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REPORT
**EXPERT GROUP MEETING ON IMPLICATIONS OF GROUNDWATER
REHABILITATION FOR WATER RESOURCES
PROTECTION AND CONSERVATION
BEIRUT, 14-17 NOVEMBER 2000**
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I. ORGANIZATION OF WORK

1. The Expert Group Meeting on Implications of Groundwater Rehabilitation for Water Resources Protection and Conservation, organized by the Economic and Social Commission for Western Asia (ESCWA) and the United Nations Environment Programme/Regional Office for West Asia (UNEP/ROWA), was held at United Nations House in Beirut from 14 to 17 November 2000 under the patronage of the Minister of Energy and Water in Lebanon. The Meeting was co-sponsored by the Federal Institute for Geosciences and Natural Resources of Germany (BGR) and the Ministry of Energy and Water in Lebanon. The Meeting constituted one of the activities planned within the framework of the 2000-2001 work programme for the Energy, Natural Resources and Environment Division of ESCWA.
2. The aims of the Meeting were to review the status of groundwater pollution at the national level, discuss groundwater rehabilitation techniques and their application in different geological environments, present relevant case studies from countries inside and outside Western Asia, review the stages reached in the monitoring and protection of groundwater sources, and promote awareness about the impact of water pollution on health and the environment.
3. The Meeting was attended by water experts and resource persons from Western Asia (including Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, the Syrian Arab Republic and Yemen) and from Germany; all had extensive experience in different areas related to the subject of the Meeting.
4. Representatives from the following regional and international organizations and funding agencies also attended the Meeting: the Rome and Cairo offices of the Food and Agriculture Organization of the United Nations (FAO), World Bank, International Atomic Energy Agency (IAEA), Arab Academy for Science and Technology and Maritime Transport (AASTMT), Arab Center for the Study of Arid Zones and Dry Lands (ACSAD), Arab Organization for Agricultural Development (AOAD), BGR, Gulf Cooperation Council (GCC), International Center for Agricultural Research in the Dry Areas (ICARDA), Islamic Development Bank (IDB), Saudi Fund for Development, World Water Council, National Center for Remote Sensing in Lebanon, and academic institutions from different parts of Lebanon (see annex I for a list of participants).
5. The Meeting documents included background papers prepared by the ESCWA secretariat; papers prepared by invited resource persons from UNEP/ROWA, BGR, and the Ministry of Energy and Water in Lebanon; country papers prepared by government-designated experts; and papers prepared by representatives from regional and international organizations and scientific institutions (see the list of documents in annex II).

II. ACCOUNT OF PROCEEDINGS*

A. OPENING SESSION

6. The Chief of the Energy, Natural Resources and Environment Division of ESCWA welcomed the participants and expressed the secretariat's appreciation to the Ministry of Energy and Water for sponsoring the Meeting. He informed the participants that the Expert Group Meeting was being convened concurrently with the fourth session of the ESCWA Committee on Water Resources. He spoke about the region's limited water resource availability, the failure to implement effective management practices, and the effects of increasing groundwater pollution on already scarce water supplies and on health and the environment. The ESCWA representative indicated that the Meeting would provide an opportunity to discuss pollution-related problems in the region and means of rehabilitating groundwater aquifers to preserve that vital source for future requirements. He reflected on the secretariat's programmed activities relating to water quality protection, the review of water strategies, the role of desalination in augmenting supply, and the promotion of groundwater management (including the management of shared sources).

* The organization of work is provided in annex III to the present report.

7. The Deputy Regional Director of UNEP/ROWA welcomed the participants and reflected on the benefits of enhancing cooperation between sister United Nations organizations and Governments in implementing joint activities relating to groundwater quantity and quality issues. He referred to the need to use water in an environmentally sustainable manner in order to maximize its economic and social benefits. The UNEP representative stated that solving water problems required an intersectoral approach that took into account the interlinkages between land and water, agriculture and water technology, and water and health. He reflected on his organization's new programme objectives with regard to water policy and strategy initiatives, which focused on assessment, management and coordination. He highlighted UNEP activities in the field of water resources management, in particular the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities and the Global International Water Assessment, noting that such activities addressed issues relating to water quality assessment, monitoring and protection, with special emphasis on groundwater, the main source for water for most of Western Asia. The representative also briefed the participants on the Global Environment Outlook process, which was based on environmental assessment and provided environmental forecasts based on policy analysis and scenario-building. He concluded with a brief on the regional preparatory process being undertaken for the 2002 Johannesburg World Summit for Sustainable Development together with the Council of Arab Ministers Responsible for Environment (CAMRE) and ESCWA.

