introduction of air in the subsoil that could result in dissolution of arsenic from arsenic containing minerals).

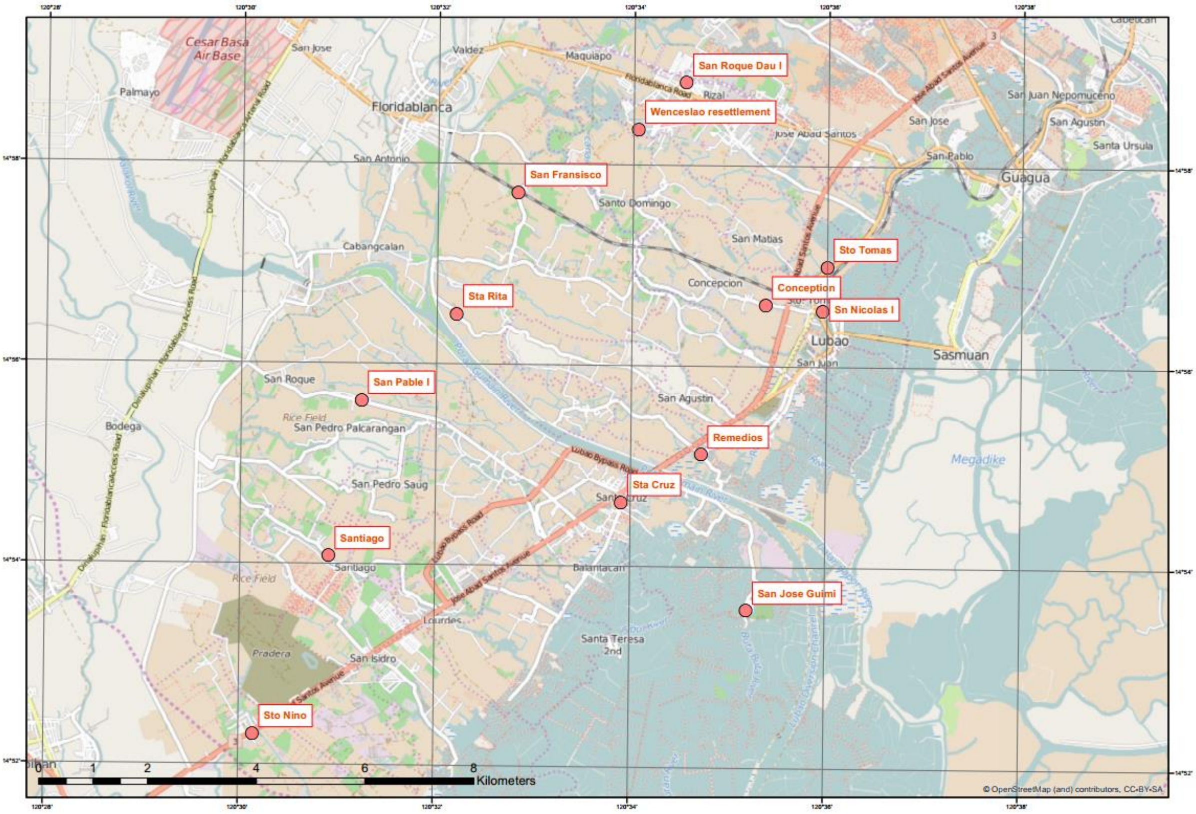

Figure 4.2: Pumping stations Lubao Water District

Table 4.2: Some pumping station characteristics

	Latitude			Longitude			Year of commissioning	Power (hp)	Elevated Reservoir
Pumping Station	D	M	S	D	M	S			
PS 1 - San Nicolas I	14	56	34.18	120	35	57.83	1963	20	20,000 Gallon
PS 2 - Sta. Cruz	14	54	38.63	120	33	54.72	1993	35	25,000 Gallon
PS 3 - Sto. Tomas	14	56	59.64	120	36	0.39	2001	30	
PS 4 - Sto. Niño	14	52	17.85	120	30	9.21	2004	30	
PS 5 - Remedios	14	55	7.37	120	34	43.41	2006	30	

PS 6 - San Roque Dau I	14	58	45.05	120	34	35.99	2007	20	100 m3
PS 7 - Concepcion	14	56	36.88	120	35	22.64	2009	25	
PS 8 - San Pablo I	14	55	38.19	120	31	12.22	2009	20	
PS 9 - Wenceslao	14	58	19.45	120	34	2.55	2010	25	-
PS10 - San Jose Gumi	14	53	34.01	120	35	12.45	2011	5	-
Santiago	14	54	18.83	120	30	34.89	2011	25	
San Francisco	14	57	46.11	120	32	53.29	2012	25	
Sta. Cruz Bypass	14	54	50.63	120	33	9.60			
Sta. Rita	14	56	30.04	120	32	12.40		20	

4.2 Pipe network

The pipework is dominated by a central east-west corridor of pipes, mainly 4" and 6" pipes, about 10km from east to west, with approximately 8 branches stretching to the north and to the south to neighbourhoods and pumping stations. These branches are usually a few kilometre in length.

There are 2 isolated mini-networks which are not connected to the main network: at San Jose Gumi and at San Roque Dau. Figure 4.3 shows a picture of a map.

