



## Groundwater Resources Development by Riverbank Filtration Technology in Thailand

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**Abstract** Riverbank Filtration (RBF) is the influx of river water to the aquifer induced by a hydraulic gradient and it is a low-cost and efficient alternative water treatment for drinking-water applications. The objectives of the project are to study the feasibility of RBF technology, design the pilot system, evaluate the feasibility of the project on socio-economic and environmental impact and transfer the knowledge of RBF technology to the state enterprise organizations, local administrative authorities and other related parties. The project consists of 3 phases, feasibility study (11 months), design and construction (14 months) and operation and maintenance (12 months). Therefore, the specific objective of this paper is to review the basic concepts of the first phase and present some case studies such as Kompahangpet area for detailed study prior the design and construction phase. The target areas are initially focused along the main river courses in Thailand such as Mekong, Ping and Chaophraya Rivers. The study procedure consists of detailed investigations: hydrology, hydrogeology, water demand, suitable socio-economic conditions, and appropriate environments. Mathematical groundwater modeling will be employed to evaluate the suitability of the selected sites. Then we will design pilot system for large scale groundwater resources development to verify that the method could be successfully employed for water resources management and could be further expanded to other areas and extended to other interested parties or organizations in the future.

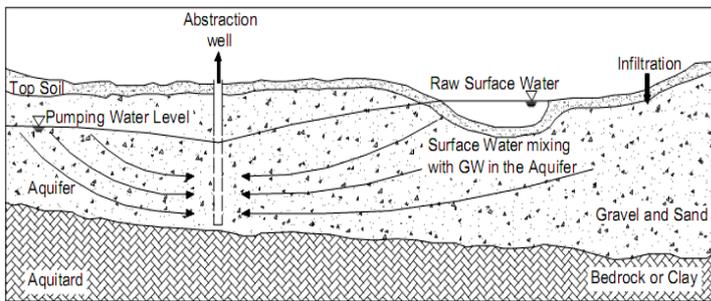
**Keywords** riverbank filtration technology, groundwater and surface water conjunctive use, hydrology, hydrogeology, water resources management

### INTRODUCTION

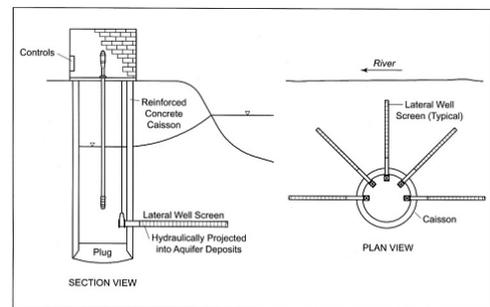
Riverbank Filtration (RBF) is the influx of river water to the aquifer induced by a hydraulic gradient. Collector wells located on the banks in a certain distance from the river (Figs. 1 and 2) create a pressure head difference between the river and the aquifer, which induces the water from the river to flow downward through the porous media into the pumping wells. By applying this system of water supply extraction, two different water resources (surface and shallow groundwater) are in conjunctive use. Riverbank Filtration (RBF) is a low-cost and efficient alternative water treatment for drinking-water applications. There are two immediate benefits to the increased use of RBF: minimizing need for adding chemicals like disinfectants and coagulants to surface water to control pathogens, and decreasing costs to the community without increased risk to human health. RBF has been successfully practiced for more than 100 years in European countries and is a current

method for water supply in many countries. For example, 50% of potable water supplies in the Slovak Republic, 45% in Hungary, 16% in Germany and 5% in the Netherlands are obtained from the riverbank filtration system (Grisczek et al., 2002; Hiscock and Grisczek, 2002; Tufenkji et al., 2002 and Lee and Lee, 2010). RBF has also been applied to acquire drinking water in many cities in the United States.

In Thailand, the Department of Groundwater Resources (DGR) awarded financial support to a consultant consortium to carry out the study on the feasibility of developing the RBF project along the major rivers to mitigate water shortage problem and provide optional supplementary water sources for domestic and industrial consumption. One of the main tasks in the RBF development project is the first phase, which is costly and time consuming. It is expected that after the pilot RBF system in Thailand is constructed and completed, the knowledge and know-how from the project will be used for the development of the master plan for the RBF system in the whole country. The RBF project, if successful, will demonstrate the systematic and sustainable integrated management of surface water-groundwater conjunctive use so as to increase efficiency in the mitigation and remediation of yearly water shortage problem in the future.