8. The Executive Secretary of ESCWA welcomed the participants and expressed his gratitude to the Minister of Energy and Water of Lebanon for taking part in the opening session and for the Ministry's support and sponsorship of the Meeting. He spoke about the importance of groundwater in most of the countries of Western Asia and the need to protect such a vital resource from excessive pumping and pollution and to ensure its conservation through the formulation of sound policies. Referring to the purpose of the Meeting, the Executive Secretary discussed the problems associated with current groundwater utilization practices employed to meet rising water demand, especially in the irrigation sector, noting that groundwater quality was deteriorating as a result of increasing pollution from the domestic and agricultural sectors and salt-water intrusion from over-pumping. He concluded by urging ESCWA members to exert more effort to combat groundwater pollution and to introduce and enforce legislation to protect and sustain groundwater sources for future generations.

9. The Minister of Energy and Water of Lebanon welcomed the distinguished gathering of water experts and spoke about the increasing water scarcity at the global level and in the ESCWA region in particular, where per capita water availability had been declining because of development activities and population increases. He said that groundwater represented a vital source of water for a large number of ESCWA member countries, accounting for 17 per cent of potential available sources. He talked about the surface water and groundwater resources available in Lebanon and the impact of over-pumping, which had resulted in salt-water intrusion. He referred to the country's water pollution from wastewater and irrigation practices and assessed the impact of such factors on the water supply and public health. He highlighted the Ministry's efforts in combating salt-water intrusion through artificial recharge, controlling drilling activities and constructing wastewater treatment plants. He also reviewed the Ministry's 10-year programme, which gave priority to groundwater protection and conservation, water quality monitoring and water treatment projects in the domestic sector.

10. The Meeting adopted the agenda and the organization of work (see E/ESCWA/ENR/2000/WG.3/L.2 and E/ESCWA/ENR/2000/WG.3/2).

B. PRESENTATION OF PAPERS

11. The Meeting focused on three broad themes: groundwater pollution and its impact, groundwater rehabilitation techniques, and groundwater protection. Within this context, papers presented by the participants addressed issues related to groundwater pollution resulting from irrigation practices, the disposal of treated and untreated wastewater, and intrusion of sea water into coastal aquifers, and the impact of pollution from different activities on health and the environment. Particular attention was given to the review of groundwater rehabilitation techniques (the main objective of the Meeting) and to the presentation of case studies on pollution

from inside and outside the region. The issue of groundwater protection was discussed at length, with emphasis placed on vulnerability assessment methodology, network design and monitoring procedures.

1. Groundwater pollution and its impact

12. The ESCWA background paper for the Meeting, entitled "Implication of groundwater protection and conservation", stressed the importance of groundwater for a large number of countries in Western Asia and examined the magnitude of water quality deterioration linked to increasing pollution from domestic, industrial and agricultural activities. The paper identified sources of pollution in general and in the ESCWA region in particular, focusing on the infiltration of unsewered domestic wastes and wastes from leaking sewers and sewage oxidation lagoons and the consequent contamination of water supply wells, springs and (especially shallow) aquifers. The paper identified the most prevalent pollution sources as residue of fertilizers and pesticides in irrigation return flow, organic components and heavy and trace metals, all of which endangered drinking water quality. Overexploitation of freshwater aquifers had allowed the intrusion of brackish water into parts of the exploited aquifer or into underlying or overlying aquifers. Socio-economic development activities in Western Asia had caused serious deterioration of groundwater quality in shallow aquifers. The paper reviewed groundwater rehabilitation techniques that could be applied inside the well, within the aquifer or via water treatment outside the aquifer. Groundwater management measures were addressed from the perspective of data collection, assessment, monitoring and protection.

13. The paper of AOAD, entitled "Pollution of groundwater from irrigation practices in the Arab countries", indicated that groundwater constituted around 15 per cent of the available water in the Arab world, and its protection should represent a priority, especially for those countries heavily dependent on such resources. The paper reviewed the most common sources and types of pollution associated with urbanization activities, the use of chemicals for fertilizers and pesticides and the reuse of wastewater and saline water in agriculture, and pollution from oil production, and pollution from human practices in rural areas. The paper also provided information on technical and administrative measures that could be undertaken to protect groundwater sources.

14. Another paper, entitled "Groundwater pollution by irrigated agriculture: a case study", evaluated the impact of certain irrigation practices on the groundwater in shallow and deep aquifers in the Eastern Province of Saudi Arabia. The results of the study indicated that the quality of deep groundwater was not affected by the percolation of irrigation water because of the presence of a thick, impervious confining layer overlying the aquifer. However, groundwater in shallow unconfined aquifers was being polluted by nitrates and some trace metals such as boron as a result of the percolation of pollutants in excess irrigation water down to the shallow water table. Fertilizers and pesticides were identified as the main sources of pollutants. The paper suggested that improving irrigation and cultivation practices could reduce pollution and minimize its impact on shallow groundwater. It was noted that such practices could be applied in other parts of Saudi Arabia to protect and conserve groundwater resources.

