出國報告（出國類別：國際會議）

會議名稱：

第八屆國際水文地質協會與第37屆國際水文地質學家會議

8th Scientific Assembly of the International Association of Hydrological Sciences (IAHS) and the 37th Congress of the International Association of Hydrogeologists (IAH)

發表論文題目：

口頭發表

應用地下水補注評估地下水環境復育之研究

The evaluation of groundwater environmental restoration by artificial recharge in Pingtung Plain, Taiwan

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派赴國家：印度 海德拉巴**(Hyderabad)**

出國期間：**98** 年 **9**月 **5~10** 日

報告日期：**98** 年 **9** 月 **24** 日

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一、摘要

國立屏東科技大學屏東科技大學坡地防災暨水資源工程研究所博士生：杜永昌，出席印度-海德拉巴(Hyderabad)2009-8th Scientific Assembly of the International Association of Hydrological Sciences (IAHS) and the 37th Congress of the International Association of Hydrogeologists (IAH)並口頭發表論文。

二、議題

國際水文地質協會International Association of Hydrological Sciences與國際水文地質學家會議International Association of Hydrogeologists爲目前國際上對於水文地質及地下水資源特別重視的單位，2009年國際性重要學術研討會於印度聯合舉辦。主要目的爲聚各國水文地質科學專家學者們發表近年的研究成果，及討論目前針對全球氣候變遷之議題，對於未來如何因應。

本次 2009是由印度，地球物理研究院（National Geophysical Research Institute, Hyderabad, India,）主辦，此次研討會主題如下：

Joint Symposia and Workshops of IAH and IAHS

◎Joint Symposia (JS.1-4)

1. Ecohydrology of surface and groundwater dependent ecosystems: Concepts, methods and recent developments.
2. Trends and sustainability of groundwater in highly stressed aquifers.
3. Improving integrated surface and groundwater resources management in a vulnerable and changing world.
4. Hydroinformatics in hydrology, hydrogeology and water resources.

◎Joint Workshops (JW.1-4)

1.Measuring and modelling interactions between surface water and groundwater

2.Transboundary Water Management : Science and policy

3.Rural and urban water systems: Minimising adverse impacts of global change on water resources

4.Isotope tracing for water balance, hydrodynamics and hydrological processes, including groundwater recharge, as an indicator of water resources sustainability.

IAHS Symposia and Workshops

◎Symposia (HS.1-2)

1.High mountain snow and ice hydrology

2.New approaches to hydrological prediction in data sparse regions

◎**Workshops (HW. 1-8)**

1. Regionalisation of models for operational purposes in developing countries
2. Sediment problems and sediment management in Asian river basins
3. Flood risk management
4. Space-time scaling for ET and soil moisture modelling using remote sensing
5. Prediction in ungauged basins ? a benchmark report
6. Precipitation variability and water resources
7. New statistics in hydrology
8. Hydrological theory and limits to hydrological predictability in ungauged basins

共計四大主題與18領域，經由出席本次國際研討會會議，能獲得更多目前國際水文地質領域之研究重點，提供未來國內研究方向與資訊。The Scientific program of the convention includes four joint symposia (JS 1-4) and four joint workshops (JW 1-4), two IAHS symposia (HS. 1-2), four IAHS workshops (HW. 1-8) and four IAH symposia (G 1-4), all focusing towards exploring the possibility of how science can help to handle the present and future water related issues.

三、參加會議

2009 年第八屆國際水文地質協會與第37屆國際水文地質學家會議於民國98 年 9 月 6~10 日在印度-海德拉巴舉行。學生總共口頭發表1篇論文，題目：The evaluation of groundwater environmental restoration by artificial recharge in Pingtung Plain, Taiwan。主要內容提出屏東平原地下水資源於台灣南部區域扮演著極重要的供水水源角色，經由分析實施地下水人工補注後，評估對於地下水環境的改善效益，不僅可對於長久以來屏東平原含水層負面行爲(如地下水位持續下降、海水入侵、地層下陷等)得以復育，更可藉由監測系統的規劃實施，量化所改善之地下水環境，並可作爲最適之水資源永續開發利用與管理保育的依據，利用MODFLOW模式模擬評估，於上游地區地下水補注與中游地區開發抽水量之相互機制。

98 年 9 月 5 日7：55分桃園國際機場搭乘泰國航空出發 (含曼谷轉 機 10 hr)至印度海德拉巴22：55分。9月6日學生前往 Hyderabad International Convention Centre研討會場報到並領取研討會資料(議程及論文摘要隨身碟一只)，研討會於9月6日下午5:30~8:45 由大會主席 Dr. V. P. Dimri, 主持開幕式，隨後即展開 5 天之研討會議程，包含相關議題演說(相關議題可參考附錄二)。學生於9月8日(星期二)上午 10:45~11: 時段進行口頭發表於JS 3.Improving integrated surface and groundwater resources management in a vulnerable and changing world領域(相關議題可參考附錄三)。

四、與會心得

台灣在此次研討會既有本校參與，2位學生與會，共發表 1 篇論文（口頭發表）。此次為學生第一次至印度參加國際研討會，亞洲地區日本與泰國皆有參與經驗，亞洲地區國家英文普遍能力遠超越台灣，且國際研究發展的能力較為快速。因此，未來應積極參與相關國際研討會議。

