The online support and training project for the groundwater sector of Lao PDR

This item was submitted to Loughborough University's Institutional Repository by the/an author.


Additional Information:

- This is a conference paper.

Metadata Record: https://dspace.lboro.ac.uk/2134/29646

Version: Published

Publisher: © WEDC, Loughborough University

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the published version.
Introduction

The Online Support and Training Project for the Groundwater Sector of Lao PDR can be accessed at www.laoshydrogeology.com. The overall objectives of the Online Support and Training project are to provide continuous support and stimulation to the development of urban groundwater supply activities in the Lao PDR. The project is funded by the Norwegian Agency for Development Cooperation (NORAD). In practical terms the project was initially designed to provide support for water supply projects based on groundwater, such as the ADB funded Water Supply and Sanitation Sector Project, implemented by Norconsult International for the Water Supply Authority (WASA). Moreover, the project serves as a professional reference site for people interested in various aspects of groundwater; in particular the conditions as found along the Mekong River and its tributaries. Furthermore the project seeks to:

- Develop rapid and cost effective methodologies for the identification of ground water bearing formations, i.e. aquifer horizons. In other words, to find adequate deposits of sand (and gravel) buried in silts and clays, by means of resistivity imaging techniques coupled with specialised geological support;
- Design an optimal, customised and cost effective procedure for exploitation and safe exploitation of ground water for urban purposes;
- To provide a series of case studies complete with full sets of project histories, scientific approaches, data sets and evaluation techniques.

The objectives of this paper are dual. First, to give a brief summary of the context motivating the present study including its main features. Second, to present recent key experiences outlining the most common geological units and inherent technical challenges encountered during development of groundwater supply in Lao PDR.

Overall context - surface water vs. groundwater

National applied hydrogeology in Laos is presently in its infancy. With an abundance of surface water the ground water supply alternative has traditionally been given low priority. However, the use of surface water sources is not without problems. Increased use and consequent contamination of the waterways implies more costly purification processes in order to safeguard communities against water borne diseases and epidemics. The operation and maintenance of traditional water purification plants have become increasingly expensive due to increased costs of chemicals, logistics, plant construction and personnel. The search for groundwater based water supply solutions represents an attempt to alleviate this situation.

The alluvial deposits underlying almost all of Laos’ waterways contain large quantities of ground water; a virtually limitless and sustainable source of water due to the proximity and potential recharge from surface water bodies. Similarly, considering the abundant rainfall largely exceeding 1500 mm per year, significant groundwater potential also exists within the sedimentary basins comprising the weathered sand/mudstone and karst terrains that make up the undulating lowlands of central and southern Laos. However, the use of groundwater is not without problems. The reason being (1)
the large heterogeneity of sub-surface strata complicating
the location of exploitable quantities of water, and (2) the
presence of mineralised strata yielding excessive concentra-
tions of undesirable elements including iron, manganese and
increased salinity with depth. Successful and sustainable
utilization of groundwater resources therefore requires these
factors to be controlled in an economically viable way. This
goal can best be achieved through solid knowledge of the
geroylogy of groundwater occurrence and behaviour in terms
of recharge, flow and hydrogeochemical characteristics.

Features of the online support and training

The Online Support and Training Project addresses the
above disciplines individually including in depth explana-
tion, examples of accompanying geophysical exploration,
test pumping analyses methods, and combined through
Case Studies and Data Sets containing assessments and
records collected at the relevant locations. To facilitate
further analysis and visualisation of thematic information
such as mapping of variations in earth resistivity, aquifer
properties and water quality, all data is geo-referenced and
presented in easily accessible formats such as MS Word,
Excel, etc. A more detailed overview of the main subject
areas follows below:

Geology

This section gives an overview of the evolution of SE Asia,
orogeny, and formation of the principal hydrogeological
units such as the massive sand/mud stone formations of the
Vientiane and the Savannakhet basins. The latter is compli-
mented by petrographic analysis of thin sections enabling
the reader to appreciate the rock texture and its mineralogy,
properties that are fundamental in determining water-rock
interactions.

Hydrogeology

This section puts the geo-hydrology in context with the
larger Water Supply and Sanitation Sector Project, listing
the sites where investigations either have been or are about
to be carried out, including also the complete assessment or
Case Study reports for the respective locations.