15. The paper entitled "Groundwater pollution control measures in Lebanon" addressed water quality deterioration at the national level caused by uncontrolled pumping and discharges of domestic and industrial wastes. The paper, presented by a representative from the Ministry of Energy and Water, also reviewed the impact of agricultural practices and leakage from the water supply and sewage networks. Other factors contributing to pollution included outdated legislation for the protection of water sources and the overlapping of tasks and responsibilities among governmental agencies involved in water-related activities. The paper included information on the Ministry's efforts to address relevant issues; mention was made of studies and field projects under development or implementation that focused on problem-solving and limited preventive measures to monitor and protect groundwater sources.

16. The paper entitled "Groundwater pollution: environmental impacts" examined existing environmental policies, regulations, laws and institutional frameworks in Western Asia. The paper highlighted critical issues, including the need to update rules and regulations and to mobilize legislative and institutional bodies to

implement pollution control measures and prevent environmental degradation, which would contribute to enhanced water availability and sustainability. The paper reviewed different approaches for mobilizing the community, with particular emphasis given to the empowerment of women, the formation of youth groups, and the implementation of public awareness campaigns.

17. The country paper of Jordan, prepared in Arabic, addressed the rise in water consumption owing to population growth and development activities. The paper outlined government efforts to manage water resources through the adoption of measures to improve institutional arrangements, the establishment of a data bank, the implementation of a groundwater monitoring programme, the construction of wastewater and industrial treatment plants, the control of pumpage to ensure safe yield, the regulation and implementation of artificial recharge schemes, and the required completion of environmental impact assessments for all projects.

18. A World Bank paper entitled "MENA/MED water initiative: proceedings of the regional workshop on sustainable groundwater management in the Middle East and North Africa: summary report" stressed the importance of groundwater in the water balance, noting that it accounted for 15 to 60 per cent of all water resources. Groundwater management could not be effectively implemented unless regulations were combined with incentives and withdrawals controlled. The paper reviewed the outcome of the regional groundwater workshop held in Sana'a, indicating the nature of emerging groundwater problems and the array of legal, institutional, economic, social and political factors affecting groundwater management. The issues of common concern identified at that workshop included overdraft, water quality and pollution, supply and demand management, data and information generation, institutional and legal reform, and public and community participation in management.

19. The paper entitled "Evaluating the potential of submarine springs: an unconventional groundwater source for the coastal area—Lebanon" focused on unconventional sources contributing to the water budget of the country's coastal area. In Lebanon all the major cities lay along the coast; all told, around 70 per cent of the country's residents lived near the Mediterranean sea. The paper emphasized the need for a decision to protect and sustainably manage submarine water sources. It was noted that the administrative staff of the central water authority could identify priorities, problems, risks and water values and could also work to obtain funds for programme implementation, while the executive branch could secure monitoring and technical support to ensure maximum performance and sustainability.

2. Groundwater rehabilitation techniques

20. The paper entitled "New approaches in groundwater rehabilitation" provided an overview of the conventional and innovative remediation technologies available. It examined a variety of potential contaminants, listed their properties, and indicated where they most frequently occurred and their mode of movement. The paper noted that substances such as chlorinated hydrocarbons, benzene, toluene, ethylbenzene, xylene, pesticides, polycyclic aromatic hydrocarbons, polychlorinated biphenyls and heavy metals were often found in soil and water samples taken from sites contaminated mainly through industrial and agricultural practices. The paper elaborated on the different technologies and techniques used for the remediation of contaminated soil and groundwater, including conventional civil-engineering-based approaches (excavation, containment and hydraulic measures), process-based and innovative conceptual approaches, treatment walls, bioremediation and monitored natural attenuation. The general applicability and limitations of such methods were addressed.

21. The paper entitled "Implications of groundwater protection and conservation" provided a comprehensive review of pollution control and groundwater rehabilitation techniques. The paper emphasized that a good basic knowledge of surface and subsurface soil profiles, aquifer characteristics and possible chemical reactions; aquifer hydrodynamics; and the physical, chemical and biological characteristics of pollutants and their behaviour was required for the design of rehabilitation schemes as well as for the monitoring and protection of groundwater systems. The paper reflected on the reality that when groundwater became polluted, it was

sometimes very difficult, if not impossible, to rehabilitate the aquifer. In addition, groundwater and contaminated-soil restoration measures could be extremely expensive, entailing large time, personnel and financial commitments. The prevention of groundwater pollution through environmentally friendly behaviour, the establishment of an effective regulatory framework, and the application of simple but intelligent technical and other precautionary measures constituted a better option than the implementation of expensive and time-consuming remedial measures in the field. The paper outlined the concepts for the design of groundwater networks, the selection of observation points, and the maintenance and operation of the networks including groundwater sampling, data processing and quality control.