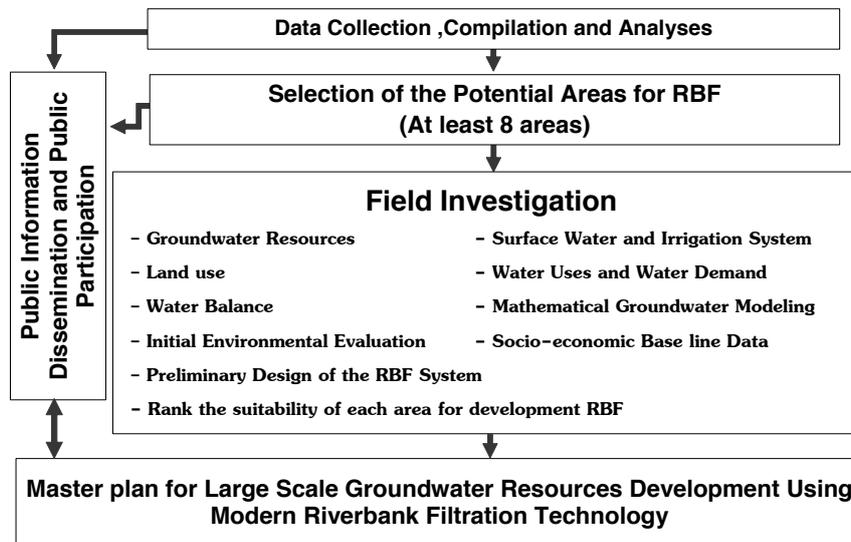
**Fig. 1 Generalized schematic section of a riverbank filtration site (After Ray, 2002)**



**Fig. 2 Cross section and plan view of a horizontal collector well (After Hunt, 2010)**

**METHODOLOGY**

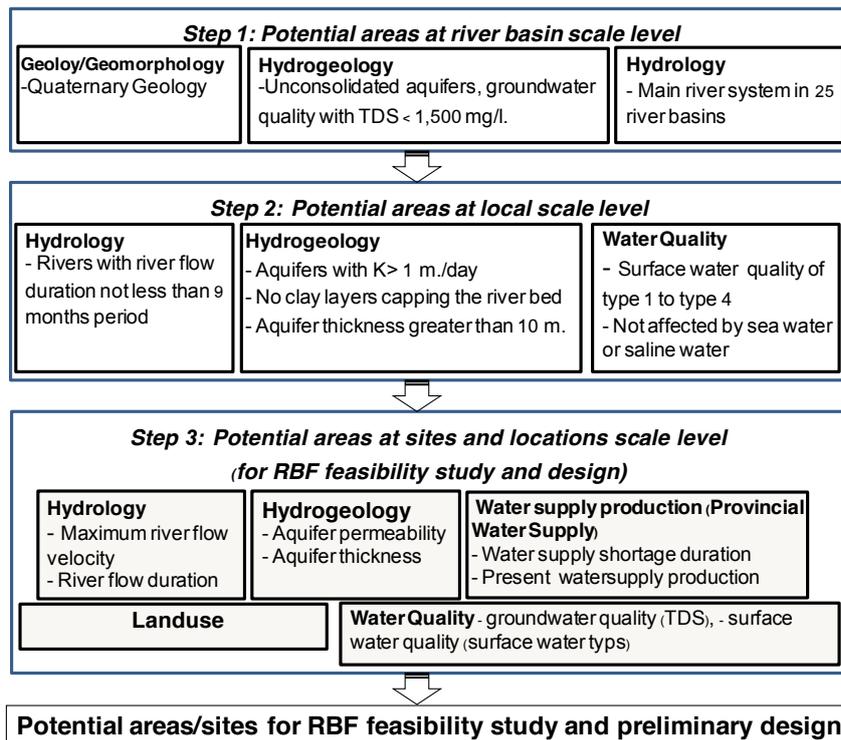
There are five main tasks conducted during the feasibility study phase (I) as shown in Fig. 3, namely 1) Data collection, compilation and analysis, 2) Selection of the potential areas for RBF construction (at least 8 sites), 3) Field investigations, 4) Public dissemination and participation, and 5) Formulation of the master plan of RBF for Thailand.



