

WATER RESOURCES ASSESSMENT YEMEN, PHASE 4

(WRAY-4)

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M I S S I O N   R E P O R T

Period : 17-25 January and 9-11 February 1993

Purpose of mission : Assistance regarding data compilation and water resources assessment

Report prepared for : Mineral Exploration Board (MEB) of the Ministry of Oil and Mineral Resources (MOMR), Sana'a, Yemen;  
Directorate General of International Co-operation (DGIS), The Hague, the Netherlands;  
Royal Netherlands Embassy at Sana'a, Yemen.

Report prepared by : Jac A.M. van der Gun,  
project supervisor/ hydrologist  
TNO Institute of Applied Geoscience,  
P.O.Box 6012, 2600 JA Delft, The Netherlands

## 1 INTRODUCTION

A mission to the WRAY-4 project in the Republic of Yemen was undertaken during the period 17-25 January and 9-11 February 1993. During this mission special attention was paid to :

- (a) summary report on the water resources of Yemen
- (b) Wadi Abyan water resources assessment study
- (c) cooperation with the TS-HWC.

A mission diary is presented in Appendix 1.

## 2 SUMMARY REPORT ON THE WATER RESOURCES OF YEMEN

During the preceding months work continued on the inventory of reports and publications; 466 titles were on the list by the beginning of February 1993. The preparation of a map and list of hydrological and hydrogeological monitoring stations, including information on the periods of record, experienced only little progress over the last few months. Base maps on the scales 1: 1,000,000 and 1: 4,000,000 had not yet been produced either, due to other priorities for the ARC/INFO group.

During the mission discussions took place with the project team 'Summary Report on the Water Resources of Yemen' both at Sana'a and at Aden; a number of relevant issues was discussed. Some of these issues are commented below.

### 2.1 Targets and accents

First of all, ideas were exchanged on what the summary report envisaged ought to be and in what aspects it should be distinct from existing reports of a summarizing character on groundwater, surface water or both.

#### *Targets*

- (a) up-to-date, clear and authoritative summary description of the water resources of the Republic of Yemen (main target).
- (b) up-to-date description of sources of Yemeni water resources information (what info is available and where can it be found?)

#### *Existing summarizing works on Yemen's water resources*

Several other related summarizing works already exist. The most important ones are:

- (a) Summary Report WRAY, 1984;
- (b) Robertson's Hydrogeological Map, 1991;
- (c) Russian Hydrogeological Map, 1991;
- (d) TS-HWC's Groundwater, Surface Water and Water Requirements reports, 1992.

A new summary report is only justified if it contains additional information, and/or includes a better scientific evaluation and/or has a better presentation (to facilitate that the information is really disseminated). The existing published reports and maps are briefly reviewed below from these angles of view.

Table 1 Information contained in the various 'summary reports'

ASPECT	WRAY'84	ROB'91	RUSS'91	TS-HWC
<b>GEOGRAPHIC COVERAGE</b>				
only former YAR	x			
only former PDRY			x	
total RoY, but fragmented				x
total RoY, homogeneous		x		
<b>SCOPE: MAIN THEMES</b>				
groundwater	x	x	x	x
surface water	x			x
water res. development & use	x	(x)		x
<b>WATER RESOURCES DATA</b>				
data availability described	x			
almost no data presented		x	x	
data mainly as examples				(x)
presentation of key data	x			
'data books' approach			x	(x)
<b>MAPS AND GRAPHS</b>				
almost no text maps/graphs			x	
many text maps/graphs	x			x
hydrogeological map		x	x	
<b>UP-TO-DATE ?</b>				
no, because of report date	x			
no, because of methodology		x		
reasonably up-to-date			x	x

Table 1 characterizes their information contents. It can be observed that none of the works mentioned fully satisfies the targets formulated above. Taken together, they do to a large extent; but lack of consistency and many contradictions between them may confuse the reader.

Hence, there is obviously a need for a **balanced and consistent summary of information on the groundwater and surface water resources and their exploitation all over Yemen.** It should contain a systematic inventory of the relevant types and sources of information, in order to facilitate the reader who is searching for more details.

Reviewing the reports and maps from a scientific point of view can only be done in a subjective way. Nevertheless, comments will follow on a number of aspects that are considered important.

- (a) The basic approach of WRAY's Summary Report (1984) is to make the reader familiar with the main outcomes of previous studies conducted. It tries to do so in a logical framework, which allows information gaps, inconsistencies or contradictions to become exposed. Relatively little attention is paid to analysis; the text dominantly focuses on the description of the information collected. Regionalization was attempted for a number of important variables, notably rainfall,

evapotranspiration, runoff and groundwater recharge. The methods applied were simple; some of them should be improved in a second edition.