22. The paper entitled "Burman, underground removal of manganese from groundwater in Beheira Governorate, Egypt" provided information on the outcome of a field study on the use of a particular treatment process for groundwater rehabilitation. The presence of manganese and iron in the Nile Delta aquifer caused problems for both pipelines and consumers. In the Kim Hamada and Itay al-Barud areas, the average concentration of each was found to be 0.41 and 1.1 milligrams per litre (mg/l) respectively. The problem emerged in 1990 with the start of chlorination and the consequent precipitation of manganese oxides in the distribution systems of the area under study. The method used by the Beheira Water Drainage Company to remove manganese from groundwater was relatively cheap and required no chemicals or special facilities such as sedimentation tanks or filters. Rehabilitation was based on the application of natural processes, mainly the injection of aerated water, which produced good results. Further evaluation was planned for the next phase, during which regular groundwater operations would be carried out by the Beheira Water Drainage Company.

23. A specific issue was addressed in a paper presented by the Ministry of Energy and Water in Lebanon, entitled "Salt water intrusion in the Hadeth aquifer: groundwater rehabilitation techniques". Salt-water intrusion was occurring in the Hadeth limestone aquifer near Beirut because the heavy pumpage of 17.5 million cubic metres (mcm) for the public water supply and uncalculated pumpage from more than 500 private wells exceeded annual recharge, estimated at 14.5 mcm. The paper described the remedial approach of injecting recharge wells with water from the Dachouniye source and the Beirut River during the wet winter season. The viability of that technique had been demonstrated through the implementation of a successful pilot recharge experiment.

24. Another paper, entitled "Implications of groundwater rehabilitation in the ESCWA region", suggested some ideas that might be applied for the exploitation of groundwater resources and assessed the potential impact of groundwater mismanagement. The paper provided a short description of the current deterioration of groundwater resources in the region, called for increased efforts to explore and evaluate viable rehabilitation techniques suitable for arid and semi-arid environments, and stressed the need to promote the exchange of experiences. The paper also presented some important economic concepts that should be applied in dealing with groundwater exploitation, depletion and rehabilitation.

25. The paper entitled "Solute transport models: an important tool for studies on groundwater protection or remediation" focused on the application of models in the assessment, monitoring and protection of groundwater resources. The paper indicated that flow and transport models were useful for assessing water quantity and quality and for evaluating solutions including pollution movement and groundwater rehabilitation. Models could help characterize systems, pinpoint gaps in data, identify locations for additional wells, address uncertainties, compare different scenarios, and indicate the best remedial or protective procedure to be applied under given circumstances. The paper provided information on the basic equations and various methods used in transport modelling. There were many computer programmes available, ranging from simple flow models using particle tracking and analytical equations models to multispecies, multiphase transport models and variable density models coupled with reaction models. Some examples of analytical and numerical models and their uses in real field situations were presented, with emphasis given to reactive transport and salt-water intrusion.

26. The country paper of the Syrian Arab Republic, prepared in Arabic, reviewed government efforts focusing on the development of water resources to provide additional supply, especially for domestic and irrigation purposes. The paper provided a brief description of the types of groundwater aquifers in the country and noted

that groundwater had been contaminated by the seepage of waste from septic tanks (which contributed nitrates), pollution from garbage and dump sites, the overuse of fertilizers (which contributed ammonia), salt-water intrusion in the coastal zone from overpumping, irrigation return flow (which contributed chloride, sodium sulphide and manganese), and the infiltration of salty water from oil operations. Other sources of pollution were identified, including gasoline leakage and power plant discharges into surface waters. The paper outlined the Government's recent efforts to implement limited water management measures including the construction of dams, artificial recharge schemes and groundwater protection programmes.

3. *Groundwater protection*

27. The paper entitled "Groundwater vulnerability mapping: decision support in groundwater resources quality protection" examined different methodologies for assessing the vulnerability of groundwater systems, including overlay and index, process-based and statistical methods. The paper indicated that qualitative overlay and index methods were still used most frequently, as data availability limited the applicability of other methods. The paper demonstrated that the application of overlay and index methods in qualitative groundwater vulnerability mapping represented a valuable tool in groundwater protection for policy makers, regional planners and water resource managers.

28. The paper entitled "Guidelines for groundwater protection and pollution control in the GCC countries" provided a brief description of groundwater resources in the Gulf region; in that arid and extremely arid part of the world, groundwater was used to satisfy more than 91 per cent of fresh water requirements. The paper reported on the deterioration of groundwater quality owing to overexploitation, anthropogenic activities, and salt-water intrusion along the eastern side of the Gulf. The main sources of pollution were identified, with mention made of the high levels of nitrates (in excess of 90 mg/l), ammonia (up to 5 mg/l) and faecal coliform; high levels of total dissolved solids (TDS) from irrigation return flow; and problems associated with gasoline tank leakage and the injection of brine from oil operations. The paper reviewed the management measures that had been implemented in the region and elaborated on the use of the geographic information system (GIS) and mathematical groundwater modelling to assess aquifer vulnerability for groundwater protection.