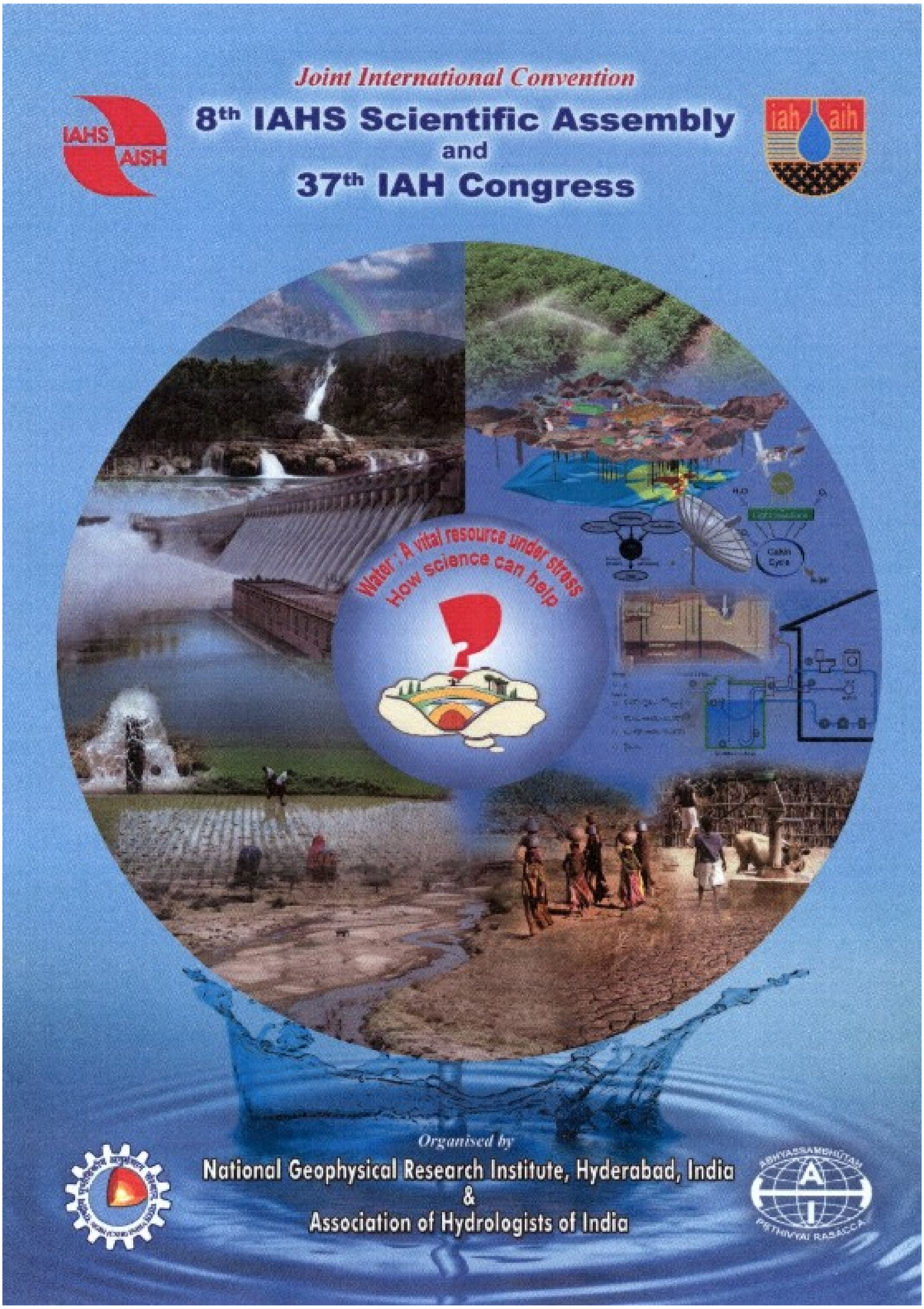
五、建議

首先感謝教育部及本校補助學生往返印度參加 2009 年第八屆國際水文地質協會與第37屆國際水文地質學家會議之部分機票費用（13,600 元），使學生能順利參加。本次參加研討會中，藉由聽取其他專家學者之專題演講及海報展示獲得許多經驗及資訊。最後，希望教育部能增加補助博士班研究生出國參加國際學術研討會費用之上限（本次出國含機票費 13,600 元，合計達 13,600 元）與名額，因國內博士國際視野普遍不足應朝向多鼓勵學生出國發表學術文章之機會，除可讓台灣學生在國際上展現傑出研究成果外，亦可以拓展博士班學生之 國際觀，並提升語文能力。

六、攜回論文集

2008 European Aerosol Conference Program 及論文摘要光碟一只。

附錄 一 論文手冊


Joint International Convention
8th IAHS Scientific Assembly
and
37th IAH Congress
IAHS AISH
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Water : A vital resource under stress
How science can help
Organised by
National Geophysical Research Institute, Hyderabad, India
&
Association of Hydrologists of India