- (b) Robertson's Hydrogeological Map (1991) follows a very clearly described methodology, but it suffers from the unsatisfactory methodological principle that only the uppermost geological unit (the one shown on a general geological map) should be mapped. For zones where deeper strata constitute the main aquifer this results in erroneous information, such as neglecting this aquifer or even attributing its potential to a superficial geological unit which has little or no potential at all ! It is evident that the map lacks proper verification on the basis of field studies or field data.
- (c) The Russian Hydrogeological Map (1991) shows much more underpinning by real field data. Furthermore, it presents a 3-D picture of aquifer bed configuration (display of superimposed hydrogeological units). The classification system is in some respects not entirely logical (e.g. 'artesian basins' appear to contain phreatic aquifers). The interpretation seems in several zones rather speculative, with interpolations over large distances. As a result of all these factors, the map differs very strongly from Robertson's map (Mukalla sandstone aquifer is very dominant on Russian map, but is absent on Robertson's map !)
- (d) The TS-HWC 'summary reports' consist of different volumes, written by different authors, and are not very coherently designed. The Surface Water Report (Jan 1992) has a rather extensive descriptive part, but pays surprisingly little attention to the presentation of measured runoff series. In stead, much emphasis is put on the generation of synthetic stream flows. The suitability of the method used to derive the volumes of runoff (Curve Number method) is questionable, and a number of synthetic runoff series are obviously in conflict with reality (e.g. Sadah basin). The authors nevertheless seem to prefer these synthetic data to the original ones. A complementary volume on the southern provinces is very provisional and does not even contain a clear catchment map. The Groundwater Report (1992) contains good descriptive parts, but it fails in its main text to define and delineate the main aquifer systems in maps and cross sections. This makes uncertain as to what hydrogeological units exactly quoted recharge and abstraction figures refer, and it does not convincingly support all remarks on groundwater management. The report on Regional Water Requirements (1992) is the most systematic of the three and seems very useful, although the figures apparently have not been verified on the basis of water use figures.

Regarding these scientific aspects, it can be concluded that:

- (a) there is a need for a much better delineation and definition of the groundwater and surface water systems;
- (b) uncertainties on aspects of major importance should not be camouflaged, but rather need to be mentioned and discussed;
- (c) regionalisation techniques are needed to extend and regionalise local information, but they should be applied cautiously, in order prevent that 'synthetic data' are overvalued and 'real data' become neglected.

Regarding the presentation, only the WRAY Report, Robertson's report and the Water Requirements report of the TS-HWC are relatively clear, systematic and easy to read as a reference work. The thick Russian Report is not written as an easy reference: it lacks sufficient text illustrations or maps (although topographic references are abundant) and the English is relatively poor; furthermore, the described hydrogeological map is available in a very limited number of copies, and is not in a shape suitable for wide dissemination (hand-painted colour maps that can not easily be reproduced). The Groundwater and Surface Water Reports of the TS-HWC are consisting of too many separate parts and would also have gained by more and more consistent illustrations and maps. None of the reports contains photographs, and the quality of the figures and maps (except for the Robertson map) is never very impressive, but often rather poor.

It can be concluded that a water resources summary report that is compact, systematic, up-to date, consistent, well-written, attractively and functionally illustrated, and not 'oversized' is not yet available.

#### *Accents for WRAY's new summary report*

From the above, it follows that the new 'Summary Report on the Water Resources of Yemen' should preferably have the following characteristics:

- (a) balanced and complete (in a geographic and thematic sense);
- (b) compact, and focusing on the overall picture instead of on details, but extensive and clear references to (original) sources of information;
- (c) emphasis on the use of illustrations, maps, graphs and (perhaps) photos;
- (d) text and illustrations should follow a very systematic pattern (standard subjects, formats, scales, legend, etc.);
- (e) major uncertainties in data and interpretation should be mentioned;
- (f) 'synthetic' or 'extrapolated' data should not obscure real observations.

#### *2.2 Planning and progress*

In spite of the existence of an extensive and detailed "Workplan for the Development of the Summary Report Hydrology and Hydrogeology of Yemen" (June 1992) progress to date is rather modest. During the discussions the following promising steps for improvement were identified:

- (a) defining priorities among the many activities stated;
- (b) stating deadlines in more detail and more explicitly;
- (c) more clear personal commitments to specific tasks;
- (d) progress meetings during which progress is systematically monitored against planning;
- (e) immediate dissemination of all items produced (maps, tables, summaries, etc.) to all six members of the study team.

Referring to the first three steps for single activities commitments were agreed upon for two periods of two months (respectively Jan/Feb and March/April 1993); an overview is summarized in Appendix 2. The general time frame is that end of 1993 a draft of the summary report should be ready; the remain-

ing six months of WRAY are badly needed to produce a final version that is reasonably checked, balanced in contents and well-presented.

