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Second report on shared natural resources: transboundary groundwaters

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Contents

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I. Introduction

1. The present addendum to the second report on shared natural resources is prepared in order to provide some technical and factual data on transboundary groundwaters. It includes aquifer models, case studies on selected regional aquifers and a selected bibliography.[1]

II. Aquifer models

2. The annex to the present addendum contains models of various aquifers. Case 1 shows a domestic aquifer that is outside the scope of the proposed convention. Case 2 shows a single transboundary aquifer. Case 3 shows a domestic aquifer hydrologically connected to an international watercourse, which would be covered both by the 1997 Convention and the proposed convention. Case 4 shows a transboundary aquifer system, consisting of a series of aquifers hydrologically connected. Case 5 shows a domestic aquifer whose recharge area is located in another State. In the instance of case 5, such an area might need to be subject to certain international regulations for proper management of the aquifer.

III. Case studies

A. Nubian sandstone aquifer system[2]

Geographical location

3. The Nubian sandstone aquifer system is one of the largest regional aquifer resources in Africa and in the world. It consists of a number of aquifers laterally and/or vertically connected, extending over more than 2 million square kilometres in the eastern part of the Libyan Arab Jamahiriya, Egypt, north-eastern Chad and the northern part of the Sudan. The Nubian aquifer is a strategically crucial regional resource in this arid region, which has only few alternative freshwater resources, a low and irregular rainfall and persistent drought and is subject to land degradation and desertification. Under current climatic conditions, the Nubian aquifer represents a finite, non-renewable and unrelated groundwater resource (the connection with the River Nile is negligible). Its filling process, that is when the recharge and discharge balance each other, is considered to have ended 8,000 years ago.

The aquifer system

4. The Nubian sandstone aquifer system can be differentiated into two major systems:

- The Nubian aquifer system

  This part of the system occurs all over the area and constitutes an enormous reservoir of water of excellent quality in its southern part and of hyper-saline water in the north. The system is under unconfined conditions south of parallel 25, and under confined conditions north of it. Its thickness ranges from less than 500 metres to more than 5,000. The calculated storage capacity of the Nubian aquifer system in both its unconfined and confined parts, within the four sharing countries, exceeds 520,000 cubic kilometres. The total volume of fresh groundwater in storage is approximately 373,000 cubic kilometres. The economically exploitable volume, estimated at 150,000 cubic kilometres, represents the largest freshwater mass and one of the most important groundwater basins in the world.

- Post-Nubian aquifer system

  This part of the system is located to the north of parallel 26 in the western desert of Egypt and the north-eastern part of the Libyan Arab Jamahiriya, and is under unconfined conditions. Its cumulative thickness is about 5,000 metres. The total volume of groundwater in storage in the post-Nubian aquifer system is 845,000 cubic kilometres, while the amount of fresh groundwater is 73,000 cubic kilometres. Low permeability layers separate the two systems.

Groundwater extraction

5. Groundwater from the Nubian sandstone aquifer system has been utilized for centuries from the oases all over the area through springs and shallow wells. However, as a result of population growth, food demand and economic development, pressure on the supply of groundwater in the region has increased rapidly over the past decades. It is estimated that 40 billion cubic metres of water were extracted from the aquifer over the past 40 years, in Egypt and the Libyan Arab Jamahiriya alone. No historical data is available for Chad and the Sudan where the present extractions and socio-economic uses are limited. Most of the present water extracted from the system is used for agriculture. Data collected shows that the present extraction represents only some 0.01 per cent of the estimated total recoverable freshwater volume stored in the system. However, this has already caused a drop of the water table, which reaches 60 metres in some places. Ninety-seven per cent of the free flowing wells and springs have already been replaced by deep wells. This has led to a rise in extraction costs as water level falls and raises the issue of equity and affordable access to this unique water source for indigenous, low-income populations. In the arid, scarcely populated Chad section of the aquifer, concerns are focused on the protection of vulnerable ecological values, including humid zones with oases and desert lakes that depend on seepage and springs from the Nubian aquifer. It is generally accepted that the huge but non-renewable Nubian storage will be sufficient for many centuries of planned mining. It is also understood that as extractions grow with the socio-economic demands, the entire shared[3] aquifer will be affected.