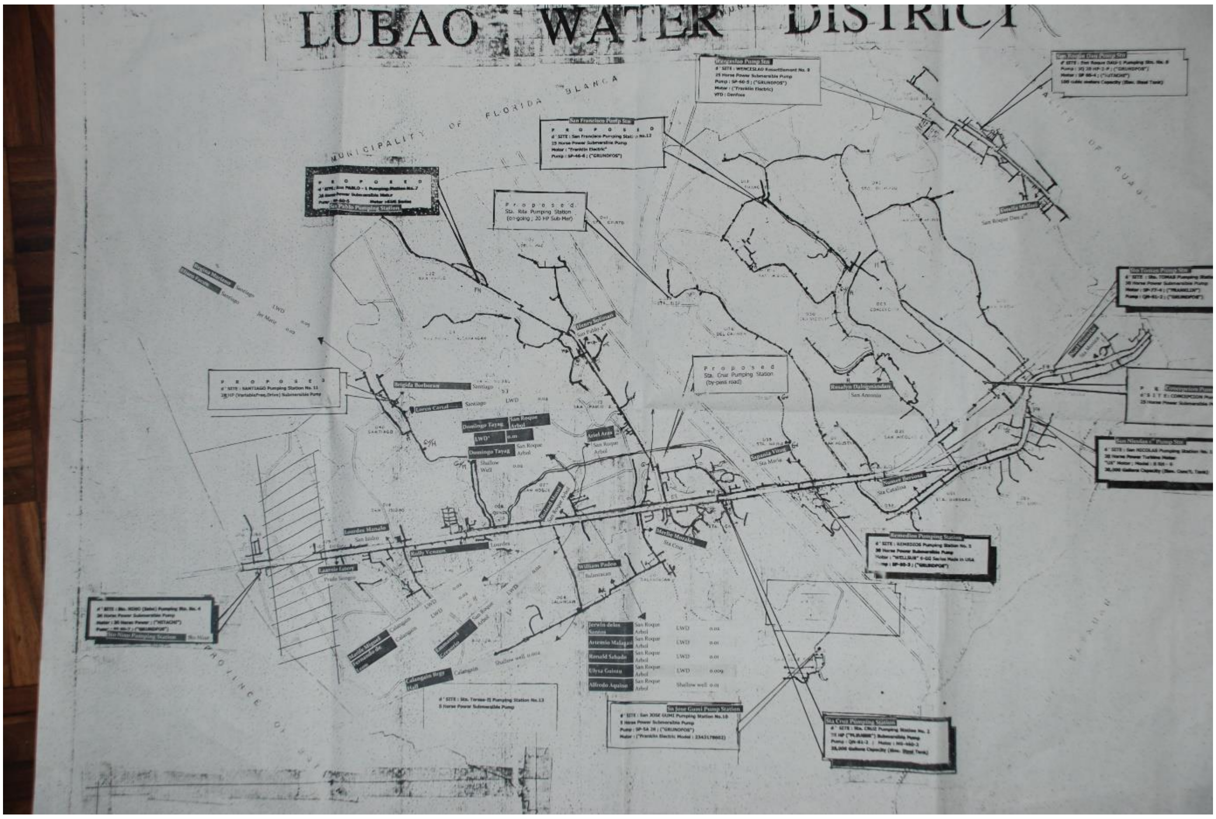

Figure 4.3: Lubao Water Supply System

4.3 Hand pumps

It is estimated that there are about 17,000 hand pumps in the area, both private and public. Most of the hand pumps are shallow (up to 6 meter deep), but there are also some deep wells with depth of up to 150 meter. Details about the spatial distribution, depth and arsenic content of the hand pumps is not available. Although new hand pumps are usually well protected, the older and private hand pumps do have a risk of contamination from the surface (e.g. during a flood). Many households still use hand pumps for drinking water supply because of the monthly fee for LWUA water supply is felt to be too high (starts at 200 pesos month).

Figure 4.4: One of the 17,000 hand pumps in Lubao district

4.4 Reverse Osmosis plant

There is only one arsenic removal treatment plant in the Lubao municipality, installed at the PS San Jose Gumi where arsenic concentrations of up 30 µg/l were found. Treatment is based on a mobile Reverse Osmosis unit with a capacity of approximately 2 l/s (figure 4.5). The plant was operational for several months and based on information from LWD provided the local population with arsenic free water. During the DDR team visit, the plant was, however, out of operation due to mechanical problems (pump motor damage).

The Lubao District Water is considering purchasing a permanent RO plant, similar to one temporarily installed.

Figure 4.5: PS San Jose Gumi and mobile RO arsenic removal plant at PS San Jose Gumi

The RO plant is very well capable of removing the Arsenic from the water, but has also some disadvantages:

- When in operation the concentrate (reject water) stream (typically >20% of the total feed to the RO unit) with 5 time higher arsenic concentration is discharged uncontrolled to the nearby canal, and from there to surface water that is spread over nearby mango and rice growth area;
- As a consequence, arsenic pollution of the aquifer, surface water and possibly crops grown in the area, takes place;
- Treatment based on RO is technically rather complex and requires skilled operators;
- RO based treatment is also expensive in terms of both investment and operational costs (e.g. electricity, cleaning and replacement of membranes);
- Though arsenic –free water is produced, product water is practically completely de-mineralized, and consequently not optimal for human consumption, and is very aggressive to water supply system. Remineralisation of RO permeate is consequently required.

Figure 4.6: RO reject draining to the nearby field (not in use during the visit)

4.5 Observations about the water supply system's operation

The Lubao water supply system, is basically a system of 12 pumping stations, all pumping untreated (except chlorination) groundwater directly into the city network based on actual water demand. Pumps are switched on and off manually at the discretion of an operator to adopt for the changing water demand over time of the day. This way of operation has the following disadvantages:

- Pumps are switched on and off during the day, resulting in fluctuating groundwater levels near that pump. High variation in pumping regime causes the water level to fluctuate, which increases the risk on clogging, scaling and oxidation. In case of presence of geological formation with arsenic, there may be locally an increased mobilisation of arsenic contamination;
- The pressures in the pipe system change over time of the day from high pressures to possibly negative pressures (vacuum);
- Pressure at any point in the system should be maintained within a range whereby the maximum pressure avoids pipe bursts and the minimum ensures that water is supplied at adequate flow rates for all expected demands. This is currently not the case as pressure control devices are absent;
- Balancing reservoirs that are required to cover hourly fluctuations of water demand are nor provided;
- Due to flow fluctuations, the applied chlorination is not optimal;
- Due to these fluctuations, contaminated (untreated) water may penetrate into the pipes during periods without or with negative pressure;

- The elevated water reservoirs are not used;
- Water quality of individual wells (pumping station) is not used as a tool to optimise the water quality (e.g. to make use of wells with the best e water quality);
- A surge in pressure and flow can occur when pumps are switched or when valves and hydrants are operated. Any change in flow can result in surge; however, the common causes are the operation of pumps, valves and hydrants. This can result in a deterioration of water quality because the surge can disturb deposits in the pipe or on the pipe wall. These operations may also cause low pressures that could allow ingress of contaminants.

Other problems noticed are:

- There is a large amount of households which are not using the water provided by the city water supply system. Either these households are not connected or they prefer to use hand pumps (with potentially a high arsenic concentration);
- Water is, besides chlorination, not treated. There are high levels of arsenic and also high concentrations of manganese and iron that have to be addressed.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Observations and recommendations

Observations	Recommendations
Geographic spread of arsenic contamination	
<u>Observation 1</u>: Based on the geographic position of the medical cases of Arsenic poisoning, and from the soils samples that were analysed, it appears that the Arsenic contamination is widespread and is found in the areas that were visited (southeast part of the volcano). In large number of samples arsenic concentration is mainly below, or just above the maximal acceptable concentration of 10 µg/l, but appears locally in a very wide range with concentrations as high as 600 µg/l.	<u>Recommendation 1</u>: It is advised to investigate the Arsenic concentration, and also the number of affected people, in areas west (Zambales), North and North-East (Tarlac, Angeles) of the volcano as well. This could be done relatively cheap and fast with appropriate field test kits supported by control analyses by reliable laboratory.
<u>Observation 2</u>: Based on water quality data, arsenic concentrations in and near Lubao seems higher than elsewhere in the visited areas (Clark, Mabalacat, and Porac). The Arsenic concentration in some localized parts of Lubao were found to be much higher than in other parts of Lubao. Especially in the South-East part of town (e.g. Santiago, San Roque Arbol) the concentrations are high.	
Observation: Analyses of relatively small number of water samples that were taken during the DDR team field visit and	<u>Recommendation 2</u>: It is recommended to:

analysed by the UNESCO-IHE laboratory show significantly higher arsenic concentrations than levels found by some local laboratories. If additional proper comparative water analyses conducted by different analyses confirm this preliminary finding, arsenic concentrations earlier reported by some local laboratories are under-estimated, and the arsenic-related problem is possibly more severe and widespread than anticipated. A firm conclusion based on currently available data is at present premature.	(a) conduct a well-designed comparative analyses of arsenic containing water samples by selected local laboratories and an external (foreign) laboratory with extensive experience for arsenic analyses, (b) improve capacity of the local laboratories with respect to arsenic analysis including analyses of samples with both very low and high arsenic concentrations.
Monitoring of Arsenicosis Observation: Detailed medical investigation of the population in the affected area was made by the Public Health Authorities. Investigation was focused on keratosis and other symptoms of progressed Arsenicosis. Clear symptoms of Arsenicosis (Keratosis, Melanosis and/or skin de-pigmentation) were observed in population that used, or have been using drinking water with elevated arsenic levels.	Recommendation 3 Medical investigation of population of affected areas should include early symptoms like skin (de) pigmentation. In addition wider awareness raising campaign on symptoms of Arsenicosis should be consider to allow early identification of symptoms by population.
Water Quality Observation: Very intensive water quality monitoring with focus on arsenic concentration was initiated by the Public Health authorities after the first Arsenicosis symptoms were identified. Water quality analyses are done by local certified laboratories, while water supply	Recommendation 4: It is recommended to make a complete inventory of all hand pumps (17,000) and deep wells in Lubao. This inventory should not only focus on arsenic, but also on broader water quality and health aspects in order to be able to link the health situation to the drinking