The progress meetings are to be held approximately twice a month. Dissemination of items produced will be via Ton Negenman who is the "mail box" where all these products are collected. General coordination is in hands of dr Abdul Mageed.

### 3 ABYAN DELTA WATER RESOURCES ASSESSMENT STUDY

A quick start of the field work in the Wadi Abyan water resources assessment was dictated by the very tight time frame of the TS-HWC Project. Only if the GDH is capable to produce, process and interpret new field data before mid-1993, these data can still be incorporated in the planning activities of the Technical Secretariat of the High Water Council (TS-HWC). Close cooperation with this organization has been GDH's and WRAY's aspiration for a long time, so this opportunity to establish it should not be missed.

For the above-mentioned reason thus far relatively little time could be spent by the project team to the review of previous studies in Abyan Delta, and to corresponding priority setting for field work. During the mission some time could be found to do some review work and to discuss its repercussions for the planning of the field work. In support of this, a field trip to Abyan Delta was made for better acquaintance with the most important features of the area and with the local working conditions. Mr Mohamed Danikh, mr Noory Gamal and mr Ton Negenman joined this trip; the well inventory crews were met, some parts of the irrigation infrastructure (e.g. Batais weir) were visited, the El Kodd meteorological station was inspected (poorly kept) and a general impression was obtained of irrigated agriculture in the Wadi Bana area and of the Wadi Hassan area immediately upstream of Batais.

#### *Geophysical study*

In view of the arrival of a short-term geophysicist to support the geophysical crews of GDH (February 1), previous studies were reviewed - in particular the geophysical study carried out by SOGREAH in 1981. Based on the results of this study it became clear that the southern part of Abyan Delta has a higher priority for exploration than the northern part where the GDH teams had started. The reasons are that it is more complex, much less explored yet, and of more significance for groundwater development and management. TNO's geophysicist correspondingly advised the GDH crews to move southwards and spend more attention to that subarea.

#### *Exploratory drilling*

The study of previous reports and the analysis made by the TNO geophysicist have made clear that the hydrogeological situation in the southern part of Abyan Delta can not be satisfactorily described and that the geo-electrical soundings can not be unambiguously be interpreted without having access to data of deeper boreholes. Unlike what was hoped for during the first planning of the project, the well inventory has shown that such boreholes do not exist in the southern zone. Consequently it is of vital interest that the project

will drill at least one deep borehole (approximately 300 m deep). During budget revision it should be a priority to allocate funds for such a drilling operation.

### *Hydrometry*

After studying the water resources management setting of the area (which was done separately for the TS-HWC/UNDP Project YEM/92/056) it became clear that monitoring wadi flows and diverted flows in the Delta Area should have very high priority among GDH's field activities. It provides a key to proper understanding and simulating surface water allocation in the Delta. Because such a monitoring programme was not yet scheduled, it was discussed with the GDH and an outline was made on how to do it. It was agreed that a team would carry out these monitoring activities continuously for a period of a few months during the coming Seif season.

## 4 COOPERATION WITH THE TS-HWC

As already mentioned above, the Abyan study is presently a focal point for cooperation between the General Department of Hydrogeology and the Technical Secretariat of the High Water Council. Both parties are motivated to use this opportunity for cooperation to its full extent, in spite of a pressing time schedule.

It is expected that further steps towards closer cooperation can be put in the near future, perhaps in a different institutional setting, - depending on what the Government of Yemen will decide regarding reorganisation of the Water Sector.

## 5 MISCELLANEOUS

Other activities developed during the mission were: (a) discussions with the two associate experts of WRAY (mr Philip Visser and mr Han Kamphuis) on their activities, opinions and aspirations; (b) discussions with several Yemeni professionals of GDH on different aspects of their work; and (c) discussions with mr Mohamed Danikh and mr Ton Negenman (CTA) on current project affairs.

