TECHNICAL REPORT

91-05

Description of tracer data in SKB´s database GEOTAB Version 1

Peter Andersson[1], Margareta Gerlach[2]

[1] Swedish Geological, Uppsala
[2] Swedish Geological, Luleå

April 1991

SVENSK KÄRNBRÄNSLEHANTERING AB
SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT CO

BOX 5864 S-102 48 STOCKHOLM

TEL 08-665 28 00 TELEX 13108 SKB S
TELEFAX 08-661 57 19

DESCRIPTION OF TRACER DATA IN SKB'S DATABASE GEOTAB. VERSION 1

Peter Andersson[1], Margareta Gerlach[2]

1 Swedish Geological, Uppsala
2 Swedish Geological, Luleå

April 1991

Information on SKB technical reports from 1977-1978 (TR 121), 1979 (TR 79-28), 1980 (TR 80-26), 1981 (TR 81-17), 1982 (TR 82-28), 1983 (TR 83-77), 1984 (TR 85-01), 1985 (TR 85-20), 1986 (TR 86-31), 1987 (TR 87-33), 1988 (TR 88-32) and 1989 (TR 89-40) is available through SKB.

SWEDISH GEOLOGICAL COMPANY
Division of Engineering Geology
Client: SKB

REPORT
ID-no: IRAP 90066
Date: 1991-04-09

DESCRIPTION OF TRACER DATA

IN SKB'S DATABASE GEOTAB

Version 1

Peter Andersson
Swedish Geological, Uppsala
Margareta Gerlach
Swedish Geological, Luleå
April 1991

ABSTRACT

During the research and development program performed by SKB for the final disposal of spent nuclear fuel, a large quantity of geoscientific data is collected. Most of this data is stored in a database called GEOTAB. Here, the data is organized into eight groups (subjects) as follows:

- Background
- Geology
- Geophysical borehole logging
- Ground surface geophysical methods
- Geohydrological and meteorological measurements
- Chemical methods
- Tracer methods
- Petrophysical measurements

The present report describes data within the Tracer methods group (tracer subject).

The results of the tracer investigations have been divided into five subgroups (methods) and each method is presented separately in the database. In addition there is a method with check tables for tracer and injection types.

DILUTION	Dilution Test
DIPOLE	Dipole Test
FLUSH	Flushing Water Test
RADCON	Radially Converging Test
RADDIV	Radially Diverging Test
TRCHECK	Check tables

A method consists of one or several data tables. In each chapter a method and its data tables are described.

CONTENTS

1 INTRODUCTION

Since 1977 Swedish Nuclear Fuel and Waste Management Co., SKB has been performing a research and development programme for final disposal of spent nuclear fuel. The purpose of the programme is to acquire knowledge and data for underground storage of radioactive waste. Measurement for the characterisation of geological, geophysical, hydrogeological and hydrochemical conditions are performed in specific site investigations as well as for geoscientific projects.

Large data volumes have been produced since the start of the programme, both raw data and results. During the years these data were stored in various formats by the different institutions and companies that performed the investigations. It was therefore decided that all data from the research and development programme should be gathered in a database. The database, called GEOTAB, is a relational database. It is based on a concept from Mimer Information System, and has been further developed by ErgoData. The hardware is a VAX 750 computer located at KRAB (Kraftverksbolagens Redovisningsavdelning AB) in Stockholm.

The database comprises eight main groups of data volumes (Figure 1-1). These are:

- **Background**
- **Geology**
- **Geophysical borehole logging**
- **Ground surface geophysical methods**
- **Geohydrological and meteorological measurements**
- **Chemical methods**
- **Tracer methods**
- **Petrophysical measurements**

In the database background information about the investigations, raw data and results are stored on line in the VAX 750, while some large raw data files are stored on archive magnetic tapes at KRAB.

This report deals with data from tracer tests and describes the data flow from the measurements at the sites to the result tables in the database. Almost all the tracer investigations were carried out by Swedish Geological, SGAB.

The results of the tracer investigations have been divided into five methods and each method is presented separately in the database. In addition there is a method with check tables for tracer and injection types.

DILUTION	**Dilution Test**
DIPOLE	**Dipole Test**
FLUSH	**Flushing Water Test**
RADCON	**Radially Converging Test**
RADDIV	**Radially Diverging Test**
TRCHECK	**Check tables**

In the following chapters the data flow of each method is described separately.

The database is continuously updated. Methods, tables or columns may change. This report will be updated accordingly.