companies in general do not have capacity to conduct water quality analyses (e.g. presence of arsenic and other metals). Costs of the water quality analyses are rather high, and water supply companies try to limit the analyses to the legally required minimum. Water quality parameters, that could be of relevance for possible water treatment in the future including ammonia, phosphate, organic matter, are practically not monitored. Data on water quality of water from the District Water Supply Systems is readily available and likely well organized. Data on water quality of individual and community based shallow wells are rather limited and likely not easily accessible. In addition to arsenic, very high manganese concentrations are found in several both shallow and deep wells in Lubao, Porac and Mabalacat. In addition to operational and aesthetic problems high manganese concentrations could have a serious adverse health effect. Highly elevated iron concentrations were found in relatively small number of wells. Presence of elevated iron concentration is associated with aesthetic and operational problems. Where present iron at elevated concentration, iron should be removed before distribution of drinking water to consumers.	water quality. Individual and community based wells with arsenic concentration exceeding the maximal acceptable concentration of 10 µg/l should be clearly marked with red pain, or where possible should be decommissioned. Tested wells with acceptable arsenic concentration should be marked with green paint. For the water quality analysis, appropriate field kits can be used, although selected control samples should be sent to a laboratory with established expertise for arsenic analysis for verification purposes. The use of smartphones with pre-loaded questionnaires, built-in GPS capability and camera in combination with a cloud database may greatly enhance the productivity and efficiency of survey teams and improve the quality and accessibility of the survey results. <u>Recommendation 5</u>: It is recommended to review the national standard for manganese in drinking water (0.4 mg/l) and to consider (strong) reduction of the maximal acceptable manganese concentration in drinking water given the aesthetic and operational problems associated with at present acceptable manganese concentration. <u>Recommendation 6</u>: Manganese present in elevated concentration in groundwater should be strongly reduced before transport and distribution of drinking water to consumers, having in mind

	operational and aesthetic problems associate with presence of manganese in drinking water. Recommendation 7: Where both elevated iron and manganese (and possibly ammonia) are present in groundwater, removal of both metals can be achieved in a single groundwater treatment plant.
The Lubao water supply system is currently not operated in an optimal way. No balancing reservoir(s) are available to cover hourly fluctuation of water demand that is at present covered directly by variable flow from the wells. As a consequence pumps are frequently switched on and off resulting in fluctuating ground water levels, pressure surges and negative pressure in pipes. All these have a negative effect on the water quality.	Recommendation 8: Detail assessment of the design and operational concept of the District Water Supply Company in Lubao should be conducted and should include detail modelling of the existing water distribution system, and provision of balancing distribution reservoirs. Change of the operational concept of the District Water Supply Company will reduce loading on the existing wells, will possibly allow closure of wells with the poorest groundwater quality and result in overall improvement of water quality of supplied drinking water. This a major project with significant capital investments that can, however, result in savings on medium and long term. Summarized this program consists of: • Groundwater treatment plants for removal of arsenic, manganese and iron contacting ground water should be seriously considered. This is likely a combination of conventional groundwater treatment (aeration-filtration) followed by adsorption or enhanced

	coagulation with an appropriate separation. • Phasing out of hand pumps, with prioritized areas, and introduction of a piped water connection • Process control of the overall network, reduce groundwater fluctuations, surges, and negative/low pressures • Water quality control improvement
Results from analyses conducted by local laboratories show that with an exception of the PS San Jose Gumi, arsenic concentration in drinking water supplied by the Lubao Water District water supply company has arsenic level ≤of the maximal acceptable concentration of 10 µg/l. A few samples of drinking water from the public water supply system collected during the short mission of the DDRT team, that were analysed by the Unesco-IHE laboratory have shown arsenic levels that exceed the maximal acceptable arsenic concentration.	Recommendation related to drinking water quality in Lubao: Monitoring of drinking water quality with focus on arsenic presence in produced drinking water should be intensified. Water supply company should establish own capacity to routinely monitor a number of basic water quality parameters including arsenic, iron and manganese. Monitoring could be initially based on use of simple but properly selected test kits. A groundwater treatment plant should be provided on permanent basis at the PS San Jose Gumi, to replace the mobile RO unit. Selection of an appropriate treatment technology should be done based on extended water quality analysis. It is very likely that treatment based on adsorption or enhanced coagulation, possibly supported by an appropriate pre-treatment will

	result in more reliable, effective and effective arsenic removal. In addition to extended groundwater quality selection of an appropriate treatment should be based on analyses of investment and operational costs and generation of liquid and solid waste streams. If additional water quality analyses confirm that groundwater from some other Pumping Stations (e.g. PS Sta Cruz, PS San Isidro, etc.) actions should be consider to minimize or avoid exposure of local population to unacceptably high arsenic concentrations. To achieve this the following steps are recommended: (a) Temporary Simple, temporary arsenic removal plant(s) should be provided (b) it should be analysed if well(s) with elevated arsenic concentration can be taken out of operation, based on the water distribution system model, including provision of balancing reservoirs in the future, (c) if the wells with elevated arsenic concentration cannot be taken out of operation effect of measure suggested for upgrading if the Lubao water supply system on groundwater quality and specifically arsenic concentration (e.g. provision of balancing distribution reservoirs) should be monitored, (d) If arsenic

	concentration will reduce sufficiently reduce due to upgrading measures temporary water treatment units should be removed; if the arsenic concentrations remain high, a permanent water treatment (arsenic removal) plants should be provided.
Data Collection Observations: A lot of data has been collected but the quality is still questionable and data processing also needs improvement The provincial proclamation to sample 3 times a year water samples and have them checked on 14+3 parameters is a good step forward. However the location and time of the samples is not well	<u>Recommendation 9</u>: Well organized monitoring of drinking water quality from different sources including drinking water from public water supply system, individual and communal wells should be further improved. In addition a central well-structured data base with a good user-interface has to be set up to store and process all this data. Very likely LWUA would be the owner of this database

administrated and this needs improvement, just as the geographical spread of the sample taking *Arsenic in the soil* The natural level of soil in Lubao shows low concentrations of Arsenic, based on a few samples collected. However, some sites show elevated concentrations, such as soils associated with the Santiago water pump, the RO discharge in Gumi, the soil in San Roque Arbol, and the sediment from Porac-Gumain River. The samples from Santiago and Gumi may be isolated concentrations and not represent their surroundings, but the samples from San Roque Arbol and the Porac-Gumain sediments may reflect some environmental conditions that foster high concentrations of Arsenic. Despite all these concentrations of arsenic in soil, it should be noted however that the concentration of Arsenic in soil sampled during the mission do not show alarmingly high levels. Rather, the levels of soil Arsenic in the elevated cases are of low concentrations that they may barely pass the US standards for arsenic concentrations in industrial soil.	In addition to currently analysed water quality parameters, some other parameters (e.g. ammonia, dissolved organic matter, phosphate, etc.) should be occasionally analysed. Recommendation 10: Soil samples should be taken on a wide scale and tested for Arsenic Recommendation 11: Surface water sampling has to be done for rivers and lakes on a regular basis by DENR. This is currently not done in the project area and it is recommended to start this on a regular basis. Recommendation 12: A periodic sampling of arsenic in local grown rice in areas with elevated heavy metal concentrations levels is advised as a control measure Recommendation 13: The use of field kits (cheap and fast, but less accurate) should be seriously considered. This will greatly improve all the uncertainties which are connected with the geographical spread and concentration of the Arsenic contamination. Use of appropriate test kit can be strongly increase number of samples that can be analysed while keeping the costs relatively low.
Source of Arsenic Based on the information available at present The source of Arsenic is not easy	The effect of the uncontrolled discharge of arsenic containing industrial waste water, with likely very high organic load, could