29. The paper entitled "Water and soil vulnerability to contamination in central Beqa'a plain - Lebanon" focused on how irrigation practices (the use of wastewater and overuse of fertilizers, pesticides and insecticides) were contributing to increased groundwater pollution levels. A field study was presented on a selected area in the Beqa'a plain measuring 127.5 square kilometres (km²) and characterized by high clay content, high pH values, and high cation exchange capacity in the soil profile, in combination with a shallow water table ranging from 0.6 to 5 metres. The study showed that over-irrigation and a percolation rate of 200-300 millimetres (mm) per year had increased the salinity and nitrate levels in the groundwater. Through the study a soil profile was obtained which indicated varying degrees of groundwater pollution vulnerability. The residence time of percolating water in the soil above the aquifer varied, ranging from several months to 10 years. The vulnerability maps developed through the study could serve as a planning tool to prevent groundwater pollution.

30. The paper entitled "Isotope studies for groundwater protection and pollution control" focused on the application of environmental isotope methods for assessing the vulnerability of groundwater resources to pollution. Such methods were used to evaluate the age distribution of groundwater resources and any changes that had occurred owing to hydrodynamic disturbances following palaeoclimatic alterations or anthropogenic activities such as intensive groundwater abstraction. Stable isotope analyses allowed researchers to estimate the mean residence time of groundwater in an aquifer up to five years, tritium allowed the detection of young groundwater in an aquifer recharged after 1963/64, and carbon dating could be used to estimate groundwater ages of up to about 40,000 years. It was maintained that pollution could be prevented through early detection of the mixture of young groundwater with a potential pollution source, an assertion supported by case studies carried out in Jakarta and Bandung, Indonesia. Groundwater mining exhausted fossil resources and could induce the movement of polluted and highly mineralized groundwater within the aquifer and in adjacent aquifers. Case

studies of the Azraq spring area in Jordan and the Thar desert in Pakistan demonstrated the usefulness of isotope methods.

31. The country paper of Lebanon, prepared by the Ministry of Energy and Water, reviewed the legal framework during the period 1920-1998 in relation to groundwater protection. The absence of comprehensive laws regulating development, utilization, monitoring and protection had contributed to the mismanagement of groundwater resources; uncontrolled pumping and drilling, combined with the dumping of wastewater and industrial wastes, had resulted in water quality deterioration in general and salt-water intrusion along the coast. Increased pollution levels were being reported in different parts of the country. The paper addressed the shortcomings of existing laws and regulations and suggested some technical, administrative and legal measures to protect groundwater sources.

32. A paper entitled "Groundwater use and groundwater protection in Germany" emphasized the importance of protecting groundwater from pollution, as it accounted for more than 70 per cent of the country's supply of drinking water. The paper elaborated on the protective measures adopted in Germany to ensure the systematic and regular monitoring of groundwater, including the use of monitoring permits issued by the Federal States to facilitate the early detection of pollution from hazardous substances, as well as various other measures to be implemented at an appropriate time. The Federal Water Act provided a comprehensive set of measures for groundwater protection and constituted an important component of Germany's environmental preservation efforts. In addition, the authorities were free to designate water protection areas and establish more stringent requirements for the monitoring and protection of any threatened groundwater sources.

III. EVALUATION OF THE MEETING

33. The Meeting organizers distributed a brief questionnaire to allow participants to assess the relevance of groundwater rehabilitation to the conservation and protection of groundwater, the quality of the papers prepared and presented, and the logistical aspects of the Meeting. The results of the evaluation indicated the following:

- (a) A total of 63 per cent of the respondents believed that the Meeting topic was relevant to their work;
- (b) The papers presented at the Meeting were of satisfactory quality, according to 60 per cent of the respondents; 27 per cent indicated that they were very relevant;
- (c) Half the participants felt that the discussions had been beneficial, and 37 per cent believed them to have been relevant;
- (d) Almost half (47 per cent) of the respondents indicated that they expected to use the information acquired during the Meeting;
- (e) Two thirds (67 per cent) felt that the Meeting had been very well organized;
- (f) Around 57 per cent of the participants indicated that rehabilitation techniques would be used by their concerned authorities.

Some analytical remarks extracted from the questionnaires are summarized in annex IV to the present report.

IV. RECOMMENDATIONS

34. The Meeting participants emphasized the vulnerability of groundwater aquifers in the region to quantity- and quality-related problems caused by overexploitation and pollution, which further reduced the already scarce

supplies available in the member countries, and called for effective measures to protect groundwater resources and rationalize their use.