Four reports dealing with different data sets stored in the GEOTAB database are in print during 1991:

These are:

TR91-01	Description of geological data in the SKB database GEOTAB. Version 2 Tomas Stark
TR91-02	Description of geophysical data in the SKB database GEOTAB. Version 2 Stefan Sehlstedt
TR91-06	Description of background data in the SKB database GEOTAB. Version 2 Ebbe Eriksson, Stefan Sehlstedt
TR91-07	Description of hydrogeological data in the SKB database GEOTAB. Version 2 Bengt Gentzschein

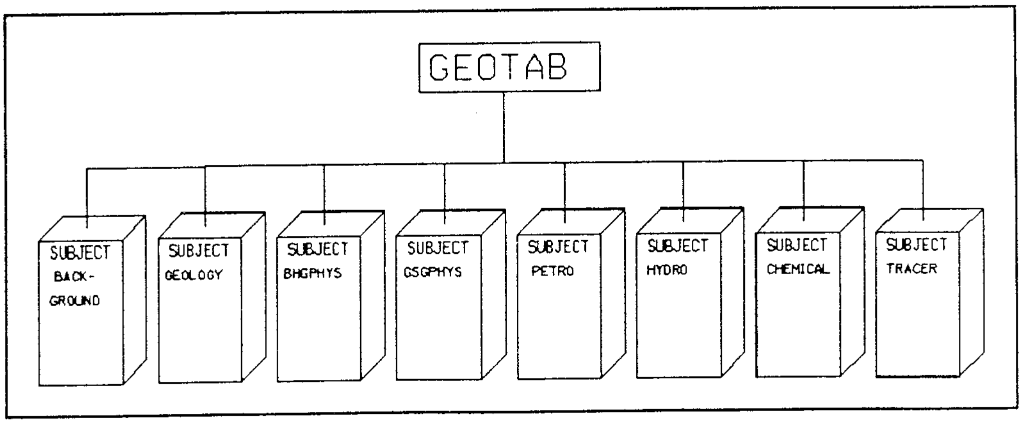

Figure 1-1 Structure of the GEOTAB database

2 GENERAL COMMENTS OF TRACER TESTS IN GEOTAB

The tracer tests performed in Sweden within the SKB programme have so far been in a developing stage. This implies that practically all tests performed have been different both regarding equipment and data flow. Therefore, it is very difficult to give a general description of a specific tracer test. This section gives a brief description of the tests and some general comments regarding equipment, accuracy and data flow for the tracer tests.

2.1 PURPOSES

The tracer tests in GEOTAB are divided into 5 different types of tests;

- dilution tests
- radially converging tests
- radially diverging tests
- dipole tests
- flushing water tests

The dilution test is a one borehole method which aim to measure the groundwater flow rate through a borehole or an isolated interval of a borehole. So far about 100 dilution tests have been performed within the SKB programme. The tests have been performed with different types of equipment which are described in Section 3.2.

The other four types of tests are similar to each other both regarding purpose and equipment. They all aim to determine hydraulic and transport parameters of the rock mass and fractures/fracture zones within the rock mass. This is accomplished by creating a flow regime as well defined as possible either by pumping or injecting water into the rock mass and introducing a tracer into the flow system.

2.2 EQUIPMENT

The equipment for tracer tests have also been much developed since the start of the tracer test within the SKB programme in 1977. Thus, the equipment has been different for each test. Therefore, in the sections describing the equipments used for each of the different types of tracer test, no detailed descriptions of different parts of the equipment has been made. Instead, a more general description has been made with references given to reports describing the equipment in more detail.

2.3 DATA FLOW

For tracer tests, the data flow from field measurements to GEOTAB is very much dependent on the type of equipment used during the test. Large scale tracer tests like dipole tests and radially converging tests are still in a developing stage and all tests are therefore different regarding equipment and performance and also data flow. In general the costs are large and there are to this date only a few tests performed within the SKB programme. It is therefore difficult to describe the data flow in detail, to do this one has to make a separate description for each test performed. Instead, a more general description of the type of data collected at field and the data flow has been made for each type of test.

2.4 ACCURACY

The term accuracy is very difficult to apply to tracer tests of this type. The tests are not standardized in any way and the results of the test are much dependent on the injection/detection procedures, tracers, influences of natural boundaries, changes of the natural gradient and many other factors. One might of course give the accuracy of each instrument or sensor used in the test but still there are much larger uncertainties coupled to the media and the procedures used and these factors are extremely difficult to give any accuracy for.

Another problem is that the equations used to calculate the transport parameters are derived by assuming some boundary conditions and initial condition which never exists in reality. Assumptions like homogeneous, infinite, isotropic, porous media makes it possible to solve the differential equations for transport of solutes but the validity of these assumptions for a particular set of test data and a specific site is difficult to estimate.