to define, and initial observations suggest that it may be caused by various conditions, both natural (geogenic) and human. A combination of different mechanisms likely contribute to arsenic presence in water sources in the study area including dissolution of arsenic containing minerals at either aerobic (e.g. arsenopyrite) or anaerobic conditions (e.g. hydrous ferric oxides), upsurge of thermal water and the effect of the volcano eruptions.	possibly also contribute (either directly, or by creating conditions that favour arsenic dissolution in the aquifer) to extremely high arsenic concentrations found in several wells in the Santiago area. It is therefore reasonable to suggest that concentration of Arsenic in the soils and sediments need to be systematically documented. This includes structured sampling and analysis for arsenic in the following: o In the original pyroclastic flow deposits lying as thick ash layers in the upper valleys, o In the volcanic ash that have been mobilized by water as lahars, o In the soil—particularly the rice farms—that have experienced airfall ash but not lahars or pyroclastic flows; o In the natural soil that are derived from older Pinatubo volcanic ash. It is imperative that various levels of samples should be taken along a vertical profile of these soil and ash materials, since leaching and possible concentration in the lower levels may be detected particularly in the thick layers. The use of augers to reach the lower levels of the soil is therefore necessary just to understand the arsenic concentration with depth. It is also imperative that this soil sampling should be coordinated with the systematic program to sample and study the Arsenic concentration in both the groundwater and surface water in the area.

Industries Some industries may have an adverse impact on the water quality in Lubao, such as the paper mill.	 Recommendation 14: It is recommended that water, sludge and waste conditions of these industries are being sampled and environmental permits are being reviewed and strictly enforced. Possible adverse effect of the discharge of untreated waste water from the paper mill factory in Lubao on groundwater quality and specifically arsenic concentration should be studied in detail. Uncontrolled discharge of untreated waste water from the paper mill factory in Lubao (and if applicable in other industrial facilities in the affected area) should be stopped
Public Awareness During the mission, it was stated that the communication of arsenic contamination is being suppressed to prevent any undue panic or adverse reaction from the population. It is also observed that although in the areas where arsenic contamination is evident with the presence of medical cases of poisoning, there are sectors of the community that are ignorant of the threat	 Recommendation 15: It is recommended that a more thorough and focused program for communicating the risk of arsenic contamination be conveyed to the general public, particularly in Lubao where the condition is well documented. This program should cover the province of Pampanga, if so warranted by later results of water and soil analysis, and the nearby provinces of Tarlac and Zambales where Pinatubo's deposits are also present Public awareness campaign should be initiated to inform population about the adverse health effect of arsenic in drinking water. Decommissioning or red marked or unsuitable wells should go in parallel with provision of alternative drinking

	water sources (connection to the public water supply system or provision of reliable household based arsenic removal units). Risk communication could be done using four channels: a. The local government system where barangay level of communication can be tapped to reach the community residents. With the involvement of the local health workers, the various sectors of society can be reached, and may be more effective if the approach will focus on the household level, since some vulnerable sectors of the population may simply ignore the symptoms as tolerable or natural. Furthermore, the Sanguniang Barangay (village council) can be asked to consider advocating, or in the extreme case, legislating measures to determine if Arsenic contamination is present in the community, and to conduct corrective measures if the results are positive. b. The public education system can also be tapped, since schools are located in all communities, the teachers can become effective risk communicators, and the children can be the advocates for both detection of medical cases of As poisoning and healthy/safe eating and drinking practices. In this endeavour, the participation of and collaboration between the educational personnel and the local government units can create an effective and powerful partnership.

	c. The water district can be tapped to advocate both medical screening and healthy/safe eating and drinking practices. It was observed that the water district offices in Lubao have strong leadership and effective administrative systems which can help both in the detection and scoping of the As contamination, and in advocating for safe and healthy lifestyle for the communities. One possibility is for the DOH to require the water district to designate one person in the organization as safe water advocate and be charged with communicating the advocacy to the communities served by these water districts. d. The rural health units may be the best advocates for detection of contamination and for corrective actions in addressing Arsenic poisoning. Since the RHUs have the mandate to safeguard the health of the community, these units can effectively conduct both the health screening and the primary health communication to the population.
Training The contamination of the groundwater by arsenic is a new phenomenon for the Philippines and it was observed that many stakeholders are unsure how to deal with the problem.	<u>Recommendation 16</u>: Experiences from other countries or regions where arsenic presence in drinking water was recognized, suggest that capacity building of different stakeholders that should play role in the search of an appropriate strategy to mitigate arsenic related problem is very important. Capacity building should include different aspects of relevance

	including technical aspects (general water supply, (ground) water abstraction and treatment, geo-chemistry, analytical aspects, environmental issues), public health in relation to arsenic effects, regulatory issues, Public relations, etc. A detailed training program shall be made to address the following audience: 1- Health workers – recognising early symptoms of Arsenicosis 2- Labs – improved analysis for arsenic and heavy metals 3- LWUA and operational staff of other water supply companies better understanding of groundwater quality and treatment and improved operation of the facilities 4- Water supply companies and other environmental staff – taking samples in a standardized way and use of field test kits for widespread sampling

5.2 Short term solutions (Pilot Project)

1) Wide spread sampling program with field test kits

Although there is an arsenic problem around Lubao, the actual extent of the problem is still undefined. It is not clear whether more cases of arsenicosis exist elsewhere around Mount Pinatubo. Early symptoms like Melanosis may be noticeable but not recognized. Moreover, the water quality of thousands of hand pumps and other water points has not been tested on arsenic content.

It is therefore crucial that data is gathered about arsenic content in soil, food and water, and that the incidence of arsenic related diseases is mapped in all districts around Mount Pinatubo. What is maybe even more important is that the gathered information about arsenic content and incidence of arsenic related diseases can be easily linked, on very short notice.

Figure 6.1: Smartphone data mapping and examples of arsenic test kits

Traditional household surveys and water quality inventories take a long time to complete, process and analyze. This is especially true when laboratory work is involved. The linkage between the two datasets on health and water quality may also be difficult considering the diverse nature of the surveys and different expertise of the staff involved (hydrogeologists, chemists and medical doctors).

To obtain a clear picture about the actual extent of the problem, both in terms of health and arsenic content in water, soil and food, we propose to carry out a large inventory by multidisciplinary teams using modern survey techniques. We advise to use a smartphone based survey technique where the GPS location and photos of possible cases can be easily stored in the survey. The survey data is shared between the teams and is directly accessible in the field using the GPS location of the smartphone. A team with hydrogeologists or chemists can retrieve the health information of patients living near a water source. Likewise, medical survey teams have direct access to the most recent water quality data in the area.

Most water samples can be analyzed using field kits and the results are entered directly in the survey on the smartphone([13]). Regular samples should be analyzed in an accredited laboratory for cross validation.

2) Pilot Project (1) – packed treatment plant

The Reverse Osmosis plant at Gumi has to be replaced because the RO technology is not the most suitable technology for this application because of its high operational costs and sensitivity: The high pressure and associated high electricity bill, cleaning and replacement of membranes, etc. Furthermore it is a problem what to do with the reject water. At least about >20% of the volume flow will be rejected with a highly concentrated (5x) arsenic concentration.

Selection of an appropriate treatment technology should be done based on extended water quality analysis. It is very likely that treatment based on adsorption or enhanced coagulation, possibly supported by an appropriate pre-treatment will result in more reliable, effective and effective arsenic removal.