Geophysics

The presence of buried coarser sand/gravel lenses and frac-
ture/weathering zones in alluvial and consolidated sedimen-
tary deposits respectively, is often a prerequisite for economic
viable abstraction of groundwater. The latter can be quite
difficult to locate efficiently and represents one important
reason why investments into the drilling of wells have been
considered unfavourably in the past, and present.

However, significant technological advances within the
field of electrical resistivity techniques during the last few
years have progressed fast. At present, rapid identification of
buried coarse sand lenses has become routine. In particular,
a technique named Resistivity Imaging can provide accurate
sand identification within a 3-400m profile in a period of
a few hours. Also, features such as karst, the presence of
conductive layers, salt water stratification, etc. can be identi-
fied along the same lines.

In addition to providing overviews of the most commonly
used geophysical methods, this section provides compre-
sensive professional support to the use and interpretation
of electrical resistivity surveys and data, including reference
to the Case Study Reports describing the interpretations at
each examined location. The latter is important because
interpretation will change in accordance with the sub-surf-
face environment, and as the project gains experience. For
example, a high resistivity area in a profile of an alluvial
deposit typically indicated the presence of favourable lenses
of gravel, while the same in a weathered sand/mudstone
indicates more impermeable (dry) consolidated rock.

Water quality and sanitation

Problems with elements such as iron and manganese rep-
resents another reason for general scepticism to the use of
groundwater in Lao PDR, (i.e. due to the associated aesthetic
effects such as colour and the potential to stain clothing).
With the exception of the younger parts of the sand/mudstone
formations, where iron and manganese are released from the
rock matrix itself, these elements are mainly present in the
deeper parts of the aquifer. Their presence can consequently
be reduced to within acceptable limits, provided special care
is taken during well installation and design.

The section contains information on water quality sampling
and analyses. Sanitation is only addressed at the recon-
naissance level with overviews and inventories of latrine
densities, and water quality in selected wells. As sample
composition may change significantly between sampling
and analyses in the laboratory, interpretation methods are
emphasised. These range from simple analyses of charge
balances to hydrogeochemical modelling to determine the
reliability of the analyses and evolution of the sampled
water respectively.

Test-pumping

Test pumping is fundamental to determining aquifer proper-
ties and the long term yield and operation of the well. This
section describes test pumping in theory as well as in practice,
through step-by-step examples and reference to the conducted
interpretations in the respective Case Study Reports.

Well drilling

Considering the varied nature of sub-surface strata requir-
ing different drilling methods, this section is devoted to
explanations of the most common methods available in the
Lao PDR, including the practical implications of the choice
doing equipment with respect to interpretations of the
hydrologic and chemical properties of the aquifer.
Illustrative results - Recent key experiences

At the moment groundwater based water supply has been constructed at two locations in Lao PDR. These are the towns of Ton Pheung and Outhoumphone. Their locations are shown in Figure 1 along with the locations of the other towns where the groundwater option has and is being evaluated. Together the experiences at Ton Pheung and Outhoumphone illustrate the challenges of,

- minimizing elevated levels of iron and manganese,
- well construction and design in unconsolidated sediments,
- locating weathered water bearing strata, and
- minimising saline upconing during pumping.

Ton Pheung

The town of Ton Pheung is situated on a lobe-like meandering of the Mekong, just south of the frontier between Myanmar and Thailand. The latter forms part of the Golden Triangle, an area that historically is well known for the growing of opium.

Groundwater characteristics at Ton Pheung consists of a semi-confined aquifer composed of permeable sand and gravel, which is fed by the fluctuating river stage and precipitation from rainfall. Water quality is generally good and low in mineral content in the top 1-2 meters of the water bearing formation. However, below this depth the water becomes anoxic (most likely due to the decomposition of organic matter in the formation). This causes entrapment of high concentrations iron and manganese.

Main challenges with respect to constructing a successful water supply system at Ton Pheung was therefore related to installing wells that would only extract water from the potable top part of the aquifer, while at the same time ensuring sufficient quantities of water using 1-2 production wells (i.e. to minimize costs and to simplify operation and maintenance). A third point is related to obtaining public acceptance and support for the proposed solution. An advantage here is that the people of Ton Pheung currently obtain their water supply from a number of hand-dug wells. Thus they are well aware of the groundwater potential provided the above criteria are met. However, this has proved an arduous task due (1) difficulties with locating suitable well sites and  (2) practical problems with drilling in the unconsolidated formation. The latter being due to the fact that the formation changes from that of largely sand to coarse gravel and large boulders at the depth where groundwater is encountered. Penetrating these deposits have resulted in frequent equipment breakdown. Typically it has taken on the order of 1 month to construct and install one well.