The only type of tracer test for which it is possible to discuss the accuracy in quantitative terms is for the dilution test (Section 3.4). There are also some comments given regarding the accuracy of the flushing water test, which is a more qualitative type of test (Section 6.4).

3 DILUTION TEST

3.1 PRINCIPLE

The point dilution method enables the determination of ground water flow in situ, in fractures and fracture zones under natural hydraulic gradient conditions, and in the direction of the natural ground water flow.
In this method the tracer is introduced as a homogeneous pulse into a borehole or a test section of borehole sealed off by rubber packers. The tracer will be diluted due to the ground water from the fracture zone flowing through the borehole. The dilution of the tracer introduced is proportional to the water flow through the borehole section, and thus to the ground water flow in the fracture zone. Within the borehole section the tracer must always be completely mixed and the concentration is measured as a function of time.

Groundwater flow rate through the borehole test section is calculated from the water volume in the test section, and the dilution as a function of time according to Equation (1). This is the solution of the equation of continuity for the dilution of a homogeneously distributed tracer solution in a constant volume V at steady-state groundwater flow.

$$Q_w = - V \times \ln(C/C_o)/t \qquad (1)$$

where

Q_w = groundwater flow rate through the borehole test section (m^3/s)
V = water volume in the borehole test section (m^3)
t = time (s)
C_o = initial tracer concentration
C = tracer concentration at time t

Dilution as a function of time is obtained from a semilogarithmic diagram of normalized tracer concentration versus time. In the ideal case the relating between time and logarithmic concentration is linear according to Equation (1).

As the dilution measurements aim in relating the measured groundwater flow rate through the borehole section to the rate of the undisturbed groundwater flow in the fracture zone, the flow field distortion must be taken into consideration, i e the degree to which the groundwater flow converges and diverges in the vicinity of the borehole section. The groundwater specific discharge (Darcy-velocity), defined as the discharge per unit cross-sectional area perpendicular to groundwater flow, is denoted by v_f. With a correction factor â, which accounts for the distortion of the flow lines owing to the presence of the borehole, it is possible to calculate the specific discharge according to equations (2) and (3). If the groundwater flow is not perpendicular to the borehole-axis, this also has to be accounted for (Gustafsson, 1986).

The cross-sectional area used to calculate the specific discharge is:

$$A = 2 \times r \times L \times \hat{a} \qquad (2)$$

Hence, the specific discharge is given by:

$$v_f = Q_w/A \qquad (3)$$

The quotient Q_w/A may thus also be expressed as a volumetric flux density, Q_f ($m^3/m^2 \times yr$).

Determination of the groundwater flow rate in each individual fissure requires either isolation of the single fissures in short test sections, or knowledge about the number of flowing fissures in the test section. Calculations of the velocity in the fissures also requires knowledge about the fissure apertures.

3.2 EQUIPMENT

Three different kinds of dilution equipments have been developed and designed by SGAB with funds from Swedish Nuclear and Waste Management Co (SKB). They are basically adopted to different types of boreholes and hydrogeological conditions.

Borehole point dilution equipment (Figure 3-1)

With interchangeable packers and dummys, this equipment makes it possible to conduct dilution measurements down to 500 m depth in boreholes with a diameter of 76 mm and greater. Dummys can be manufactured at any length, allowing an optional test section length between 0.3 - 20.0 m. The dilution of a dye tracer is measured optically in-situ with a borehole transmission meter. The tracer is thoroughly mixed during the process of dilution by a circulation pump. The pump is fixed to the upper packer, above the test section to avoid density induced currents due to heating. The intake and outlet of the pump emerges through tubes into the test section and the outlet is arranged in such a way that the optics of the transmission meter is flushed to avoid clogging.

The dye tracer is injected into the test section from a tank via a shunt on the pump outlet. The tank contains tracer solution enough to perform 15 dilution measurements in 2 m long test sections in a 110 mm diameter borehole. The circulation pump, tracer tank and valves etc. are encapsulated in a pressure compensated steel cylinder.

The dilution rate, at constant groundwater flow, is inversely proportional to the water volume in the test section. Therefore this volume is minimized by dummys in order to reduce the time necessary for an accurate measurement of the dilution.

At the ground surface is a control unit via a signal cable to the down-hole equipment used for tracer injection and mixing rate control. The control unit also handles storage of concentration versus time data. Processing of data is made with a microcomputer.