Arsenic removal through enhanced coagulation comprises pre-oxidation with a strong oxidant (e.g. chlorine, potassium permanganate, ozone, etc) followed by coagulation with iron or aluminum based coagulants and (multi-media) filtration. Pre-oxidation is essential if arsenic is present as As(III). Available water quality data and specifically presence of dissolved iron and manganese strongly suggest that groundwater in the affected area is anoxic and consequently that the arsenic which is present in the groundwater is most likely in the form of As(III).

Adsorptive arsenic removal with commercial iron-oxide based adsorbent will comprise filtration through a filter bed made on one of commercially available adsorbents. Extensive pre-treatment will be required to allow adsorptive filter to act as a polishing treatment step focused on arsenic removal. Commercial iron based adsorbent cannot be regenerated and should be replaced when saturated with arsenic.

An alternative adsorptive arsenic removal is IHE ADART process based on arsenic adsorption on Iron Oxide Coated Sand (IOCS). IOCS is a by-product of Dutch iron

[13] See example at http://akvo.org/products/akvoflow/

removal groundwater treatment plants and is consequently very cheap (approximately 1/10 of the costs of commercial adsorbent). In contrast to commercial adsorbent, arsenic saturated IOCS can be regenerated in-situ with ferrous iron solution. Due to lower porosity in comparison to commercial adsorbent IHE ADART process will require longer contact time (larger filter surface area).

A comparative assessment of suggested treatment options is given in Tab. 5.1

Table 5.1 Comparison of arsenic removal through (a) Enhanced Coagulation, (b) Adsorption with commercial adsorbents and (c) IHE ADART

Component	Enhanced Coagulation	Adsorption with commercial adsorbent	IHE ADART
Investment costs	Relatively low	Higher due to high cost of commercial adsorbents	Comparable to higher in comparison to adsorption based on commercial adsorbent due to longer contact time
Use of chemicals	Chemicals required for pre-oxidation (e.g. chlorine, ozone permanganate) and coagulation (Fe- or Al salts) widely available and relatively cheap. High chemical dosages required for groundwater with high arsenic levels with associated high operational costs.	No chemical required for arsenic removal	Chemical (acidic solution of ferrous iron) required only for regeneration (typically conducted weekly to monthly)
Use of (strong) oxidants	Pre-oxidation required when arsenic present as As(III) present.	Not required	Not required
Treatment process	Relatively simple, daily handling of (hazardous) chemicals	Simple filtration process easy to operate	Simple filtration, process easy to operate; some skills required for regeneration (preparation of stock solutions)
Arsenic removal efficiency	Highly efficient removal of flocs required to achieve very low arsenic level in treated water. Well- optimized system can achieve very low arsenic;	Very low arsenic level in treated water can be achieved	Very low arsenic levels in treated water can be achieved

Component	Enhanced Coagulation	Adsorption with commercial adsorbent	IHE ADART
Effect of groundwater quality matrix on treatment performance	Adjustment of chemical dosages required for changes of groundwater quality. Presence of phosphate, organic matter, ammonia, etc. will introduce the need for higher dosages of chemicals	High pH, presence of phosphate, arsenic as As(III), etc. (strongly) reduces adsorption capacity and introduces the need for frequent media replacement.	Presence of phosphate, high pH and As(III) reduces IOCS adsorption capacity; effect can be compensated by more frequent regeneration.
Production of health hazardous oxidation by-products	Use of chlorine or ozone as pre-oxidants will result in formation of health hazardous (carcinogenic by-products) Use of permanganate – no health hazardous by-products formed but it is difficult to establish required dosage (overdoses introduces pink colour, under-dosing will result in insufficient As removal)		
Waste production	Large volumes of toxic-sludge produced	Much smaller waste streams produced mainly solid waste (As-saturated adsorbent)	Much smaller waste streams produced mainly solid waste (As-saturated adsorbent) that can be classified as inert waste (low disposals costs)
Filter run length / backwashing frequency	Short filter runs (frequent filters backwashing required) with associated reduced water recovery.	Much longer filter runs with associated higher water recovery. Low frequency of filters backwashing	Much longer filter runs with associated higher water recovery. Low frequency of filters backwashing.
Pre-treatment	Required for anoxic e.g. ammonia, methane containing groundwater	Required for anoxic e.g. ammonia, methane containing groundwater	Required for anoxic e.g. ammonia, methane containing groundwater
Operational costs	Relatively high if safe treatment/disposal of produced waste is required;	High due to high costs of replacement of commercial adsorbent	Low due to expected long life of adsorbent (IOCS), low adsorbent cost, marginal use (for regeneration) of very cheap chemicals and low waste production.
Footprint of the plant	Small	Small (comparable to enhanced coagulation)	Somewhat larger (due to longer contact time in adsorptive filters)

In addition to extended groundwater quality selection of an appropriate treatment should be based on analyses of investment and operational costs and generation of liquid and solid waste streams.

It is proposed to investigate the possibility of leasing a suitable such a packed unit water treatment plant, possibly in a container, to Lubao for a period of time.

Figure 6.2: Mobile arsenic removal plant based on IHE ADART process (left), and Plug and play tailor-made emergency water treatment plant, (example Engeldot Water (right)

Figure 6.2: Plug and play tailor-made emergency water treatment plant (Example Engeldot Water)

3) Pilot Project (2) – household filters

It is proposed to identify a second area with high Arsenic concentrations (eg San Roque Arbol) and provide a large number of households with arsenic filters. These filters are typically cheap cost less than $10. Consequently we propose to identify an area where up to 100 filters could be provided and monitored during prolonged period of time (to gain experience with such a solution over time. The water quality shall be monitored for each installation, e.g. with test kits). It can be considered to test 2 or 3 different models that are available on the market or that can be produced locally. In addition to arsenic household treatment units should be selected to also effectively remove other water quality parameters of relevance (e.g. iron, manganese, etc).

Figure 6.3: Various household arsenic filters (examples Dr Ten, Adedge, DWC)

Fig. 6.4: Unesco-IHE Arsenic Removal Family Filter (left)

4) Lab analysis improvement

Preliminary laboratory results show, as explained in paragraph 3.3, that significant deviation of determined arsenic concentration exist between results of local laboratory and the UNESCO-IHE laboratory. The quality of arsenic analyses has likely to be improved by means of a lab quality program. The scope of that program would entail:

1) Evaluation of suitability of applied analytical techniques by selected labs in Philippines (incl. the methods, protocols and equipment used,on-site screening of procedures)
2) Control arsenic (possibly iron, manganese) analyses for a number of standard samples (with different concentrations from very low to very high);
3) Control arsenic (possibly iron, manganese) analyses of a field samples (collected in Philippines) by several accredited labs in Philippines in a parallel with analyses conducted by an experienced lab;
4) Training of local lab staff in Philippines;
5) Introduction of procedures, training for arsenic speciation and analyses of parameters not analysed at present (eg DOC, Ammonia, arsenic speciation);
6) Joint assessment of arsenic test kits and related training of local staff.
7) Capacity building (training) of the DOH and water utility staff on , water supply concepts, groundwater quality, hydro-geology, groundwater treatment including arsenic related issues;

5.3 Long term Solutions

1) Lubao water quality improvement project, involving hardware (treatment plants, pipes, pumping stations, control means, reservoirs etc) and improved operation of the systems.

The scope for a TA project would include:

Network Improvement

- Mapping of the Lubao pipe network in GIS;
- Hydraulic Modeling of the city pipe network, including the pumping stations and elevated reservoirs;
- Optimizing of the existing system by adding components (reservoirs) or modifying pumping capacities. The optimization should aim at a positive pressure at all sections of the network all the time, a steady flow situation most of the time to avoid groundwater fluctuation and intrusion of polluted groundwater;
- Optimizing the existing process control by adding process control devices (pressure control, flow control);

- Optimizing and enlarging the existing system by adding neighborhoods which are not yet connected;
- Concept design of the pipe network and pumping station improvements, including process control instruments, and a process computer (PLC) possibly in connection with a SCADA system;

Water Quality Control and Water treatment

- Introduce a system of (semi) real time Arsenic monitoring at all pumping stations and some additional locations. That can possibly be done by simple field test kits with a daily test;
- Introduce a database of the water quality testing;
- Concept design of a water treatment facility (As, Fe and Cd removal) near each pumping station. Try to reach an economy of scale considering the large number of pumping stations. Consider clustering of water treatment. Make use of the results of the pilot plant.