Water quality

6. In the unconfined part of the Nubian aquifer system, water quality is good to excellent all over the area. In its confined part (to the north, in Egypt and in the Libyan Arab Jamahiriya), the water quality changes laterally and vertically; the upper part of the aquifer system contains freshwater while the lower part of the aquifer system becomes saline very rapidly.

7. The groundwater of the post-Nubian aquifer system shows a wide variation in chemical quality. In areas of intensive development, the good quality of the water is endangered by the upcoming and/or the lateral flow of saline water. There is lack of detailed information to make a synthesis of this problem, even at the regional level. Increased groundwater extraction, where it is close to the freshwater/saline water

interface, may augment the risk of deterioration of the water quality by the intrusion of saline water into the freshwater.

International cooperation

8. Since the early 1970s, Egypt, the Libyan Arab Jamahiriya and the Sudan have expressed their interest in regional cooperation in studying and developing their shared resource. In July 1992, a joint authority was established between Egypt and the Libyan Arab Jamahiriya, subsequently joined by Chad and the Sudan. Among other things, the Authority is responsible for collecting and updating data, conducting studies, formulating plans and programmes for water resources development and utilization, implementing common groundwater management policies, training technical personnel, rationing the aquifer waters and studying the environmental aspects of water resources development. An integrated regional information system was developed with the support of the Center for Environment and the Development of the Arab Region and Europe. On 5 October 2000, the four Member States signed two agreements on procedures for data collection, sharing and access to the system, as well as updating the information.

B. Guarani aquifer system[4]

General description and beneficial uses

9. The Guarani aquifer system, also called the Mercosul aquifer, includes areas of Argentina, Brazil, Paraguay and Uruguay. It is contained in aeolian and fluvial sands, usually covered by thick basalt flows (Serra Geral Formation), which provide a high confinement. Its thickness ranges from a few metres to 800. Water of very good quality is exploited for urban supply, industry, irrigation and for thermal, mineral and tourist purposes. A project for the environmental protection and integrated sustainable management of the Guarani aquifer is being elaborated with the support of the Global Environmental Fund, the World Bank, the Organization of American States and the universities of the four States.

Mathematical model and database

10. The mathematical model assists in introducing improvements in the conceptual model and better identifying the uncertainties. Data needs to be consistent and comparable. It would be necessary to create, arrange and disseminate a full database, to be shared by all stakeholders of the Guarani aquifer system. A *Consejo Superior*, drawn from the four States, has been established to coordinate the work programme for the management of a study of the aquifer resources. Guarani consultative meetings were held in August 2001 to discuss the international shared aquifer resource management programme and its scope.

Essential data

11. Surface area: 1,200,000 square kilometres.

Population: 15 million inhabitants, 6 million live where the aquifer outcrops.

Resources in storage: 40,000 cubic kilometres.

Current production: More than 700 wells draw 1,000 cubic metres per hour by pumping or 100 to 500 cubic metres per hour using surge wells.

C. Franco-Swiss Genevese aquifer[5]

Geographical location

12. The Franco-Swiss transboundary Genevese aquifer extends between the southern extremity of Lake Geneva and its effluent the Rhone River. The aquifer is located partly on the southern border of the Canton of Geneva with the French Department of Haute Savoie. The aquifer is crossed over from east to west by the Arve River, a tributary of the Rhone originating in France, and thus benefits from natural recharges averaging 7.5 million cubic metres per annum. The average water level is between 15 and 80 metres deep.