35. It was noted that because aquifers in the region were vulnerable to pollution, special attention should be given to the formulation and adoption of effective policies for their protection. Preventive measures were often more cost-effective than rehabilitative or remedial solutions. In view of the above, the participants adopted the recommendations below:

A. RECOMMENDATIONS TO MEMBER STATES

36. It is recommended that member States consider the following:

(a) Formulating practical, integrated groundwater management policies appropriate to each country's situation. Such policies should enable the concerned authorities to guard against water depletion and degradation, deal effectively with diffuse pollution, and prevent further water contamination, especially by hazardous substances, in order to protect public health and the environment and deal with accidental pollution. This may be achieved through various means, including the following:

- (i) Adopting appropriate instruments and measures for the implementation of groundwater management policies, updating and reforming regulatory frameworks (regulations and by-laws), and developing and implementing enforcement mechanisms that clearly define the responsibilities of the various agencies concerned. Involving stakeholders in enforcement is a practical option that should be considered by member States;
- (ii) Developing and adopting sound agricultural policies and irrigation practices suitable for arid lands. Adequate attention should be given to the application of decision support systems to ensure an optimal match between water quality, crop, soil and climate to optimize productivity, and to minimize the qualitative and quantitative impact of agricultural activities on groundwater aquifers;

(b) Enhancing the capabilities of groundwater protection departments in member States through the following:

- (i) Developing and strengthening groundwater quantity and quality monitoring systems. Particular attention should be given to the development of reliable and comprehensive databases that can be used to facilitate efforts to assess and prevent pollution and design appropriate rehabilitation measures;
- (ii) Preparing groundwater vulnerability maps and integrating them into geographic information systems to facilitate analysis. This information may be used in decision-making processes, with emphasis given to the delineation of "wellhead protection areas" around municipal water wells and the control of groundwater-polluting activities within such areas;

(c) Encouraging research and studies to develop and update standards for the assessment and monitoring of groundwater quantity and quality; and preparing guidelines for the implementation of those standards;

(d) Implementing programmes to increase the awareness of local communities and encourage their participation in the monitoring, management, conservation of groundwater aquifers and their protection against all types of pollution;

(e) Encouraging the adoption of protective measures, including those based on the Polluter Pays Principle, and carrying out environmental impact assessments for development projects that may pollute water resources;

(f) Focusing special attention on building capacities in groundwater modelling and the use of GIS and other special techniques for the assessment of groundwater aquifer vulnerability;

(g) Working to increasing groundwater use efficiency in the various sectors, and giving priority to rehabilitating and protecting groundwater by organizing workshops and training courses to disseminate relevant information.

**B. RECOMMENDATIONS TO THE ESCWA SECRETARIAT, UNEP/ROWA AND
OTHER REGIONAL AND INTERNATIONAL ORGANIZATIONS**

37. International and regional organizations, and ESCWA in particular, are called upon to enhance cooperation in areas of common interest relevant to groundwater rehabilitation, protection and management, and to enter into discussion so that agreement may be reached on effective measures to support efforts by member States to implement the recommendations of this Meeting.

38. ESCWA and other United Nations entities should engage in a cooperative effort to launch a regional project in member States to develop and strengthen the capacities of departments involved in groundwater protection, primarily through the organization and support of training workshops and seminars and the provision of technical assistance relating to groundwater rehabilitation, protection and conservation; and should exchange data and information on various phenomena relating to environmental degradation, in particular those adversely affecting the quality of groundwater in member States.