Implementation of the long term project:

- Feasibility study, including capex and opex, and an increase of revenues;
- Identification of a capability building component;
- Identification of further financial restructuring of the LPWD, and potential PPP structures;
- Funding by loan or private funding by means of a PPP structure;
- Implementation.

5.4 Planning and Financing

The following long and short term measures have been identified:

Table 5.2: Summary of recommended measures

Item		Cost estimate	Recommendations	Duration	Outcome
Further screening of the problem area	Wide spread water quality sampling program with field test kits and smart phones	30,000 euro plus local manpower to be provided my DOH	1	1 month	Much better insight in the footprint of the problem area, and better insight in the arsenic concentration in a wide area, and identification of hot spots
	Medical screening in a wider area , also considering early symptoms	Action DOH	3		
Pilot project for imediate improvement and testing of technologies	Pilot Project (1) – packed treatment plant	Quotation to be obtained	8	3 months preparation and shipment	Testing of better technology to remove arsenic near a pumping station, safe drinking water for a neighbourhood
	Pilot Project (2) – household filters	10,000 euro plus local installation and monitoring costs	8	1 month preparation , trial can last 1 year	Testing of various types household filters, safe drinking water for 100 families
	Inventory of all handpumps in the problem area	Action LWUA, DOH	4	6 months	Safe water
	Sample programme industry near Lubao	Action DENR	14	continuous	Environmental management, improved water quality
Lab & data improvement	Lab analysis improvement	20,000 - 50,000 euro for testing and training	2	1-2 months	Better quality of local labs and better test results

	Improvement of water quality data sampling, testing and data management	Action LWUA	9, 10, 11, 12, 13	continuous	Improved water quality sampling, and data management
	Improvement of water quality data sampling, testing and data management	Action LWUA	9, 10, 11, 12, 13	continuous	Improved water quality sampling, and data management
Technical Assistance programme	Lubao water quality improvement project – TA component	100,000 – 150,000 euro for technical assistance and concept design	6,7,8	3-4 months	A design of an improved water supply system resulting in a more steady flow, positive pipe pressures, less groundwater fluctuations, more control and better water quality
Lubao Water Quality Improvement Project	Lubao water quality improvement project implementation, construction	1-2 million euro	18	12 months	Implementation of the Lubao water quality improvement programme
	Public awareness and training		15, 16		

The water quality improvement project can be financed by:

1) A local, provincial or governmental budget
2) A (soft) loan from a commercial bank, development bank (DBP, Landbank) or a donor (ADB, WB)
3) Private funding by means of a PPP construction. A PPP tender has to be prepared by a consultant and approved by NEDA, Currently Manila has been privatised and Davao is under preparation. Most utilities are still owned by LWUA
4) A partial grant from various development instruments in combination with local funding or a loan

Grants for Technical Assistance (TA) can –possibly- be awarded by:

World Bank

The World Bank is the largest external source of financing for water projects, which totaled US$7.5 billion in FY11, comprising 53% for water supply and sanitation, 12.5% for irrigation and drainage, 23.5% for hydropower, and 9.9%for flood protection. The

Water practice includes World Bank operations, the Water unit, the Water and Sanitation Program, the Water Partnership Program, the Cooperation in International Waters in Africa, and the Southern Africa Water Initiative.

Asian Development Bank

The Water Financing Partnership Facility consists of 3 pillars, the Multidonor Trust Fund, the Netherlands Trust Fund and the Gates (sanitation) Trust Fund. The Gates fund focuses on Sanitation, The Netherlands Trust Fund is limited to focus countries Bangladesh, Indonesia, Myanmar and VietNam. Activities in the Philippines therefore cannot be financed through the NL Trust Fund. Funding is possible through the Multi Donor trust fund. These trust funds are in general used as grants for TA, for instance Project Preparatory Technical Assistance (PPTA), Capacity Development TA (CDTA) or Research and Development TA. These are therefore not loans and not huge amounts for investments in infrastructure.

The best approach is an application either via the operational project officer for the country/thematic portfolios and whom are responsible for setting up/designing loans and therefore projects (ADB, South East Asia Department (SERD), and the Philippines Resident Mission).

RVO (Dutch Government)

The programme that is most suitable for partly funding of the Lubao Water Supply Project is the Drive Program (Development Related Infrastructure Investment Vehicle). With DRIVE the Ministry of Foreign Affairs of thr Netherlands facilitates investments in infrastructural projects that contribute towards a good business climate and entrepreneurship in the area of water, climate, food security and sexual and reproductive health and rights (SRHR). Projects must be supportive of, and build on the Dutch agenda for aid, trade and investment, for instance by joining initiatives that have already been developed as part of Dutch development policy.
Projects are with a size of between 5 million and 60 million euros (including financing costs).

To qualify the project should adhere to the following selection criteria:
http://english.rvo.nl/subsidies-programmes/development-related-infrastructure-investment-vehicle-drive

ANNEX A: Participants field trip Pampanga, 12-14th October 2015

DRR Team members

1. Rudolf Muijtjens, MSc, Team leader, water supply expert (Royal HaskoningDHV Manila)
2. Theo Kleinendorst, MSc, geo-hydrologist (Acacia Water)
3. Branislav Petrusevski, Prof, Dr , water treatment expert (UNESCO-IHE)
4. Emmanuel Ramos, Dr , Geologist

DOH

5. Dr. Leonita Gorgolon/Director/DOH Regional Office-Central Luzon
6. Dr. Lailani Mangulabnan/DOH Regional Office-Central Luzon
7. Dr. Maila Rostrata/Medical Specialist IV/DOH Regional Office-Central Luzon
8. Engr. Allen Inductivo/Engineer III/DOH Regional Office-Central Luzon
9. Dr. Reynaldo Alipio/Rural Health Physician/Lubao Rural Health Unit
10. Engr. Luis Cruz/Supervising Health Program Officer/DOH-Main Office
11. Mr. Francis Paule/Nurse III/DOH-Main Office
12. Engr. Ana Trinidad Rivera/SHPO/DOH-Main Office

From Provincial and Municipal Government:

1. Governor Lilia Pineda - Province of Pampanga
2. Mayor Mylene Cayabyab - Municipality of Lubao

ANNEX B: Minutes of meeting – wrap up meeting 15th October 2015

Republic of the Philippines
Department of Health

DISEASE PREVENTION AND CONTROL BUREAU

October 19, 2015

Minutes of the Meeting
Feedback Meeting on Dutch Scoping Mission
October 15, 2015 (9:00AM onwards)
OSEC Conference Room

Present:

Dr. Gerardo Bayugo	DOH-OTS
Dr. Anthony Cu	DOH-OTS
Dr. Irma L. Asuncion	DOH-DPCB
Engr. Ana Trinidad Rivera	DOH-DPCB
Mr. Francis Paule	DOH-DPCB
Dr. Allan Evangelista	DOH-BIHC
Ms. Heidi Umadac	DOH-BIHC
Dir. Leonita Gorgolon	DOH-RO III
Dr. Maila Rostrata	DOH-RO III
Dr. Lailani Mangulabnan	DOH-RO III
Engr. Allen Inductivo	DOH-RO III
Engr. Virgilio Bombeta	LWUA
Atty. Archie Asuncion	DENR-NWRB
Mr. Alejandro Soliven	DPWH
Ms. Rosela Gomez	DOST-ITDI
Ms. Blessie A. Basilia	DOST-ITDI
Mr. Jos Hubber	Dutch Embassy
Ms. Eileen Vizmonte	Dutch Embassy
Ms. Andrea Lazaro	DFA-European Affairs
Dr. Reynaldo Alipio	RHU Lubao
Mr. Emmanuel Ramos	Netherlands DRR
Mr. Rudolf Muijtjens	Netherlands DRR
Mr. Branislav Petrjevski	Netherlands DRR
Mr. Theo Kleinendorst	Netherlands DRR

The meeting started at 9:00am presided by Assistant Secretary Gerardo V. Bayugo, chairman of the Technical Working Group.