附錄二 特別演說

Inaugural Lecture By Ghislain de Marsi Freshwater Stocks on Earth as Ice, Surface water, Ground Water: Are we Loosing Water?
Special Lecture By Stephen Foster Hard Rock Aquifers in Tropical Regions- Using Science to inform Development and Management Policy
Invited Talks
Towards a rational water management and utilization of water resources in arid zones: Application to the integrated management of water resources of various qualities in the Jordan Rift Valley J. Guttman, H. Hotzl, J. Bensabat, L. Wolf and T. Milgrom
Managing Aquifer Recharge and Discharge to Sustain Irrigation Livelihoods under Water Scarcity and Climate Change Peter Dillon
Whole System Modelling and Hydroinformatics Ian Cluckie and Yangbo Chen
Eco-Environmental Drivers in Hydrology: how hydroinformatics can help Arthur Mynett
Harnessing Hydrological Systems Knowledge fro Improved Water Resource Management in Water Stressed Cities like Singapore Vladan Babovic and Raghuraj Rao
Hyporheic controls on groundwater-surface water exchange and nutrient transport and transformation in lowland vs. upland rivers Stefan Krause, Staffordshire
Environmental Management Plan for Development of Sustainable Hydrological Regime in New Urban Node at Tellapur, Greater Hyderabad L. Surinaidu
Three decades of scientific development of hydrology-how has this helped to ameliorate transboundary water related conflicts. Alice Aureli and Bhanu Neupane
Source to Sink of Sediments from Mountainous Rivers in Taiwan Shuh-Ji-Kao, Kandasamy Selvaraj and J.D. Mlliman
An Overview on Sediment Problems and Management in Iran S.H.R. Sadeghi
Sediment problems and sediment management in the Indian Sub – Himalayan region Umesh Kothyari

附錄三 相關議程

Joint Symposia (JS 1-4)	Joint Workshops (JW 1-4)	IAHS Symposia (HS 1-2)	IAHS Workshops (HW 1-8)	IAH symposia (G 1-4)
JS1: Ecohydrology of surface and groundwater dependent ecosystems: Concepts, methods and recent developments	JW1: Measuring and modelling interactions between surface water and groundwater	HS1: High mountain snow and ice hydrology	HW1: Regionalisation of models for operational purposes in developing countries	G1:Groundwater resources development in hard rock terrains
JS2: Trends and sustainability of groundwater in highly stressed aquifers	JW2: Transboundary Water Mangement: Science and Policy	HS2: New approaches to hydrological prediction in data sparse regions	HW2:Sediment problems and sediment management in Asian river basins	G2:Groundwater quality and pollution in hard rock aquifers
JS3:Improving integrated water resources mangement, including groundwater, in a vulnerable and changing world	JW3: Rural and urban water systems: Minimising adverse impacts of global change on water resources	-	HW3: Flood risk management	G3:Groundwater resource management in hard rock areas
JS4: Hydroinformatics in hydrology, hydrogeology and water resources	JW4: Isotope tracing for water balance, groundwater recharge, hydrodynamics and hydrological processes as an indicator of water resources sustainability	-	HW4: Space-time scaling for ET and soil moisture modelling using remote sensing	G4:Socio-economic issues relevant to groundwater in hard rock areas
-	-	-	HW5: Prediction in ungauged basins - a benchmark report	-
-	-	-	HW6: Precipitation variability and water resources	-
-	-	-	HW7: New statistics in hydrology	-
-	-	-	HW8: Hydrological theory and limits to hydrological predictability in ungauged basins	-

附錄四 論文全文

The evaluation of groundwater environmental restoration by artificial recharge in Pingtung Plain, Taiwan

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Abstract Pingtung Plain has abundant groundwater resources. The overall study objective focuses on groundwater restoration. In this study, MODFLOW was applied to evaluate the groundwater recharge dynamics between the recharge in the upstream reaches and pumping in the downstream reaches. Using the simulation model, the results show that storage of the groundwater increased by 683 266 m^3/year and 2 471 765 m^3/year and the groundwater table has risen 0.91 m and 1.21 m in Kaoping Lake and Wanlung Lake, respectively. From the view of STORAGE Change, the Wanlung Lake was found to be the most suitable area for constructing the artificial lake for artificial recharge. The variation of the groundwater storage of the aquifer is an important factor in artificial recharge. Managing artificial groundwater recharge can provide for shortages of good quality surface water during flood season, caused by higher turbidity, and conjunctive water use of surface and groundwater resources in the future.

Keywords artificial recharge of groundwater; MODFLOW; simulation

INTRODUCTION

Pingtung Plain is located in southern Taiwan and extends approximately 1210 km^2.There is a very high annual rainfall in this area; however, the amount of rainfall received varies significantly over the course of the year. In terms of measurement data, 90% of the annual precipitation falls during the rainy season (i.e. May to September) while only 10% of the rainfall occurs during the dry season (October to April). This uneven distribution in the monthly rainfall poses a major problem to the planners involved in the protection and utilization of water resources in Pingtung Plain. As a result of the hypsographical variation, the water resources are not readily stored into aquifer, but tend to flow rapidly into the ocean. Consequently, the utilization rate of surface water resources is limited in Taiwan. However, the thriving aquaculture found along the southwestern coastal areas of Taiwan is dependent on availability of abundant freshwater. In most cases, this freshwater has been supplied by the intensive pumping of groundwater. This has led to a drop in the local groundwater level, and in severe cases has resulted in land subsidence and seawater intrusion.