Groundwater extraction

13. The Genevese aquifer is exploited for drinking water supply by 10 wells on the Swiss side and 5 on the French side. The total extracted volume of water averages 15 to 17 million cubic metres per annum, out of which the French withdrawals represent some 2 million cubic meters. Between 1940 and 1960, water extractions from the Genevese aquifer were very close to the average natural recharge. Between 1960 and 1980, the aquifer was over-drafted, with extractions reaching up to 14 million cubic metres in 1971, almost twice its potential yield. Such an over-pumping has lowered the water table by more than 7 metres in 20 years, reducing the total groundwater storage by about one third. For this reason, the Canton of Geneva initiated negotiations with the French Department of Haute Savoie to consider the implementation of a recharge installation for the joint management of the transboundary aquifer.

International cooperation

14. The negotiations between the Canton of Geneva and the French Department of Haute Savoie were concluded in 1977 with the signature of an arrangement on the protection, utilization and recharge of the Franco-Swiss Genevese aquifer in 1977. The agreement entered into force on 1 January 1978.

15. The essential provisions of the arrangement cover the following matters:

(a) The Commission:

The arrangement created a Genevese Aquifer Management Commission, composed of three members from each party, with the stipulation that two members of each delegation must be water specialists (article 1). The mandate of the Commission is to propose a yearly aquifer utilization programme, taking into account, as far as possible, the needs of various users on each side of the border, to formulate any proposals required to ensure the protection of the resource and to remedy possible causes of pollution (article 2, para. 1). The Commission gives its technical opinion on new water extraction works and utilization, as well as on the modification of existing ones and audits the construction and operation costs of the groundwater recharge installation (article 2, paras. 2 and 3). The Commission has the duty to take an inventory of all existing waterworks allowing the utilization of the resources of the aquifer, whether public or private (article 4). All waterworks must be equipped with a device for the recording of the volume of water extracted from the aquifer. Such a device shall be gauged and sealed at the initiative of the Commission. Water extractions shall be read and registered periodically (article 6).

(b) The groundwater recharge installation:

The arrangement provides (article 8) for the Republic and Canton of Geneva to construct and to operate the required groundwater recharge installation of which it is and remains the sole owner. The Canton of Geneva is liable for any damages caused to the quality of the waters of the aquifers resulting from failure to maintain the recharge installation (article 18, para. 1).

(c) Water rights:

Article 9, paragraph 1, provides that, based on the dimensions and capacity of the artificial recharge installation, French authorities shall ensure that the aggregate of water extractions by the users located within French territory shall not exceed 5 million cubic metres, inclusive of a free allocation of 2 million cubic metres. Exceptionally, the Swiss party may request the French party to forfeit part or all of its free allocation.

(d) Water pricing:

The Canton of Geneva has proceeded with the computation of the corresponding construction costs of the groundwater recharge installation. The operational costs are reconciled yearly. The French share is then computed yearly, including the French contribution to the construction of the groundwater recharge installation (amortization annuity) and the operational costs in proportion to the total volume extracted by French users.

(e) Water quality:

Water extracted from the aquifer shall be analysed by both sides on the basis of standard qualitative analysis criteria established by the Commission; such analyses shall be made at regular intervals (article 16). A warning system shall be maintained in the case of accidental pollution likely to affect the water quality of the aquifer (article 17). The French and Swiss collectivities are liable for acts of pollution occurring within their national territories.

16. The arrangement has been concluded for a period of 30 years (article 190). It is automatically renewable for periods of 5 years unless terminated by either party serving the other a one year prior notice. The 1978 arrangement between the Canton of Geneva and the French Department of Haute Savoie has adopted a pragmatic approach, and now represents more than 25 years of practical success.

D. Mexico-United States of America border[6]

17. Along their common border, Mexico and the United States of America share surface water, mainly in the Rio Grande (Rio Bravo in Mexico) and Colorado Rivers as well as groundwater in at least 15 aquifers. The fact that most of the common border lies within water-scarce regions has resulted in intense competition over the water resources of the two major rivers and also of the aquifers. This is illustrated in the two examples below: the El Paso-Juarez case and the Upper San Pedro River basin case.