Highlights:

1. Mr. Muijtjens Team Leader of the Technical Assistance Team presented the preliminary report of the Scoping Mission done last October 12-14, 2015.

   A. Accomplishments:

   a. Data Collection
   b. Collaborative meetings on activities conducted relative to the arsenic problem with various stakeholders as follows:
      - DOH Regional Office III – health surveillance and monitoring of drinking water for arsenic levels.
      - Provincial Government of Pampanga and municipality of Lubao – support activities in the monitoring, surveillance and management of patients.
      - Local Water Districts
      - Clark Development Corporation (CDC) – water monitoring for Clark locators.
      - CRL Laboratories – analytical procedures.
      - Various patients – history of exposure.
   c. Soil sampling – will be tested in Manila using an X-Ray Flourescent (XRF) machine (c/o Mr. Emmanuel Ramos-Geologist).
      - During the mission soil samples were obtained from the nearby surroundings of Santiago PS, residential areas of the affected patients, Pasig-Potrero River, Porac-Gumain River, and coal ash from the papermill.
   d. Water sampling-will be tested simultaneously by National Reference Laboratory (NRL), CRL Laboratories and in the Netherlands.
      - 13 water samples were obtained from hand pumps of residents and patients in Lubao, sludge from the papermill and water from Local Water Districts.

   B. Next Steps:

   Final report of the Dutch mission will include the following:

   a. Data analysis of environmental, hydrogeologic and geologic results.
   b. Analysis of samples (soil and water) during the scoping mission.
   c. Workshop in the Netherlands with academic and private institutions who may provide technical assistance to the Philippines.

d. Finalization of report which will consist of the following:
    - Findings of the mission and conclusion.
    - Recommendation for a follow-up project.
    - Recommendation for a sampling/monitoring phase
    - Recommendation/s for a pilot project
    - Funding requirements

C. Possible Solutions:

a. Water Supply System improvement in Lubao.
    - Computer modelling of the water supply network.
    - Design and construction of system improvements
    - Reduction of hand pumps usage, or regular testing of hand pumps with Arsenic Field Kits.

b. Sampling and monitoring improvement
    - Calibration of the laboratory tests.
    - Better data collection and storage.
    - Sampling (surface water, ground water, and soil)
    - Screening of early manifestation of Arsenicosis (e.g. Melanosis) in combination with the awareness campaign.

c. Use of reliable Arsenic Test Kits.

d. Capacity building of the Local Water District Staff.

e. Pairing of Lubao Water District with a Dutch Water Utility for improved management and quality control.

ISSUES AND CONCERNS:

ISSUES	DISCUSSIONS	ACTIONS TAKEN/AGREEMENTS
Workshop in Netherlands with academe and private institutions who may provide technical assistance to the Philippines. (November 9, 2015)	Who will participate in the said Workshop in Netherlands?	• Various companies, universities that have involvement in Arsenic problems in Netherlands will participate on the said workshop.
Increase level of Manganese will interfere the level of Arsenic	Analysis of laboratory results revealed that there were increased levels of Manganese in areas of Lubao based	• Increase in Manganese levels may pose serious health threats, but it may have no

	on previous monitoring .	correlation to the levels of Arsenic.
Pilot Project	How long is the duration of the pilot project?	• Duration of the pilot project is still unclear; however this will be scheduled for November 2015.
Field Test Kit	Is there a need for any confirmatory test?	• Field test kits will be used for screening purposes.
Presence of Arsenic in Food.	Analysis in crops and rice is important?	• Rice maybe affected by Arsenic due to the water used in irrigation. • If the volcano is involved, we must do systematic water and soil sampling.
Soil Samples	What to do if soil samples were found to be elevated in Arsenic?	• The concern is that as from the soil will percolate and contaminate the ground water aquifer. • Local Water Districts should ensure that supplied water is free from arsenic. • Soil sampling results to be released by October 16, 2015.
Timelines and Priorities		• Dutch TA Team has been provided with the preliminary findings and all data that were collected will be processed and analyzed before arriving at the conclusions as well as priorities and recommendations. (within the next 3 weeks)

The meeting was adjourned at 10:45AM

Prepared by:

FRANCIS R. PAULE, RN
Nurse II, DPCB-ERDD

Approved:

IRMA L. ASUNCION, MD, MHA, CESO IV
Director IV, DPCB

GERARDO V. BAYUGO, MD, MPH, CESO III
Assistant Secretary of Health
Office for Technical Services

ANNEX C: Minutes of meeting – kick-off meeting 10th September 2015

ANNEX C: Minutes of meeting – kick-off meeting 10th September 2015

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Republic of the Philippines

Department of Health

DISEASE PREVENTION AND CONTROL BUREAU

ANNEX B: MINUTES OF MEETING

NOT FOR CIRCULATION

September 15, 2015

Minutes of the Meeting
Safe Water Task Force Water Quality Monitoring
September 10, 2015 (4:00PM onwards)
OSEC Conference Room

Present:

Sec. Janette Loreto-Garin	DOH
Dr. Irma L. Asuncion	DOH-DPCB
Dr. Mario Baquilod	DOH-DPCB
Engr. Ana Trinidad Rivera	DOH-DPCB
Ms. Maylene Beltran	DOH-BIHC
Dr. Aleli Sudiacal	DOH-BIHC
Dr. Leonita P. Gorgolon	DOH-RO III
Mr. Rudolf Muijtjens	Netherlands TA Team
Mr. Rene Broekhuizen	Netherlands TA Team
Ambassador Marion derckx	Dutch Embassy

The meeting started at 4:30pm presided by Dr. Janette Loreto-Garin, Secretary of Health.

AGENDA:

1. Introduction of the Technical Assistance Team from Netherlands.
2. Presentation of updates on the situation of Pampanga.
3. Presentation of draft Terms of Reference.
4. Drafting of Program/Itinerary for the TA Team.

Secretary Garin provided feedback on the Cabinet Cluster Meeting held last August 20, 2015. In which a Safe Water task Force was created with the DPWH as the Chair and DOH as the Co-Chair. Members of the said Task Force include DOST, DILG, DENR, Presidential Communications Office and LWUA. Some of the highlights of the meeting include the following:

1. Establishment of standards for safe water c/o DOH and DOST.
2. Assistance to the affected residents.
3. Explore tapping of the Quick Response Fund as funding source.
4. To define the extent and magnitude through Scoping.

Mr. Rudolf Muijtjens, team leader of the Technical Assistance Team from Netherlands discussed the project objectives, proposed itinerary, team composition and their needs.

The Technical Assistance Team composed of the following:

NAME	BACKGROUND
Mr. Rudolf Muijtjens	Team Leader Large environmental programmes Water Supply projects, water treatment
Mr. Branislav Stefanevski	Arsenic Expert on Water Treatment Laboratory Monitoring
Mr. Theo Kleinendorst	Hydrogeologist Ground water modelling Ground water management
Mr. Emmanuel Ramos	Geologist, Geophysisist, Vulcanologist

Project Objectives:

1. Environmental profile –problem definition.
2. Implement Risk Reduction Initiatives.
3. Monitor Health Effects.
4. Enhance laboratory techniques and water quality monitoring.
5. Formulation of a long term project proposal including funding assistance.