MISSION DIARY

- 17 January Travel Amsterdam - Sana'a.
- 18 January Introductory talks at GDH (CTA, Director General, etc.)  
Discussion with mr Ali Gaber Alawi, Chairman of the Mineral  
Exploration Board  
Review of state of activities national summary report on water  
resources  
Review of reports on Abyan Delta
- 19 January Briefing on progress ARC-INFO  
Briefing on progress in the Abyan study  
Discussion with associate experts on their activities  
Preparations for trip to Aden and Abyan Delta
- 20 January Ascension of the Prophet Mohamed (public holiday)  
Study of reports  
Discussion with associate experts
- 21 January Public holiday  
Study of reports
- 22 January Friday  
Study of reports
- 23 January Trip to Aden  
Discussions with Aden staff of Department of Hydrogeology on  
activities related to Summary Report.
- 24 January Continuation of discussions with Aden staff of Department of  
Hydrogeology on activities related to Summary Report.  
Visit to Abyan Delta (fields crews and familiarization with the  
area) and return to Sana'a
- 25 January Discussions at GDH, Sana'a
- 26 - 28 Assignment at TS-HWC (UNDP project)  
January
- 29 January Preparation of technical information on Abyan Delta for WRAY  
visiting geophysicist
- 31 January - Assignment at TS-HWC (UNDP project)  
8 February
- 9 February Discussions at GDH,  
Adjustment between Abyan programmes of GDH and TS-HWC
- 10 February Discussions at GDH,  
Adjustment between Abyan programmes of GDH and TS-HWC, in  
particular regarding an additional spate allocation monitoring  
programme
- 11 February Final discussions at GDH, incl. status-quo of geophysical work.  
Travel Sana'a - Amsterdam.



## SHORT-TERM OUTLINE PLANNING SUMMARY REPORT ON THE WATER RESOURCES OF YEMEN

## (1) PRIORITIES FOR OUTPUTS TO BE FINALISED DURING JANUARY - FEBRUARY 1993

ITEM	WHO RESPONSIBLE ?	REMARKS
1 List of literature references (use standard format)	Abdallah Saleh Dr Abdul Mageed Abdallah Saleh	compiling (N.Prov.) compiling (S.Prov.) typing (WP 5.1 text file)
2 List of hydromet. stations (including obs.period,agency, coordinates, elevation, etc.)	Abdul Aziz A.M./Salem b-Sh Abdul Aziz	compiling (N.Prov.) compiling (S.Prov.) typing (WP 5.1 table file)
3 Topographic basemap (GIS plot) (at different scales)	Nabeel Abd.Q.	1 : 1,000,000 UTM 1 : 4,000,000
4 Priority setting for reports to be read + who reads what	Ton Negenman	individual lists of reports to be read January through May 1993
5 Collecting relevant reports (copies)	Salem ba-Shuaib	emphasis on the ones on priority list (see item 4)
6 Regional zoning of Yemen (a) geographic units (b) basins and catchments (c) groundwater provinces zones (provisional) (on scale 1 : 4,000,000)	Jac van der Gun	will provide basis for report structure, regional maps and aggregation level
7 Map of hydromet. stations (1 : 1,000,000 & 4,000,000)	Abdul Aziz Salem ba-Shuaib Abdul Aziz	compiling data (N.Prov.) compiling data (S.Prov.) drafting (GIS)
8 Generalized geological map (1 : 4,000,000)	Ton Negenman Salem, Abdallah, dr Abdul Mageed	based on Robertson; compare with others
9 Stratigraphic table	dr Abdul Mageed & Abdallah	collect all known Yemeni strat. tables; analyze and compile

## (2) PRIORITIES FOR OUTPUTS TO BE FINALISED DURING MARCH-APRIL 1993

ITEM	WHO RESPONSIBLE ?	REMARKS
10 Reading and abstracting reports	all; format for abstract to be developed by Jac vd Gun	standard format for abstracts; copy/file selected figures and tables (consult Workplan)
11 Table of monthly rainfall figures (all stations)	Abdul Aziz & Salem Abdul Aziz	collecting typing (WP 5.1 table file)
12 Table of monthly runoff figures (all stations)	Abdul Aziz & Salem Abdul Aziz	collecting typing (WP 5.1 table file)
13 Table of monthly meteo data (selected stations)	Abdul Aziz & Salem Abdul Aziz	collecting typing (WP 5.1 table file)
13 Computing Penman $E_o$ and $ET_p$	methodology: Jac vander Gun computing: Abdul Aziz & Salem	for all selected stations (item 13) typing (WP 5.1 table file)
14 Analyze rainfall series reliability variability in space/ time intensities	Abdul Aziz & Salem	spreadsheet files and graphs
15 National isohyet map (1 : 1,000,000 & 4,000,000)	Abdul Aziz & Salem	try to define 'standard period'
16 Hydrogeological classification of the geological formations	Salem (south) & Jac (north)	regio-wise compilation (combine later) typing (WP 5.1 table file)
17 Map of terrain characteristics related to runoff production (1 : 1,000,000 & 4,000,000)	Ton Negenman	runoff producing and absorbing zones, (see WRAY and TS-HWC reports), vegetation, terraces, etc.
18 Map(s) of groundwater level contours (1 : 1,000,000)	Abdallah	based on different studies (mark the year)
19 Map(s) of groundwater EC contours (1 : 1,000,000)	Abdallah	based on different studies
20 Table of groundwater recharge by zone	Jac vander Gun	mention method used and reference; typing WP 5.1 file)