**Fig. 3 Protocol of the feasibility study phase (I)**

**DEVELOPMENT OF THE SITE SELECTION PROCEDURE**

In this study, the development of the site selection criteria for the RBF was initiated by reviewing and compiling existing RBF case studies worldwide. The various site selection criteria from the available case studies were focused upon the key performance indicators for RBF system. Essential data clusters and necessary specific parameters were identified and categorized. The selection procedure is divided into 3 steps (Fig. 4), namely; Step 1: Potential River Basin Level, attempts to identify the RBF potential areas in Thailand at the river basin (regional) scale; Step 2: Potential Local Areas Level, attempts to identify the RBF potential local areas within the potential river basins obtained from Step 1; Step 3: Potential Site Level, attempts to identify the RBF potential sites and locations within the local areas obtained from Step 2. The potential sites and locations obtained from Step 3 will be used for more detailed site investigations to determine the RBF key performance parameters for the RBF system design and construction. After more detailed examination of existing available data was carried out, a new adjustment and arrangement of data groups and selection procedure was conducted. Considering the site selection procedures, steps and selection criteria in Fig.4, a series of thematic maps were compiled or prepared for each selection steps. River basin map in Thailand (Fig. 5) and the distribution of areas 2-km away from main riverbank were acquired to overview the availability of surface water. The thematic map from Quaternary geologic map was overlaid on the groundwater quality map to obtain the RBF hydrogeologic suitability map. The preliminary potential areas for the RBF system derived from Fig. 6 covering approximately 15,839 km<sup>2</sup>. The river hydrograph information shows that the river flow of the main rivers varied from 4 - 12 months flow duration.



**Fig. 4 Overall procedures for RBF site selection**

River water quality map was obtained from the Department of Pollution Control. The RBF aquifer thickness and aquifer permeability were reviewed and compiled from the existing RBF system case studies and the range of practical aquifer thickness and aquifer permeability values were identified and the suitable range was selected to fit the existing available data for Thailand. A total number of 13,581 available groundwater wells were compiled from the National Groundwater Database, DGR. A number of 4,881 groundwater wells with well logs were sorted and 414 wells satisfied the criteria. The distribution of 414 groundwater wells were prepared as well as

hydrologic data consisting of existing 190 river gauging stations, river cross sections and profiles, river hydrographs, and river flow velocity were compiled and analyzed. Land use data and maps of various scales were compiled from the existing database of the Department of Public Works and the Department of Land Development. The expected main water users from the RBF system in Thailand are the Provincial Waterworks Authority. Water demand for provincial water supply is, therefore, considered as one of the parameters for RBF system site selection. The water demand for provincial water supply as of 2010 was compiled.

At the local and site suitability scale level, the considered site selection criteria include 5 components, namely, hydrology, hydrogeology, water quality, land use, and provincial water supply production capacity as categorized, scored and weighted in Table 1. Based on the scoring and weighting of the selection criteria, there are twelve potential areas as indicated in Fig. 6. Subsequently, the RBF system key performance parameters for preliminary RBF system will be systematically analyzed for designing and constructing for the first two sites in the phase II. The site investigation data determined from this stage of data acquisition as shown in Figs. 7, 8 and 9 are representing one of the detailed case studies (Kamphaengphet area).

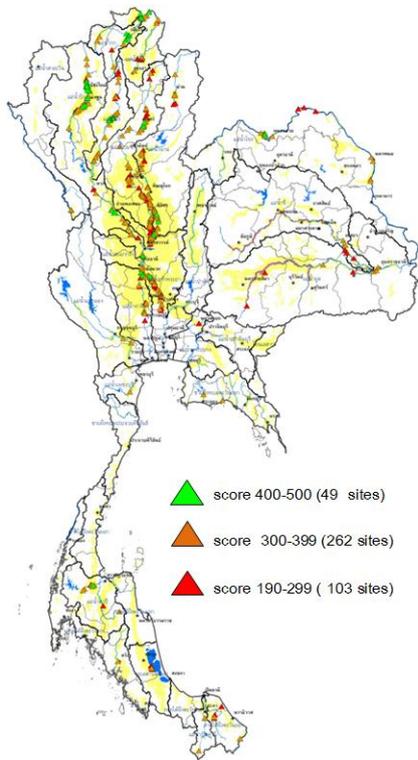
**Table 1 Scoring and weighting of selection criteria**