Bilateral cooperation

18. Mexico and the United States have concluded several treaties since the nineteenth century related to their common border. The table below lists some recent agreements related to the environment and water resources. No agreement related to groundwater management exists, despite the recommendation made in Minute 242 of the International Boundary and Water Commission.

Date	*Agreement*	*Purpose*
14 November 1944	"Water treaty"	To regulate the utilization of the Colorado and Tijuana Rivers, and of the Rio Grande (Rio Bravo). Creates the International Boundary and Water Commission with one section in the United States and one in Mexico
30 August 1973	Minute 242: Permanent and definitive solution to the international problem of the salinity of the Colorado River	The Minute incorporates the decisions adopted to definitely solve the salinity problem of the Colorado River. The Minute limits groundwater pumping in the immediate vicinity of the Arizona-Sonora Boundary (concerns the Yuma Mesa aquifer) "**pending the conclusion by the Governments of the United States and Mexico of a comprehensive agreement on groundwater in the border areas**" [emphasis added by the Special Rapporteur]
14 August 1983	Agreement on cooperation for the protection and improvement of the environment in the border area	Establish the basis for cooperation between the parties for the protection, improvement and conservation of the environment
13 November 1992	Minute 289 of the International Boundary and Water Commission — observation on the quality of the waters along the United States and Mexico border	The International Boundary and Water Commission will develop an appropriate monitoring programme and database for the observation of the quality of the surface and groundwaters under the Integrated Border Environment Plan (25 February 1992)

The El Paso-Juarez case

19. The two adjacent border cities of El Paso, Texas, United States, and Ciudad Juarez, Chihuahua, Mexico, face a severe water crisis. The region, which is home to close to 2 million people, has a climate typical of arid to semi-arid regions (the annual rainfall is less than 17 millimetres). The main sources of water are the Rio Grande and two aquifers, the Hueco Bolson and the Mesilla Bolson.

20. The Hueco Bolson, the primary source of water, extends northward into New Mexico (United States of America) and southward into Mexico. El Paso currently depends on groundwater from the Hueco Bolson for about 45 per cent of its water needs. The rest is provided from the Rio Grande (40 per cent) and the Mesilla Bolson (15 per cent). Ciudad Juarez, which has roughly double the population of El Paso, depends entirely on water from the Hueco Bolson to meet its demand.[7] It is estimated that the aquifer will be depleted of all fresh water that can be economically retrieved by 2025, or even earlier. Since 1940, the level has dropped by as much as 45 metres.

21. The Mesilla Bolson is located primarily in New Mexico, with small portions in Mexico and Texas. The Rio Grande is considered its main source of recharge. Water levels in the aquifer remain relatively constant.

22. Water quality in the Hueco Bolson has been degraded over time as a result of groundwater withdrawals and other human activities. The water quality pumped from the Mesilla Bolson improves with the depth of wells. While the aquifer is showing some level of water quality deterioration, the overall quality is better than in the Hueco Bolson. Generally, historical large-scale groundwater withdrawals, especially from municipal well fields in the downtown areas of El Paso and Ciudad Juarez, have caused major water-level declines. These declines, in turn, have significantly changed the direction of flow, rate of flow and chemical quality of groundwater in the aquifers.

23. The region has experienced a very high growth rate, especially on the Mexican side. As the population growth is expected to continue, so is the demand for water. Through strict conservation efforts, the city of El Paso has reduced its per capita water use. However its per capita consumption (around 600 litres per person per day) is double that of Ciudad Juarez where hundreds of thousands of residents live without direct water supply in their households. Beyond the specific issue of groundwater depletion, the case underlines the wider issue of cross-border economic issues of wealth and affordability.