The results of previous studies in artificial recharge of groundwater have indicated that the groundwater environment can be improved and restored (Bouwer, 1999; Ting *et al*., 2002; CTCI, 2002; Yang, 2006). The overall study objective focuses on groundwater restoration. In this study, MODFLOW was applied to evaluate the groundwater recharge dynamics between the recharge in the upstream reaches and pumping in the downstream reaches.

STUDY AREA AND METHODOLOGY

Geographical location

Pingtung Plain is located in southern Taiwan. There are nine groundwater sub-regions from north to south, and these are mostly in the south (SRWRO, 2005). It mainly comprises the flat area of the catchments of the Kaoping, Tungkang and Linpeing rivers. The regional area covers in total 25 counties in Pingtung and Kaohsiung cities. This elongated plain covers an area of 1210 km^2, being 22 km wide in an east–west direction and 55 km long the north–south direction. The groundwater sub-region of Pingtung Plain is mainly in the east and close to the Central Mountain (Fig. 1).

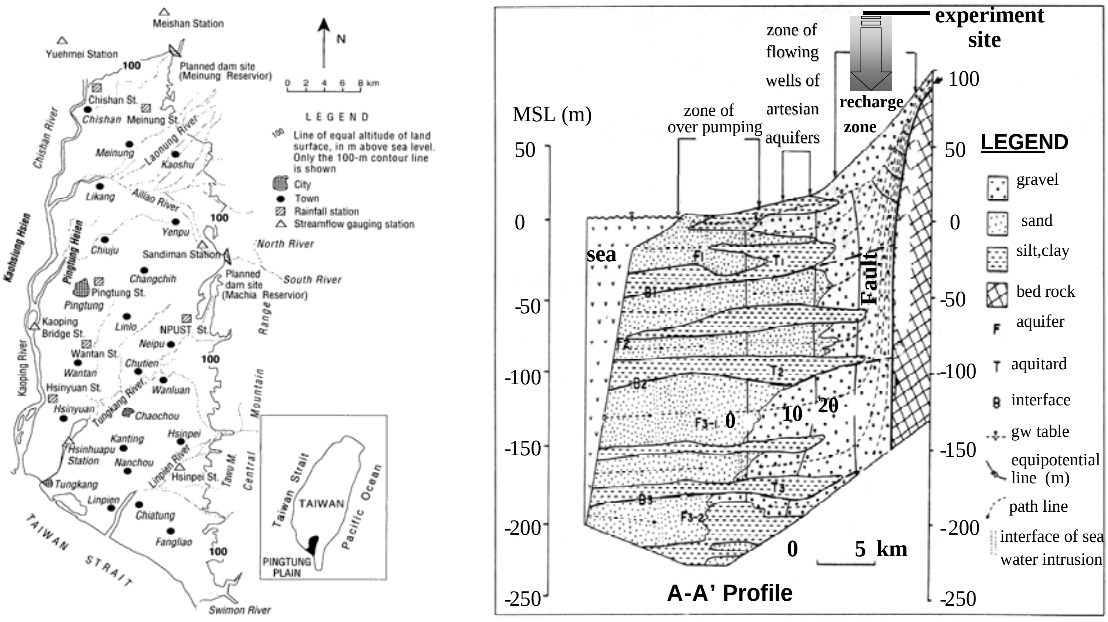


Fig. 1 Location of study area in Pingtung Plain, Taiwan, and geological profile (Ting, 1997).

Climatic regime

The climate of Pingtung Plain is sub-tropical; rainfall is alternately affected by typhoons in summer, producing most of the rainfall. The rainy seasons lasts from May to September. The groundwater of Pingtung Plain mainly comes from rainfall then through infiltration into the aquifer in the mountains and, consequently, the groundwater table is higher during the rainy .

The maximum average rainfall is 3146 mm, 2980 mm, 2246 mm, 2152 mm, 2249 mm and 2460 mm in the Laonung, Ailliao, Chishan, Kaoping, Tungkang and Linpien river basins, respectively. The maximum average wind speed is 5.0 m/s in November and the minimum is 2.6 m/sec. Average annual temperature in Pingtung is 25.2°C. Average annual evaporation is about 1723 mm.

Surface water

The Pingtung Plain mainly comprises flat areas of the Koaping, Tungkang and Linpien river catchments, as well as several small streams; the three main rivers finally flow into the Taiwan Strait. In the *Yearbook of Hydrology* (Water Resources Agency, 2007) the Ministry of Economic Affairs show the average annual discharges as approx. 6330 Mm^3 for Koaping River, 952 Mm^3 for Tungkang River and 728Mm^3 for Linpien River. Other parameters are given in Table 1.

In this study, MODFLOW was applied to evaluate the groundwater recharge dynamics between the recharge in the upstream reaches and pumping in the downstream reaches. The results from groundwater model are then used to manage and deploy the water resources of Pingtung Plain, as below:

Table 1 River and hydrological characteristics in Pingtung Plain (WRA, 2007).