Annex I

LIST OF PARTICIPANTS

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Annex II

LIST OF DOCUMENTS

Symbol	Title
E/ESCWA/ENR/2000/WG.3/L.1	Provisional agenda
E/ESCWA/ENR/2000/WG.3/L.2	Proposed organization of work
E/ESCWA/ENR/2000/WG.3/3	Implication of groundwater protection and conservation
E/ESCWA/ENR/2000/WG.3/4	Groundwater vulnerability mapping: decision support in groundwater resources quality protection
E/ESCWA/ENR/2000/WG.3/5	Pollution of groundwater from irrigation practices in the Arab countries
E/ESCWA/ENR/2000/WG.3/6	Groundwater use and groundwater protection in Germany
E/ESCWA/ENR/2000/WG.3/7	New approaches in groundwater rehabilitation
E/ESCWA/ENR/2000/WG.3/8	Water and soil vulnerability to contamination in central Beqa'a plain – Lebanon
E/ESCWA/ENR/2000/WG.3/9	Evaluating the potentials of submarine springs: an unconventional groundwater source for the coastal area – Lebanon
E/ESCWA/ENR/2000/WG.3/10	Salt water intrusion in the Hadeth aquifer: groundwater rehabilitation techniques
E/ESCWA/ENR/2000/WG.3/11	Groundwater pollution control measures in Lebanon
E/ESCWA/ENR/2000/WG.3/12	Guidelines for groundwater protection and pollution control in the GCC countries
E/ESCWA/ENR/2000/WG.3/13	Groundwater pollution by irrigated agriculture: a case study
E/ESCWA/ENR/2000/WG.3/14	قضايا هامة بالنسبة لاعادة تأهيل مصادر المياه الجوفية في منطقة الإسكوا
E/ESCWA/ENR/2000/WG.3/15	Implications of groundwater rehabilitation in the ESCWA region
E/ESCWA/ENR/2000/WG.3/16	Groundwater pollution: environmental health impacts
E/ESCWA/ENR/2000/WG.3/17	Burman, underground removal of manganese from groundwater in Beheira Governorate, Egypt
E/ESCWA/ENR/2000/WG.3/18	Solute transport models: An important tool for studies on groundwater protection or remediation
E/ESCWA/ENR/2000/WG.3/19	Isotope studies for groundwater protection and pollution control
E/ESCWA/ENR/2000/WG.3/20	MENA/MED water initiative: proceedings of the Regional Workshop on Sustainable Groundwater Management in the Middle East and North Africa
E/ESCWA/ENR/2000/WG.3/CP.1	ورقة قطرية - الجمهورية اللبنانية
E/ESCWA/ENR/2000/WG.3/CP.2	ورقة قطرية - المملكة الأردنية الهاشمية
E/ESCWA/ENR/2000/WG.3/CP.3	ورقة قطرية - الجمهورية العربية السورية

Annex III

ORGANIZATION OF WORK

Tuesday, 14 November 2000

8.30 - 9.30		Registration.
9.30 - 10 a.m.	<u>Item 1</u>	Opening session.
	<u>Item 2</u>	Adoption of the agenda.
	<u>Item 3</u>	Adoption of the programme of work.
	<u>Item 4</u>	Presentations by keynote speakers including the Chief of the Energy, Natural Resources and Environment Division of ESCWA, the Deputy Regional Director of UNEP/ROWA, the Executive Secretary of ESCWA and the Minister of Energy and Water in Lebanon.
10 - 10.30 a.m.		Break.
	<u>Items 5-8</u>	Presentation and discussion of working papers, country papers, and the papers of international organizations, universities and research institutions.

THEME I. GROUNDWATER POLLUTION AND ITS IMPACT

*(Chairperson: Mr. Hassan Hachem, Ministry of Energy and Water, Lebanon;
co-chairperson: Mr. Jamil Al-Alawi, World Water Council;
moderator: Mr. Mohamed Abdulrazzak, ESCWA)*

10.30 - 11 a.m.	Implications of groundwater rehabilitation in the ESCWA region (Ms. Rawya Kansoh, ESCWA).
11 - 11.30 a.m.	Groundwater pollution by irrigated agriculture: a case study (Mr. Walid Abderrahman, UNEP/ROWA).
11 a.m. - noon	Groundwater pollution control measures in Lebanon (Ms. Mirvat Kraidieh, Ministry of Energy and Water, Lebanon).
Noon - 1.45 p.m.	General discussion.
1.45 - 2 p.m.	Break.

Wednesday, 15 November 2000

THEME I. GROUNDWATER POLLUTION AND ITS IMPACT (*continued*)

(*Chairperson: Mr. Abdullatif Al-Mugrin, GCC; co-chairperson: Ms. Nicola Martin, BGR; moderator: Ms. Rawya Kansoh, ESCWA*)

- | | |
|-------------------|---|
| 8.30 - 9 a.m. | Evaluating the potentials of submarine springs: an unconventional groundwater sources for the coastal area – Lebanon (Mr. Mohammad Khawlie, National Centre for Remote Sensing, Lebanon). |
| 9 - 9.30 a.m. | New approaches in groundwater rehabilitation (Mr. Omar Joudeh, ESCWA). |
| 9.30 - 10.15 a.m. | Groundwater pollution: environmental and health impacts (Ms. Mey Jurdi, UNEP/ROWA). |
| 10 - 10.30 a.m. | General discussion. |
| 10.30 - 11 a.m. | Break. |
| 11 - 11.30 a.m. | General discussion. |

THEME II. GROUNDWATER REHABILITATION TECHNIQUES

(*Chairperson: Mr. Abdulla Al-Thary, Yemen; co-chairperson: Mr. Waleed Al-Zubari, UNEP-ROWA; moderator: Mr. Christian Weingran, BGR*)

- | | |
|-------------------|---|
| 11.30 a.m. - noon | Burman, underground removal of manganese from groundwater in Beheira Governorate, Egypt (Mr. Hassan Warda, BGR). |
| Noon - 12.30 p.m. | Solute transport models: an important tool for studies on groundwater protection or remediation (Mr. Klaus Schelkes, BGR). |
| 12.30 - 1 p.m. | Salt water intrusion in the Hadeth aquifer: groundwater rehabilitation techniques (Mr. Bernard Massaad, Ministry of Energy and Water, Lebanon). |
| 1 - 1.30 p.m. | Break. |
| 1.30 - 2.30 p.m. | General discussion. |