The Upper San Pedro River Basin case

24. The San Pedro River is one of only two rivers that originate in Mexico and flow northward into the United States. One of the most outstanding features of the basin is its native biodiversity. More than 400 bird species, as well as many other species, live in or migrate through the basin.

25. Groundwater in the basin has two main sources, the regional and the floodplain aquifer, which are interconnected. The recharge of the regional aquifer comes mainly from the mountain fronts. The aquifer is mostly unconfined, although it is confined in some of its parts. The floodplain aquifer is recharged mainly by runoff and regional aquifer contribution. The floodplain aquifer is unconfined.

26. In the United States, the Upper San Pedro River basin area has experienced rapid population growth, which has increased water demand and put pressure on the groundwater supply. Most hydrologists agree that excessive pumping from the regional aquifer has produced a cone of depression that dewaters the floodplain aquifer by lowering the water table. As a result, the San Pedro River has become ephemeral in some locations. This could have serious effects on the international bird flyway and could also impact the economy of neighbouring communities. At

issue is not only the availability of water, but also the threat of excessive lowering of the water table, which puts riparian vegetation and biodiversity at risk.

IV. Selected bibliography on law of transboundary groundwaters[8]

27. This selected list of recent publications on the law on transboundary groundwaters is not meant to be comprehensive.

Arias, H. M., "International groundwaters: The Upper San Pedro River Basin case", *Natural Resources Journal*, vol. 40, No. 2.

Barberis, J. A., *International groundwater resources law*, Rome, FAO Legislative Studies, No. 40, 1986.

Caponera, D. A. and D. Alhéritière, "Principles for international groundwater law", *Natural Resources Journal*, vol. 18, 1978.

Chávez, O. E., "Mining of internationally shared aquifers: The El Paso-Juárez case", *Natural Resources Journal*, vol. 40, No. 2.

Eckstein, G., and Eckstein, Y., "A Hydrogeological Approach to Transboundary Ground Water Resources and International Law", *American University International Law Review*, vol. 19, 2003.

FAO/UNESCO, *Groundwater in international law* (vol. 1 *Review and Assessment* (provisional); vol. 2 *Compilation of Treaties and Other Legal Instruments* (provisional)), FAO Legislative Studies, 2004 (forthcoming).

Feitelson, E. and M. Haddad (eds.), *Management of shared groundwater resources: the Israeli-Palestinian case with an international perspective*, Boston [etc.]: Kluwer Academic Publishers, 2001.

Fuentes, X., "The utilization of international groundwater in general international law", *The reality of international law: essays in honour of Ian Brownlie*, Oxford, Clarendon Press, 1999.

Van Haasteren, J. A. and Van den Berg, R. (eds.), *Pesticides et eaux souterraines*, Strasbourg, Conseil de l'Europe, 1993.

Hayton, R. D. and A. E. Utton, "Transboundary groundwaters: the Bellagio Draft Treaty", *Natural Resources Journal*, vol. 28, 1989.

Kayane, I., "Global warming and groundwater resources in arid lands", *Freshwater resources in arid lands*, Tokyo, United Nations University Press, 1997.

Lefevre, J., "Integrating groundwater quantity control into European Community water policy", *Review of European Community and International Environmental Law*, vol. 8, 1999, No. 3.

Managing Shared Aquifer Resources in Africa, *Proceedings of the International Workshop, Tripoli, Libyan Arab Jamahiriya, 2-4 June 2002*, UNESCO-IHP, 2004 (forthcoming).

Mechlem, K., "International Groundwater Law: Towards Closing the Gaps?", *Yearbook of International Environmental Law*, vol. 40, 2003 (forthcoming).

Moench, M. (ed.), *Groundwater law: the growing debate*, Ahmedabad: VIKSAT-Pacific Institute Collaborative Groundwater Project, 1995.

Murillo, A., J. Bough and H. Cook, "Groundwater abstraction and legislative control", *Water law*, vol. 10, No. 4.