| Type     | Selection Criteria                                       | Unit             | Score              |             |             | Weight |
|----------|--|------------------|--------------------|-------------|-------------|--------|
|          |  |                  | 1                  | 3           | 5           | 100    |
| <b>1</b> | <b>Hydrology</b>   |                  |                    |             |             |        |
| 1.1      | River Flow Velocity                                      | m/sec            | 0.5-1              | 1-1.5       | ≥ 1.5       | 10     |
| 1.2      | River Flow Duration                                      | Month            | 9                  | 10-11       | 12          | 15     |
| <b>2</b> | <b>Hydrogeology</b>                                      |                  |                    |             |             |        |
| 2.1      | Aquifer Thickness  | m.               | 10 – 14.9          | 15 – 19.9   | ≥ 20        | 20     |
| 2.2      | Aquifer permeability                                     | m./day           | 1 – 4.9            | 5 – 9.9     | ≥ 10        | 10     |
| <b>3</b> | <b>Water Quality</b>                                     |                  |                    |             |             |        |
| 3.1      | Surface Water  | Water Type       | 4                  | 3           | 1 - 2       | 5      |
| 3.2      | Groundwater (TDS)  | Mg/l             | 601 - 1,500        | 301 - 600   | ≤ 300       | 10     |
| <b>4</b> | <b>Landuse (RBF system construction site)</b>            | Landuse Type     | Community/industry | Agriculture | Open/public | 5      |
| <b>5</b> | <b>Water Supply Production (Provincial Water Supply)</b> |                  |                    |             |             |        |
| 5.1      | Raw water shortage                                       | Month            | < 1                | 1 - 3       | ≥ 3         | 5      |
| 5.2      | Present Water Supply Production                          | mil. cu.m. /year | <1                 | 1-5         | ≥ 5         | 20     |

## CASE STUDY

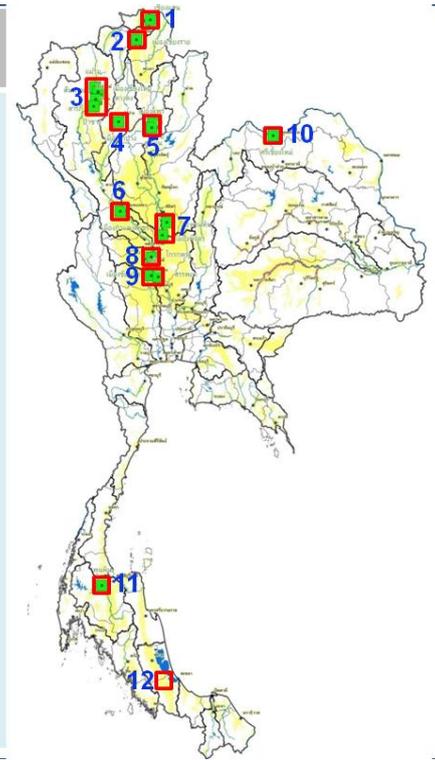
Kamphaengphet area (No. 6 in Fig. 6) was selected by a ranking procedure, where the detailed study including hydrologic and hydrogeologic investigations was conducted. The Ping River is the major river flowing across Kamphaengphet Province which is located in Central Thailand. Hydrologic investigation consists of the study of river morphology, infiltration tests (field and laboratory), stream profile measurements and water quality sampling as shown in Fig. 7. There are 32 observation wells (diameter of 2 inches) and 12 test wells (6 inches), pumping tests and quantity and quality monitoring of surface and groundwater was conducted over the area of 70 km<sup>2</sup> during the year 2011. A hydrogeologic map under a scale of 1:50,000 was constructed in order to evaluate the yield of shallow groundwater and interaction between river water and shallow groundwater. Subsequently, detailed physical and chemical parameters were analyzed and then a numerical flow model was applied to determine the available yields of groundwater and the behavior of interaction of river water and groundwater. Moreover water demand from Provincial Waterworks Authority of Kamphaengphet Province and initial engineering design, public hearing and SWOT analysis

(Strength, Weakness, Opportunity and Threat) from the local communities will be evaluated for the final site selection prior the construction phase (Phase II).