Thursday, 16 November 2000

THEME II. GROUNDWATER REHABILITATION TECHNIQUES (*continued*)

(*Chairperson: Mr. Mohamed Al-Eryani, ESCWA; co-chairperson: Ms. Mey Jurdi, UNEP/ROWA; moderator: Mr. Peter Kessler, BGR*)

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|-----------------|--|
| 8.30 - 9 a.m. | New approaches in groundwater rehabilitation (Mr. Christian Weingran, BGR). |
| 9 - 9.30 a.m. | MENA/MED water initiative: proceedings of the Regional Workshop on Sustainable Groundwater Management in the Middle East and North Africa (Ms. Doris Koehn, World Bank). |
| 9.30 - 10 a.m. | Water and soil vulnerability to contamination in central Beqa'a plain – Lebanon (Mr. Talal Darwish, National Centre for Remote Sensing, Lebanon). |
| 10 - 10.30 a.m. | General discussion. |
| 10.30 - 11 a.m. | Break. |
| 11 - 11.30 a.m. | General discussion. |

THEME III. GROUNDWATER PROTECTION

(*Chairperson: Mr. Habib El-Habr, UNEP/ROWA; co-chairperson: Mr. Walid Abderrahman, UNEP/ROWA; moderator: Mr. Peter Kessler, BGR*)

- | | |
|-------------------|---|
| 11.30 a.m. - noon | Groundwater use and groundwater protection in Germany (Mr. Peter Kessler, BGR). |
| Noon - 12.30 p.m. | Guidelines for groundwater protection and pollution control in the GCC countries (Mr. Waleed Zubari, UNEP-ROWA). |
| 12.30 - 1 p.m. | Groundwater vulnerability mapping: decision support in groundwater resources quality protection (Ms. Nicola Martin, BGR). |
| 1 - 1.30 p.m. | Break. |
| 1.30 - 2 p.m. | Isotope studies for groundwater protection and pollution control (Mr. Mebus Geyh, IAEA). |
| 2. - 2.30 p.m. | Pollution of groundwater from irrigation practices in the Arab countries (Mr. Isam Mustafa Abdel Haleem, AOAD). |
| 2.30 - 3 p.m. | General discussion. |

Friday, 17 November 2000

THEME III. GROUNDWATER PROTECTION (*continued*)

(*Chairperson: Mr. Mohamed Al-Yami, Qatar; co-chairperson: Mr. Habib El-Habr, UNEP/ROWA; moderators: Mr. Hassan Hachem, Ministry of Energy and Water, Lebanon; and Mr. Mohamed Abdulrazzak, ESCWA*)

8.30 - 9 a.m.		Groundwater contamination and groundwater vulnerability to pollution in the Ghouta plain in the Syrian Arab Republic and the central Beka'a valley in Lebanon (Mr. Manfred Hobler, ACSAD).
9 - 10 a.m.	<u>Item 6</u>	Country paper presentations reflecting national experiences (Jordan and Lebanon).
10 - 10.30 a.m.		General discussion.
10.30 - 11 a.m.		Break.
11 a.m. - noon		Country paper presentation (Syrian Arab Republic).
Noon - 1 p.m.		Conclusion and recommendations.
1 - 1.30 p.m.		Break.
1.30 - 2.30 p.m.		Adoption of the final report.

Annex IV

EVALUATION OF THE MEETING

Efficiency	Effectiveness	Impact	Further suggestions	Overall assessment
<ul style="list-style-type: none"> Most of the presentation materials were not well prepared or delivered for the benefit of the audience. Some duplication of information was noted. Most of the data presented was already well known. Economic aspects were not covered. Specific methods of treatment were not explored. Recommendations were good but require implementation measures. 	<ul style="list-style-type: none"> The presentations could have been grouped according to subject to keep the audience focused. More focused papers and discussions were needed. More time should have been allocated for discussions, especially for discussion of problems between experts. Field visits relevant to the main topic of the meeting should have been conducted. 	<ul style="list-style-type: none"> It was perfect, but the meeting should have been announced ahead of time in newspapers. Failure in audio transmission affected the discussions. More comprehensive water resource profiles of member countries were needed. The meeting was very interesting and useful. Administrative issues should have been assigned more importance. 	<ul style="list-style-type: none"> Future meetings should be oriented towards decision makers. Papers should be translated into Arabic and interpretation should be provided during meetings. More Asian, East Asian and European participants should be invited. Groundwater contamination by solid waste should be covered as one of the major problems in Lebanon. A systematic approach should be taken to regional water problems. 	<p>The meeting was successful in highlighting and identifying common groundwater pollution in Western Asia.</p>