River	Inflow Location	Elevation (m)	Outflow location	Length (km)	Average slope	Basin area (km^2)	Average rainfall (mm)	Average discharge (Mm^3)
Koaping	Mt. Morrison	3997	Hsinyuan	171	1/150	3 256	2 547	6 330
Tungkang	Ailliao	1138	Tungkang	44	1/500	472	2 093	952
Linpien	Central Mt.	2880	Linpien	42	1/15	344	3 314	728

Model description

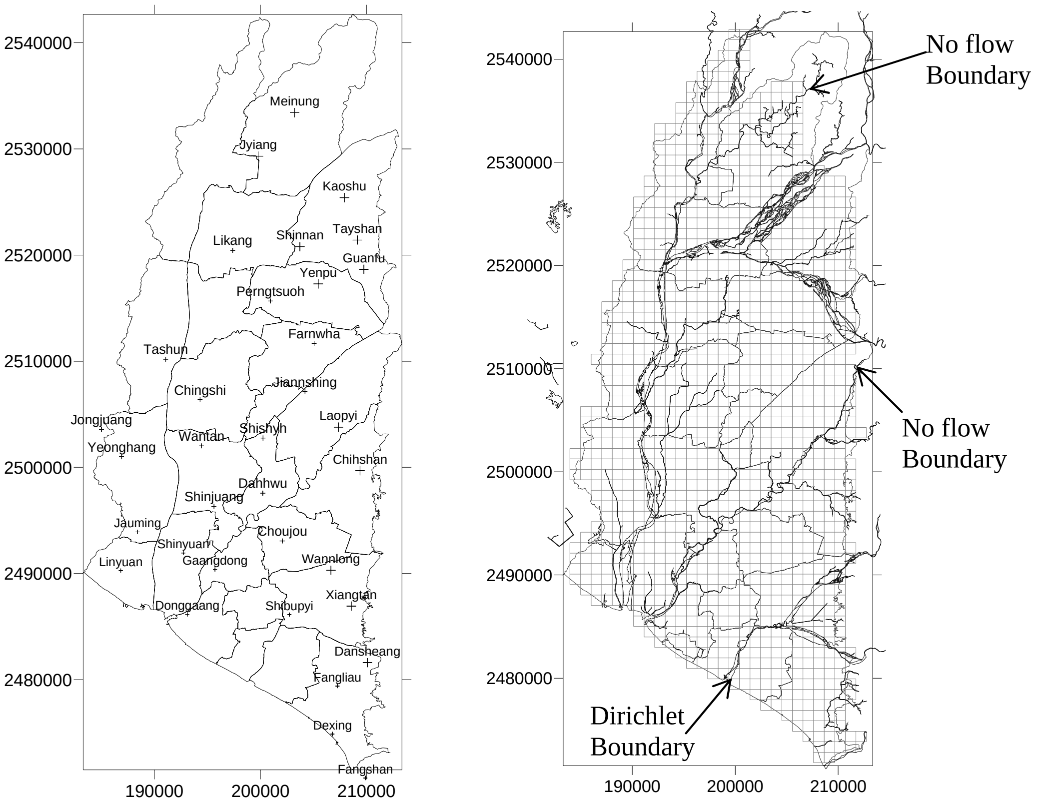
Defining a conceptual structure of the groundwater system is a necessary prerequisite to numerical simulation **(**SRWRO, 2007). The main purpose is to simplify the field problem and frame the associated field data, through the conceptual model to create a rational quantification with hydrogeology and hydrological stresses (Ting, 1997). The hydrological stresses which need to be considered when simulating groundwater flow in the plain, such as: abstraction from wells, precipitation, recharge,interaction with river, evapotranspiration and boundary condition.

Model construction

An important tool to characterize the aquifer is its hydrogeological profile, which was prepared for by the central Geological Survey and Ministry of Economic Affairs, WRA. (2001). Figure 2 shows the observation wells; in total there are 52 aquifer monitoring stations and 127 wells set up in Pingtung Plain which provide the hydrogeological and observation data for the conceptual model.

Model grid and aquifer system

There are seven layered hydrogeological units in the aquifer, reaching down to about 220 m depth, to relate to the aquifer system data (Table 2) and observation wells as Fig.2 (a). Actually, the conceptual model can be simplified into a three-layer system: the first layer was defined as unconfined aquifer, and the second and third were defined as unconfined/confined interactive aquifer. Based on data availability and hydrogeological conditions, the grid spacing in both the x and y directions is 1000 m. The aquifer system is bounded by mountains in the north and east, by Funshin Hill in the west and by Taiwan Strait in the south as Fig. 2 (b).



(a).observation wells (b). boundary

Fig. 2 Location of observation wells and boundary conditions in Pingtung Plain. Check text boxes

Table 2 The depth of hydrogeological layers in study area (unit: m).