Noting that the mineral content of the water is going to be proportional to the residence time or the time of contact the groundwater experiences while flowing through the aquifer, the lowest mineral content is therefore likely to be found in areas of coarser more permeable sediments, and where these sediments lie at shallow depths reducing the travel distance for infiltrating recharge water. Following this line of reasoning, and using electrical resistivity to increase the chances of striking suitable sub-surface strata, a total of eight boreholes were attempted of which five have been installed. Of these five, three have demonstrated sufficient yield and acceptable water quality during long term test pumping. Two of the boreholes have been installed as production wells. Commissioning and handing over of the Water Supply Works is expected to take place in May/June 2004.

Outhoumphone/Xeno

Outhoumphone is located on a in middle southern portion of the country. The area is relatively flat, consisting mostly of rice-paddies. The aquifer is one of fractured sandstone/mudstone with a relatively low storage potential (less than 1 %). Due to the presence of evaporites (mainly gypsum) at depth, it is only the top 10 to 20 meters of the formation, which provides water of acceptable quality. As a result there were significant doubts as to whether the aquifer would provide sufficient water to meet the projected demand for an estimated future population (18,000) people. However, the areal extent of the aquifer is considerable, covering some 160 Km2 and recharge is on the order of 1500 mm per year, indicating (in theory) sufficient amounts of water. To examine this point in greater detail a groundwater model was developed for the entire area. The groundwater model allowed quantification of the multiple effects of pumping and recharge, and was consequently an important tool in supporting the case for constructing a water supply system based on groundwater. The remaining water supply alternative for the area would have been to defer investment, and wait for sufficient funds to construct a pipeline from the nearest surface water resource (the Mekong river) in Savannakhet located 35 Km West of Outhoumphone. The
cost of the surface water is estimated at about 3 times that of the current groundwater alternative.

Construction of the groundwater supply system started in the middle of January of 2003 with pre-drilling of test-boreholes, which later pending yield would become production boreholes. In total over 100 boreholes were drilled. The boreholes were sited by a saturation electrical resistivity-imaging programme (more than 100 profiles) were conducted to locate potential water bearing fractures and strata. On average the success rate was 50-60 %, and about 50 boreholes have been chosen for production wells. These are distributed between 3 well fields in the north-western, eastern and southern parts with respect to the town centre. Location map is shown in Figure 2 together with the different types of data collected such as blow blow yield, conductivity and down the hole resistivity, and how these are collated and compared with observations of cuttings for hydrogeologic interpretations.

Concluding remarks

The groundwater supply systems at Ton Pheung and Outhoumphone are scheduled to be commissioned and handed over to the respective municipal authorities during 2004. Noting the current skepticism regarding the use of groundwater, the successful installations of ambitious groundwater supply systems in challenging geological formations represents pioneering achievements, a point which is likely to positively impact future initiatives and investments in the water sector.

For example, to our knowledge the groundwater supply system in Outhoumphone is unique with regards to urban water supply in not only Laos, but also Southeast Asia and perhaps significant parts of the world. The long-term sustainability of this and other projects will ultimately be determined by the capacity and skills of the local population to maintain the technical installations and comply with recommended pumping rates and schedules. These are important elements in groundwater management and protection.

But perhaps more importantly the experiences demonstrate the complexity of the natural settings and the need to communicate the lessons learned. It is here the real value of an Online Support and Training is evident, enabling the local geo-hydrologist access to an extensive information base and scientific tools. As a result it is hoped that the project will stimulate further interest in the potential of groundwater, to improving and promoting sustainable water services solutions within Lao PDR and the Mekong basin.

References


Contact address

Johan B. Siqueland Knudsen
Hydrogeologist/Hydrogeochemist
Norconsult International AS
Sandvika,
NORWAY

Fridtjov Ruden
Hydrogeologist/Senior Advisor
Norwegian Institute for Water Research NIVA
Oslo,
NORWAY

Bjørn T. Smith
Senior Water and Sanitary Engineer
Norconsult International AS
Sandvika,
NORWAY