Mumme, S. P. (ed.), Special issue on Transboundary Groundwater Management on the US-Mexico Border, *Natural Resources Journal*, vol. 40, No. 2.

Regional aquifer systems in arid zones, managing non-renewable resources, *Proceedings of the International Conference, Tripoli, Libyan Arab Jamahiriya, 20-24 November 1999*, International Hydrological Programme, IHP-V, Technical documents in Hydrology, No. 42, UNESCO, Paris, 2001.

Salman, S. M. A. (ed.), *Groundwater: legal and policy perspectives: proceedings of a World Bank seminar*, Washington, D.C.: World Bank, 1999.

Schiffler, M., *The economics of groundwater management in arid countries: theory, international experience and a case study of Jordan*, London [etc.]: Frank Cass, 1998.

Teclaff, L. A. and A. E. Utton (eds.), *International groundwater law*, London, Oceana Publications, 1981.

United Nations Environment Programme, UK Department of International Development, Belgian Development Corporation (DGDC), British Geological Survey, *Groundwater and its susceptibility to degradation: a global assessment of the problem and options for management*, UNEP, Nairobi, 2003.

Vance, B., "Total Aquifer Management: A New Approach to Groundwater Protection", *University of San Francisco Law Review*, vol. 30, spring 1996.

Notes

[1] The United Nations Educational, Scientific and Cultural Organization (UNESCO) arranged to send three experts to Tokyo in March 2004 to work together with the Special Rapporteur to prepare this addendum. Those experts are Alice Aureli and Raya Stephan of UNESCO and Jaroslav Vrba, Chairman of the International Association of Hydrologists Commission on Groundwater Protection. Materials in this addendum are contributed by the members of the Internationally Shared Aquifer Resources Management Initiative.

[2] Contributed by Raya Stephan and Bo Appelgren of UNESCO.

[3] Experts use the term "shared" in this addendum in the geographical sense that the aquifer is located across borders.

[4] Contributed by Emilia Bocanegra and Carlos Fernadez Jauregui in case studies from the international shared aquifer resource management framework document, International Hydrological Programme (sixth session), UNESCO.

[5] Contributed by Raya Stephan of UNESCO.

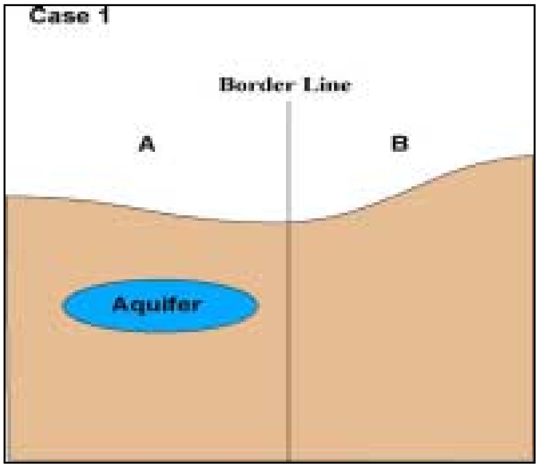
[6] Contributed by Raya Stephan of UNESCO.

[7] Chávez, O. E., "Mining of internationally shared aquifers: The El Paso-Juárez case", *Natural Resources Journal*, vol. 40, No. 2, 2000.

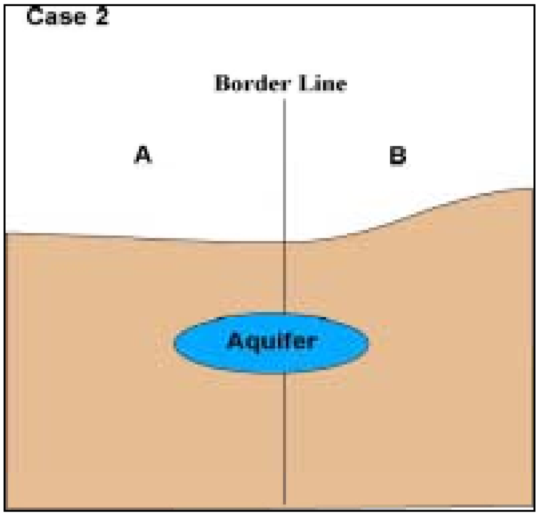
[8] Compiled by Kerstin Mechlem of the Food and Agriculture Organization of the United Nations.