Toponym	Layer: F1	T1	F2	T2	F3-1	T3	F3-2
Linyan	44.5	22	14.5	24	68	0	57
Sipu	37	13	54	10	52	0	0
Jongjuang	54.5	0	65.5	0	78	6	6
Chingsi	47.5	0	57.5	4	89	6	6
Datan	40	5.5	44.5	15	70	7	48
Sinjhuang	31	27	43	0	81	0	28
Likang	44.5	0	79.5	0	81	0	5
Wanluan	53.5	5	54.5	13.5	49.5	22	12
Jiansing	51	0	64	0	83	3	11
Xishi	36.5	8.5	63	0	65.5	16	21.5
Shibupyi	23.5	23.5	45.5	23	62.5	18	15
Wannlong	80.5	6.5	50.5	0	72.5	0	0
Shinuan	26.5	18.5	38	12	80	0	35
Keefung	30	19	42	10	83.5	0	45.5
Majia	83.5	0	62.5	0	64	0	0
Chanliao	57	0	47	0	57.5	19	39.5
Yeonghang	62	0	41.5	6	70.5	4	36
Chunchou	43	0	79.5	0	82.5	0	15
Meinung	43	0	27	0	0	0	0
Haifong	52.5	0	62.5	0	89	6	10
Choujou	27	31.5	47.5	0	74	0	40
Konggang	33	29	22.5	16.5	73	0	46
Wantan	52	0	48	4.5	70	25.5	20
JiuRu	47	0	65	8	84	0	16
Yenpu	65	0	67	0	78	0	0
Kaoshu	80	0	72	0	46	0	0
Tayshan	65	0	70	0	75	0	0
Nei-Pu	45	7.5	59.5	0	68	7	23
Laopi	45	10.5	61.5	0	73	0	20
Dansheang	86	0	9	0	0	0	0
Dansheang	67	9.5	59.5	0	4	0	0
Fangshan	73	0	51	0	80	10	6
TaChung	47.5	8.5	51	0	84	0	29
Kanding	37.5	17.5	30	23.5	76.5	0	35
Fangshan	36	0	0	0	0	0	0

RESULTS AND SIMULATION

Water balance

The results of the water budget are given in Table 3. In term of the results, the well abstraction was approx. 1330 Mm^3/year. The river leakage into the aquifer was approx. 201 Mm^3/year, and the aquifer outflow to the river was approx. 167 Mm^3/year. The water balance clearly indicates that recharge is principally derived from precipitation on the plain and lateral inflow from numerous mountains and slopes during the rainy period.

Case study

The purpose of the case studies is evaluation of recharge so that we obtain the best simulations for the well abstraction study. Because of the artificial recharge of groundwater in the upstream area, the groundwater can be used downstream. The sites chosen for simulation are Kaoping Lake site and Wanlong Lake site, as shown Fig. 3.

Table 3 Groundwater balances for Pingtung Plain in 2000 (m^3/year).

-	Inflow	Outflow
Storage Change	827 284 670	889 898 716
Outside area	16 660 865	7 395 217
Well abstraction	0	1 338 587 726
Lateral inflow mountain	959 322 179	0
Precipitation	447 691 061	0
Evapotranspiration	0	48 501 500
River exchange	201 306 593	167 298 860
Total	2 452 265 369	2 451 682 019

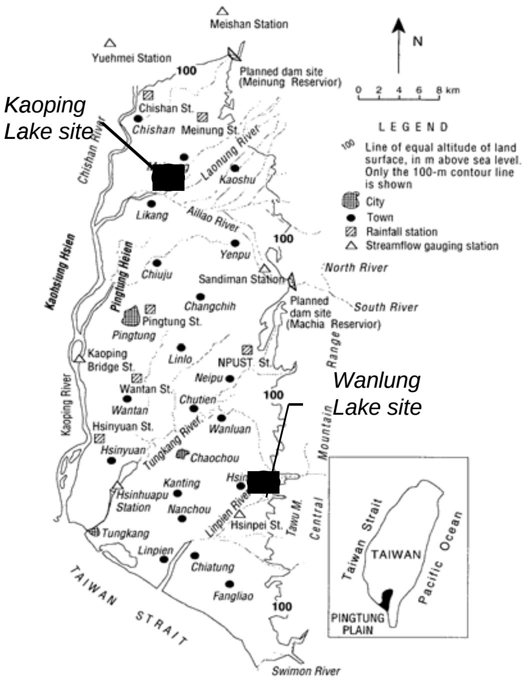


Fig. 3 Locations of the Kaoping Lake and Wanlung Lake. **Map is essentially same as in Figure 1. Is it essential?** **A: the map showed the site of pilot study, I hope to keep the map in here.**

Case study A

In study A, the hypothesis is of artificial recharge in the rainy season (June to August) on Kaoping Lake; the simulation condition was 345 000 m^3/day recharged into aquifer. In addition, these studies hypothesize that there are two flow lines of aspect to analyse water level variation in downstream, then to evaluate the water balance, as shown Fig. 4. The groundwater variation was effected by the artificial recharge, with an average rise of 0.91 m and the aquifer storage increased by 683 266 m^3/year, as shown Table 4 and Fig. 5, respectively.

Case study B

In the case of study B, the hypothesis is implementation of artificial recharge in the rainy season (June–August) on Wanlung Lake; 400 000 m^3/day recharged into the aquifer. In addition, these studies hypothesize that there are three flow lines of aspect to analyze water level variation in downstream, then to evaluate water balance by the way, as shown Fig. 6. The groundwater variation was effected by the artificial recharge; the average rise was 1.21 m and the storage change was an increase of 2 471 765 m^3/year in the aquifer. The results are illustrated in Table 5 and Fig. 7.