Technical Assistance Team Timeline of Activities:

Activities	Brief Definition	SEPTEMBER	OCTOBER	NOVEMBER
Kick-Off		September 10		
Data Collection	Geo map c/o DOH and other agencies.	3rd to 4th Week		

ANNEX C: Minutes of meeting – kick-off meeting 10th September 2015

Mission	Area Visit		1st to 2nd Week	
Workshop (Netherlands)	Technical Workshop to comply with the Ar standards.		4th Week	
Reporting (Phase 1)	Report what have found during the mission and workshop and come-up with next steps.			1st week
Pilot Project	Setting up of small treatment unit/plant			2nd week and will last for 6 months
Monitoring	Water Quality Monitoring			2nd week and will last for 6 months

TA Team needs from DOH:

1. Data (Please see attached).
2. Setting up of meetings with stakeholders in Manila and Pampanga.
3. Liaise the mission in Pampanga. (October 12-14, 2015).
4. De-briefing. (October 15/16, 2015)

ISSUES AND CONCERNS:

ISSUES	DISCUSSIONS	ACTIONS TAKEN/AGREEMENTS
Disposal of waste water on the use of Reverse Osmosis (RO).	TA Team said that the use of RO in a wide scale is too expensive.	• Filtration is recommended. • Dutch experts will look for an appropriate technology.
Local Chief Executives commitment.	LCEs don't want to be involved due to the possible effect to their investments, tourism and agriculture.	• To appoint focal person. • Dr. Mario Baquilod and Engr. Ana Rivera and representative from PNRI appointed as focal person.

		• Dr. Gerardo Bayugo appointed in behalf of the Secretary Garin during meetings.
List of Data Needed		• To communicate via email.
Involvement NGOs	Involvement of NGOs maybe crucial in advocacy.	
El Niño	Impact of El Niño to water contamination of Arsenic	• To be mentioned in the report of the Dutch TA Team.
Funding/Administrative Concerns		• The Netherlands will shoulder the salaries of the TA Team. • Philippines will shoulder local expenses.

The meeting was adjourned at 5:30PM

Prepared by:

FRANCIS R. PAULE, RN
Nurse II, DPCB-ERDD

Approved:

ANA TRINIDAD RIVERA, ChE, MSC
Supervising Health Program Officer

JOSELITO M. RIEGO DE DIOS, CE, SE, MPH
Chief Health Program Officer

FRANKLIN C. DIZA, MD, MPH
Medical Officer V, DPCB-ERDD

ANNEX D: Minutes of meeting – Arsenic workshop the Hague, Netherlands 9th November 2015

Memo Expert meeting arsenic removal Philippines

Van: NWP

Aan: Experts arsenic removal

Datum: 9-11-2015

Onderwerp: Report arsenic removal Philippines

On November 9 an expert meeting on arsenic removal in the Philippines was organized by the Netherlands Water Partnership (NWP) and the Dutch Enterprise Organization (RVO), as a follow-up of the DRR-Team mission in October this year. During this meeting DRR-Team mission leader Rudolf Muijtjens presented the preliminary findings of the mission. Furthermore, experiences and expertise on this topic were exchanged and suitable activities for a follow-up were discussed. This report discusses the most important points of discussion and conclusions of the meeting.

Presentation Rudolf

In addition to the presentation (click here) the following remarks were made:

- Arsenic concentrations not extremely high (many just below permissible limit of 10 ppb). Higher values mainly near city of Lubao.
- However, arsenic concentrations measured in labs in the Philippines are much lower than the concentrations found in labs in the Netherlands (UNESCO-IHE). This should be verified before conclusions can be drawn.
- Concentration arsenic in water from hand pumps is higher compared to concentration in water from deep wells. The problem is that water from the hand pumps is free and is therefore widely used.
- Disease symptoms are typically for arsenic, so it is best to test on arsenic levels first. But maybe for a follow up we should consider testing on other (toxic) chemicals as well.
- Contamination in agriculture (rice, mango). Very important issue, but outside scope of this mission.
- Question: Is the solution to this problem cleaning the soil, or preventing people from drinking polluted water?
  → Generally, these problems have a regional scale, it is too expensive to clean all polluted soil. The whole area is not even identified yet. For now, we start in the city of Lubao.

Short-term actions

1) Finalizing mission report by DRR-Team

- Extend of arsenic problem
- Concentrations (possible reanalysis of samples in other lab in NL)
- Where is contemned water used?

2) Feedback mission report by experts present at meeting today

- Possible solutions/approaches (arsenic removal, water treatment)
- New insights

3) Finding funding

- WHO, WB, ADB?
- Local water company (state owned) is fully cooperating, but has limited funds.
- There might be small budgets available from the Philippines, but limited.

Long-term actions

4) Quick and dirty large scale sampling program

- Using field test kits (note: also some of the field kits are underestimating values. So test kit should be selected carefully)

5) Pilot project water treatment

- Water treatment facility/unit

6) Secure the water supply system of Lubao

- Connection to drinking water supply system
- Each household equipped with water filter

5.5.1 List of attendees

Name	**Organization**	**Pitch**
Rudolf Muijtjes	DRR-Team leader	-
Branislav Petrusevski	DRR-Team member (UNESCO-IHE)	Knowledge on arsenic removal solutions for over 15 years. Producing drinking water without arsenic from different groundwater sources (adsorbsion, centralized systems).
Theo Kleinendorst	DRR-Team member (Acacia water)	Willing to help defining the exact extend of problem by guiding campaign that is necessary to collect samples.
Gerrit Miedema	Dr. Ten Presentation	Our contribution could be a demonstration and analysis of an arsenic reduction filter in a demo project at household level. Also, we develop solar desalinization systems.
Marcus van de Vaart	Engeldot water	Willing to contribute in pilot project. Experience in water treatment.
Arslan Ahmad	KWR	Water treatment: Low concentrations of arsenic can also be a threat, therefore, KWR is supporting water companies with reaching the target of 1mg/l arsenic in the water. KWR develops solutions that fit in current treatment systems, but also innovative solutions. Same can be done for the area in the Philippines.
Jan Appelman	RHDHV Presentation	Expertise on Arsenic removal (waste water treatment, sludges, drinking water). Proposed solutions: Now: upgrading drinking water plants, mid-term: extend distribution network (which wells are good, which ones are bad). Long term: choose technology where amount of

		waste is limited, cultural change (water not for free anymore).
Dingeman van Woerden	Royal IHC – training instutute for dredging	We provide dredging equipment and solutions on: i) how to dredge without disturbing the environment (transport and storage) and ii) how to connect treatment system to removal plant (dredger).
Jasper Griffioen	TNO, Universiteit Utrecht Presentation	Professor water quality management (groundwater, systems analysis, arsenic, but also fluoride, probabilistic mapping, low cost treatment techniques)
Michiel Schöller	Trion PuriTec Consulting & Engineering Presentation	Specialized in field of heavy metals and drinking water treatment. Offers assistance in: i) analysis phase, ii) designing and performing lab and pilot tests (also on site) and iii) design and implementation (together with, possibly, local contractors) of drinking water treatment plants.
Jink Gude	TU Delft	Coordination of in-depth research on arsenic removal (Nicaragua, Bangladesh, Netherlands), arsenic behavior under the ground, but also on microorganisms in filter beds as a method to enhance arsenic removal.
René Broekhuizen	RVO	
Angelita Kappers	RVO	
Peter van den Horn	NWP	
Anne Kleene	NWP	