**Fig. 5** Locations of the potential areas for RBF feasibility study

| 12 Delineated for potential RBF system |                                 |
|--|---------------------------------|
| 1.                                     | Chiangsan, Chiang Rai Province  |
| 2.                                     | Muang, Chiang Rai Province      |
| 3.                                     | Chiang Mai-Lam Phoon Province   |
| 4.                                     | Muang, Lam Phang                |
| 5.                                     | Muang, Phrae Province           |
| 6.                                     | Muang, Kamphaengphet Province   |
| 7.                                     | Muang, Phichit Province         |
| 8.                                     | Krokphra, Nakhonsawan Province  |
| 9.                                     | Muang, Chainat Province         |
| 10.                                    | Srichiangmai, Nongkhai Province |
| 11.                                    | Phoon Phin, Suratthani Province |
| 12.                                    | Hat Yai, Songkhla Province      |



**Fig. 6** Twelve areas delineated for potential RBF system detailed feasibility study and design  
Case study: Kamphaengphet Area

## SUMMARY AND CONCLUSIONS

RBF has the potential to supply water to numerous cities around the world. Many cities are currently using surface water that is often of poor quality. Gradual conversion of surface water intakes to bank filtration can help improve the water quality. The development of the site selection criteria for the RBF system was initially commenced by identification of selection criteria for regional area scale site selection and then zoom-in into the local area scale level and finally to the site and location scale level. The established key performance criteria for the RBF system site selection include 5 groups of data sets, namely; hydrology, hydrogeology, water quality, land use in the construction site, and water demand. Once the potential sites or locations for the RBF system are finally selected, a detailed field investigations program was made for the RBF site characterization. The obtained site parameters will be used for preliminary RBF system design and pilot construction.

By the way, RBF system is a new technology of conjunctive use of surface and groundwater resources for Thailand. RBF also offers an innovative solution for water resources management of the project. It offers many advantages in terms of low cost, simplicity, robustness etc. A successful project depends upon strong technical understanding combined with support by government, water authorities and communities.