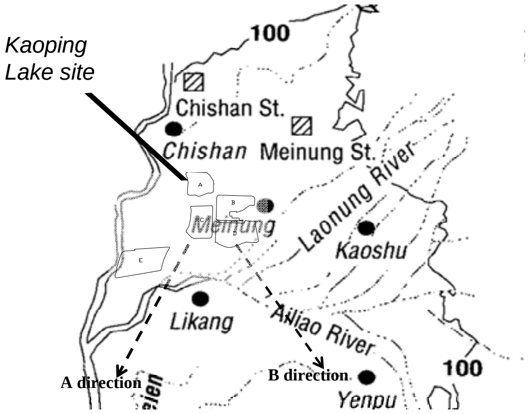


Fig. 4 Location of Kaoping Lake in Pingtung Plain.

Table 4 The variation of groundwater in downstream (unit: m).

Flow lines	Position of observation	June	August	October	December
	Downstream 2000m	1.16	4.43	3.45	2.4
A	Downstream 5000m	0.24	1.01	1.32	1.33
	Downstream 10000m	0.078	0.145	0.285	0.427
	Downstream 2000m	1.66	4.18	2.99	2.22
B	Downstream 5000m	0.065	0.46	0.73	0.79
	Downstream 10000m	0.014	0.024	0.102	0.175

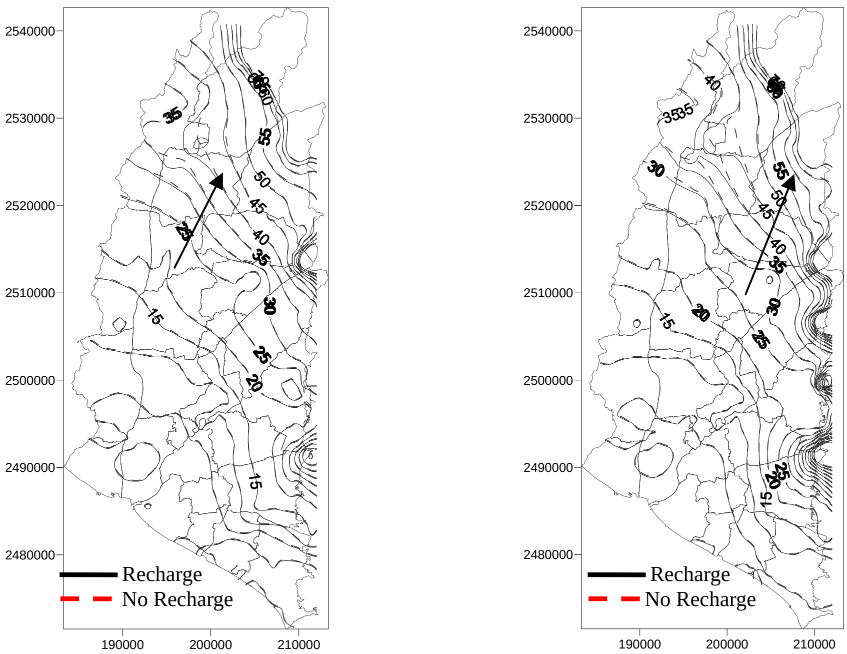


Fig. 5 Contour maps of recharge for layer 1.

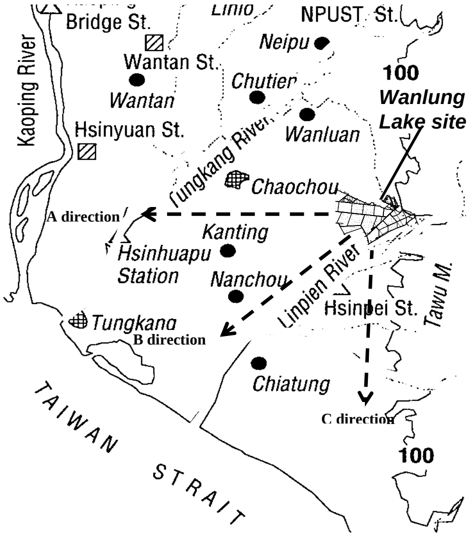


Fig. 6 Location of Wanlung Lake in south of Pingtung Plain.

Table 5 the variation of groundwater in downstream (unit: m)

Flow lines	Position of observation	June	August	October	December
	Downstream 2000m	2.98	3.34	1.62	1.12
A	Downstream 5000m	0.67	1.52	1.23	0.94
	Downstream 10000m	0.0019	0.023	0.073	0.132
	Downstream 2000m	1.91	2.45	1.51	1.09
B	Downstream 5000m	0.06	0.38	0.59	0.64
	Downstream 10000m	0.0012	0.009	0.026	0.05
	Downstream 2000m	3.02	2.85	1.65	1.15
C	Downstream 5000m	0.34	1.0	1.04	0.93
	Downstream 10000m	0.05	0.23	0.35	0.41