Annex

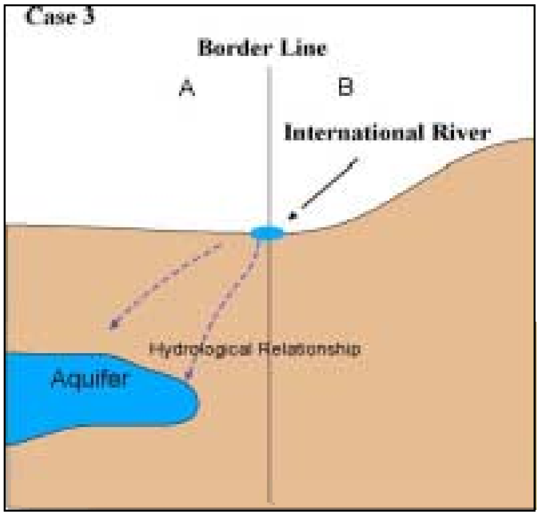
Aquifer models[a]



A domestic aquifer

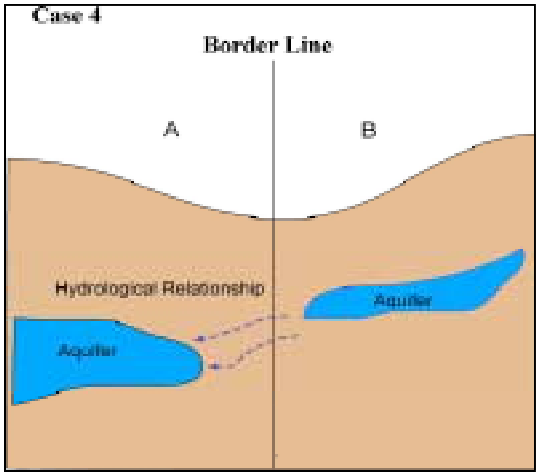


A transboundary aquifer unrelated hydrologically with surface water

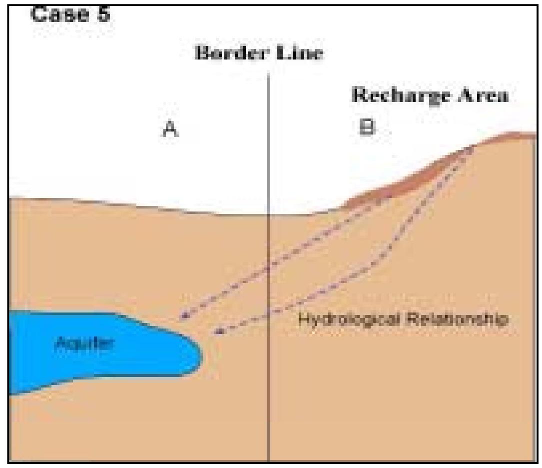


An aquifer that is entirely in the territory of a State linked hydrologically with an international river

[a] Based on the presentation by Shammy Puri, Chairman of the International Association of Hydrogeologists-Transboundary Aquifer Resource Management Commission and Coordinator of the international shared aquifer resource management initiative, during the meeting held at UNESCO headquarters in Paris on 2 and 3 October 2003.



An aquifer that it entirely in the territory of a State but is hydrologically linked with another aquifer in a neighbouring State



An aquifer that is entirely in the territory of one State but whose area of recharge is in a neighbouring State. The recharge could be any body of surface water