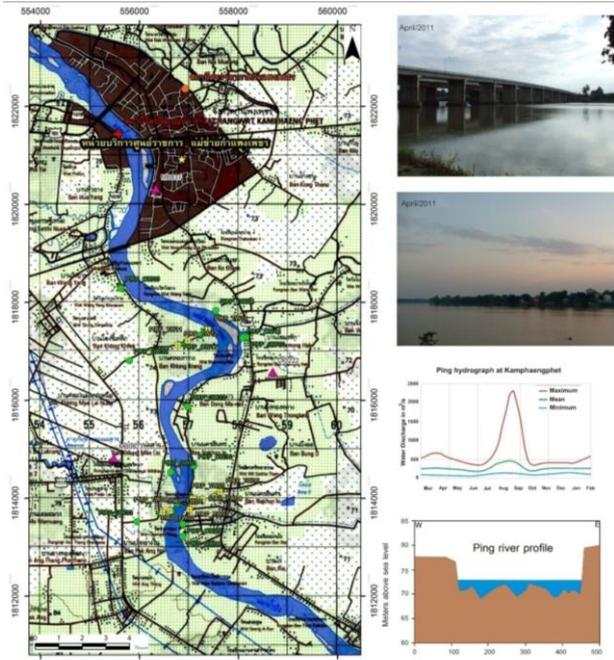


Fig. 7 Topography and hydrology of Kamphaengphet area

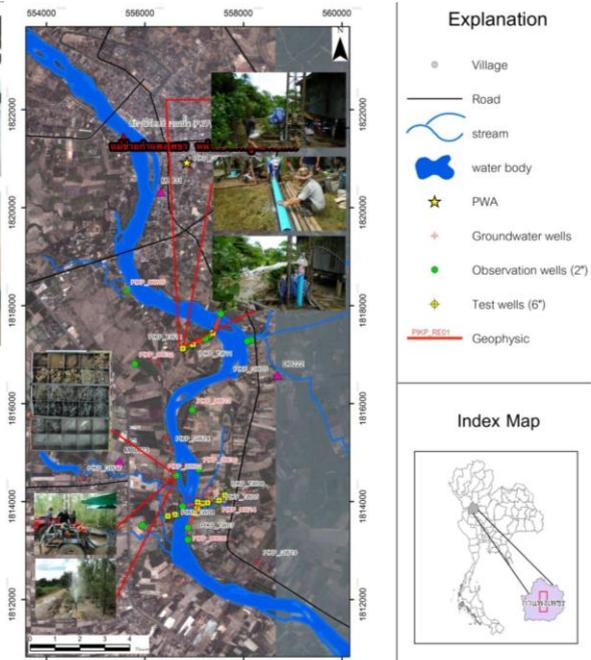


Fig. 8 Hydrogeologic investigations: observation well and test well drilling and monitoring

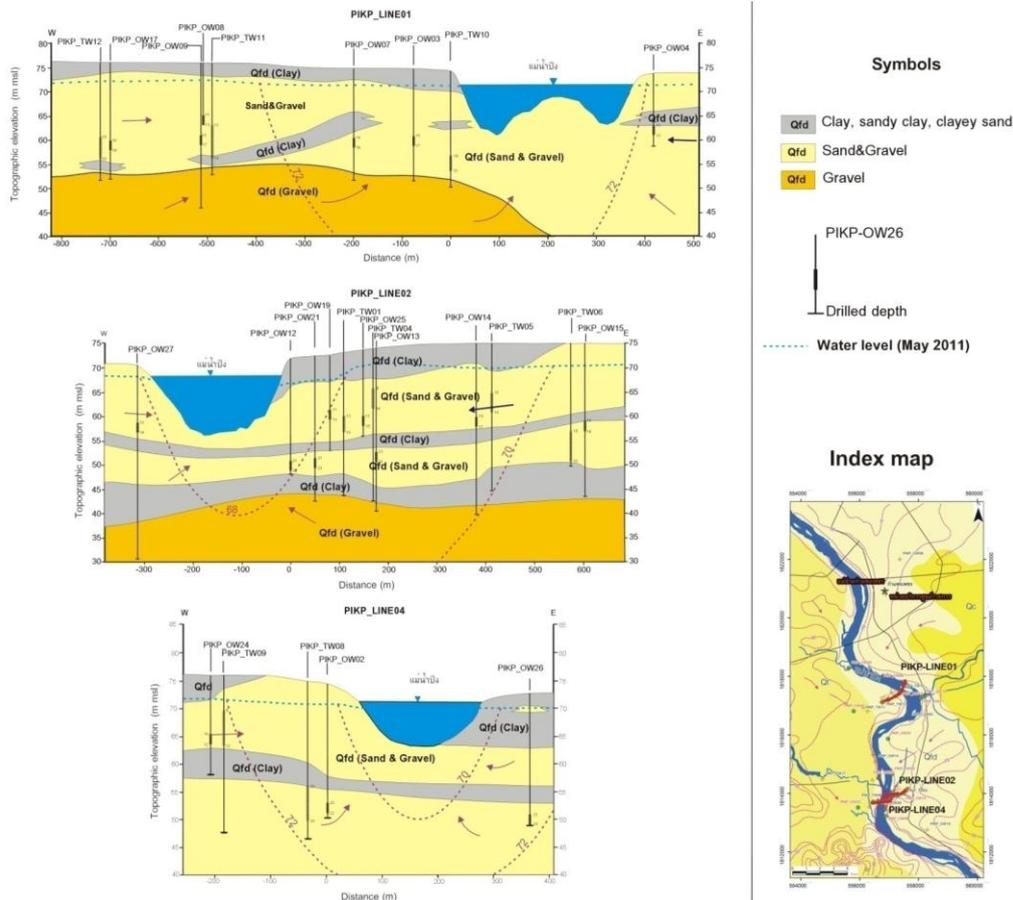


Fig. 9 Hydrogeologic cross sections of the potential RBF site (Kamphaengphet Area)

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