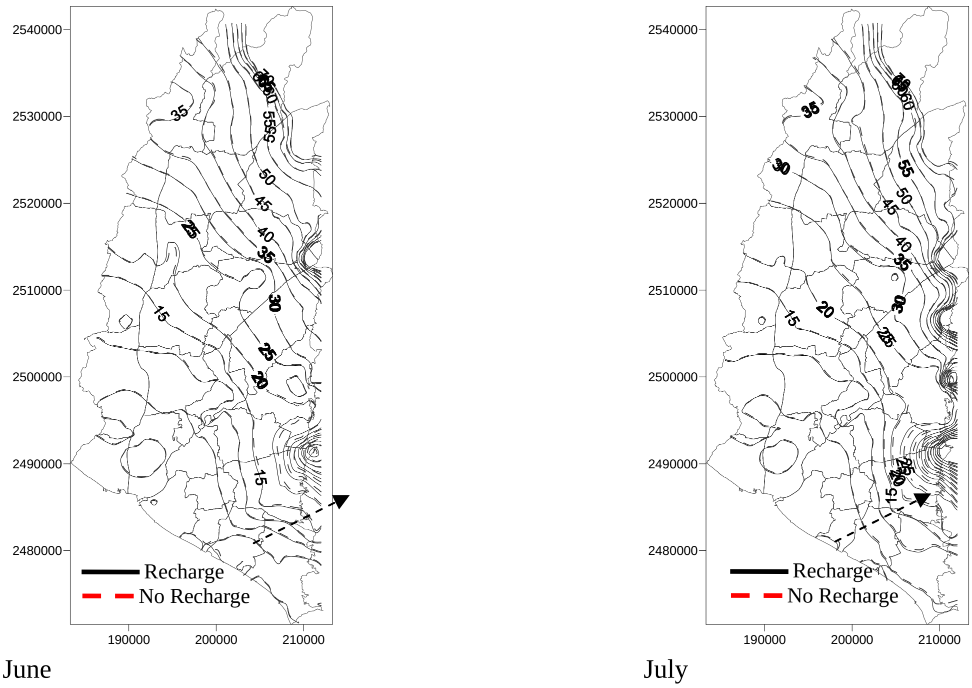


Fig. 7 Contour maps of recharge for layer 1.

CONCLUSIONS

Using the simulation model, the results show that the storage of the groundwater increased by 683 266 m^3/year and 2 471 765 m^3/year and groundwater table has risen by

0.91 m and 1.21 m in Kaoping Lake and Wanlung Lake, respectively. From the point of view of storage change, Wanlung Lake was the most suitable area to construct the artificial lake, and more so than Kaoping Lake. The variation of groundwater and storage in the aquifer are important factors in artificial recharge.

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REFERENCES

Bouwer, H. (1999) Artificial recharge of groundwater: system, design, and management. In: *Handbook of Hydraulic Design* (ed. by L. W. Mays), chapter 24. McGraw-Hill.

Central Geological Survey MOEA (1994) Hydrogeological Map of Pingtung Basin, Taiwan.

CTCI Corporation Taiwan (2002) Integrated Plan of Water Resources Development and Protection for Pingtung County and Groundwater Recharge of Groundwater Project at the Proximal Fan of Linpien Alluvial Plain, Taiwan. Project Report. Pingtung County, Taiwan. (in Chinese with English abstract).

Southern Region Water Resources Office (SRWRO) (2005) Pilot Study on Artificial Recharge of Groundwater for Pingtung Plain (1/3), WRA, MOE, Taiwan.

Southern Region Water Resources Office (SRWRO) (2007) Pilot Study on Artificial Recharge of Groundwater for Pingtung Plain (3/3), WRA, MOE, Taiwan.

Ting, C. S. (1997) Groundwater Resources Evaluation and Management for Pingtung Plain, Taiwan. PhD Thesis, Free University of Amsterdam, The Netherlands. ISBN 909008794x.

Ting, Cheh-Shyh, C.Y. Lin, C.H. Chuang and C.C. Liu 2002, Pilot Study for Artificial Recharge of Groundwater in High-Infiltration Basin, Proceedings of 4th International Symposium on Artificial Recharge of Groundwater, Adelaide, Australia, A.A. Balkema publishers Rotterdam. Pp.479-484.

Water Resources Agency (2007) *The Restoration of Groundwater Environment and Monitoring Planning System for Pingtung Plain*. MOE, Taiwan.

Yang, H. K. (2006) Clogging effect on artificial recharge of groundwater in the Pingtung Plain—a case study at Wanlong artificial lake. MSc Thesis, National Pingtung University of Science and Technology, Taiwan.

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Dear Mr. Tu,

On behalf of the Local Organizing Committee (LOC) of the Joint International Convention (JIC), we have great pleasure in inviting you to the 8th Scientific Assembly of the International Association of Hydrological Sciences (IAHS) and the 37th Congress of the International Association of Hydrogeologists (IAH) being held in Hyderabad during 6 – 12 September, 2009. Being an expert in the field of water resources your active participation in the JIC will be of immense value. With regard to the presentation of your research paper, we request you to kindly comply with the requirements and suggestions, being made by the Convener of your session. This invitation does not carry with it any offer of financial support.

We look forward for your active participation and meeting you in Hyderabad.

Yours sincerely,

P. Rajendra Prasad
Convener, LOC and
Vice-President, IAHS

S.N.Rai
Convener, LOC and
Vice-President, IAH

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