The equipment operates on mains voltage 220/240 V AC or a rechargeable battery 24 V DC, 18 Ah. With the rechargeable battery the operating time is approximately 300 hours.

Besides the dilution of the tracer the hydraulic head and the temperature are measured in the borehole test section. The hydraulic head is measured during the dilution process because in a fractured medium a change in the hydraulic head normally indicates that the hydraulic gradient, and thus the groundwater flow, is changed.

When lowering the equipment into the boreholes, suspended particles such as drilling debris, precipitations etc. interfere with the optical measurement of the tracer concentration. Therefore the turbidity is measured. The tracer is injected when the suspended particles have settled, which, besides high transmission, corresponds to a constant low value of the turbidity.

The equipment also includes a device for water injection with which it is possible to measure/check the hydraulic conductivity of the test section by means of a slug test.

Surface sampling dilution equipment (Figure 3-2)

The principle of the surface sampling dilution equipment is basically the same as the borehole point dilution equipment. However, it is a simpler construction with all electronics, pumps etc. located on the ground surface. It has both advantages and drawbacks compared to the borehole dilution equipment.

Test sections longer than 20 m can be measured, but it has no built in facilities for measurements of hydraulic head or temperature in the test section. The maximum depth to the groundwater table is restricted to c. 8 m due to the location of the circulation pump at the ground surface.

The tracer dilution versus time is measured by analysis of samples taken with an automatic sampler in the circulating water . This equipment enables any type of tracer to be used, since at ground surface any analyzing method for tracer content can be applied. As water is lost from the test section with the samples, sampling will cause a dilution of the tracer which is not due to the groundwater flow through the test section. This is compensated for at low flow rates.

The multipacker system (Figure 3-3)

The multipacker system is designed for telescope boreholes. Up to 10 test sections can be isolated for hydraulic head monitoring and two of these sections can also be equipped for dilution measurements. The circulation pump is placed down-hole in a standpipe enabling measurements even at depths greater than 8 m to the groundwater table. The tracer test unit has the choice of sampling intermittently, or the use of a flow-through cell for continuous measurement of the dilution. Tracer injection is carried out using a dosage pump. The tracer unit is mounted to the downhole equipment with quick couplings, thus making it possible to serve several multipacker systems with one surface tracer unit.

3.3 DATA FLOW

There are three different kinds of equipment used for the dilution tests as earlier described and the data collected depends on which equipment being used (Figures 3-1,3-2,3-3). All three equipments measure the dilution of an artificially introduced tracer, i.e. concentration versus time. The point dilution equipment (Figure 3-1) measures directly in situ and concentration, given as transmission of light, is directly stored in a data logger. The data is then brought back to the office and dumped on a computer for further processing. In addition, temperature and turbidity of the water in the test section is measured by downhole sensors with the point dilution equipment. The temperature and turbidity data are used as a check of how stable the conditions are during the test and they are not stored on the data logger. With the two types of surface sampling equipments (Figures 3-2 and 3-3) these parameters are not measured. Data flow from dilution tests with the point dilution equipment is shown in Figure 3-4

The surface sampling equipments samples the test section with automatic time-controlled solenoid valves. Samples are then brought to the laboratory for analysis of tracer content and data is entered manually into the computer. Optionally, the tracer concentration versus time may be directly measured in situ and registered on a chart recorder. Data flow from dilution tests with the surface sampling equipment is shown in Figure 3-5.

Besides the dilution of the tracer the hydraulic head is measured in the test section and in adjacent test sections and boreholes in order to determine the hydraulic gradient during the test. The hydraulic head is measured with all three equipments.

3.4 DILUTION DATA IN GEOTAB

The flyleaf data and result data from the dilution tests are stored in the following tables in the database (a detailed description of the data tables is found in Appendix 1):

DILUTF1	Flyleaf 1	- Company, person(s) responsible, reference to report,archive and data storage
DILUTF2	Flyleaf 2	- Circulation and injection time data, packer inflation and deflation time data
DILUTF3	Flyleaf 3	- Tracer information
DILUTF4	Flyleaf 4	- Comment table
DILUTF5	Flyleaf 5	- Pump data
DILUTGEO	Data table	- Geometry in borehole section
DILUTD	Data table containing C, C/C_o, $elog(C/C_o)$	
DILUTCD	Calculated data table	

In the main group HYDROLOGY containing hydrological and meteorological measurements, groundwater level data are stored in the table:

GRWBSD Manual ground water head measurements

Ground water pressure data registered by pressure transducer are stored on magnetic tapes at SKB Stockholm and a notation of the data file is made in the table DILUTF1.

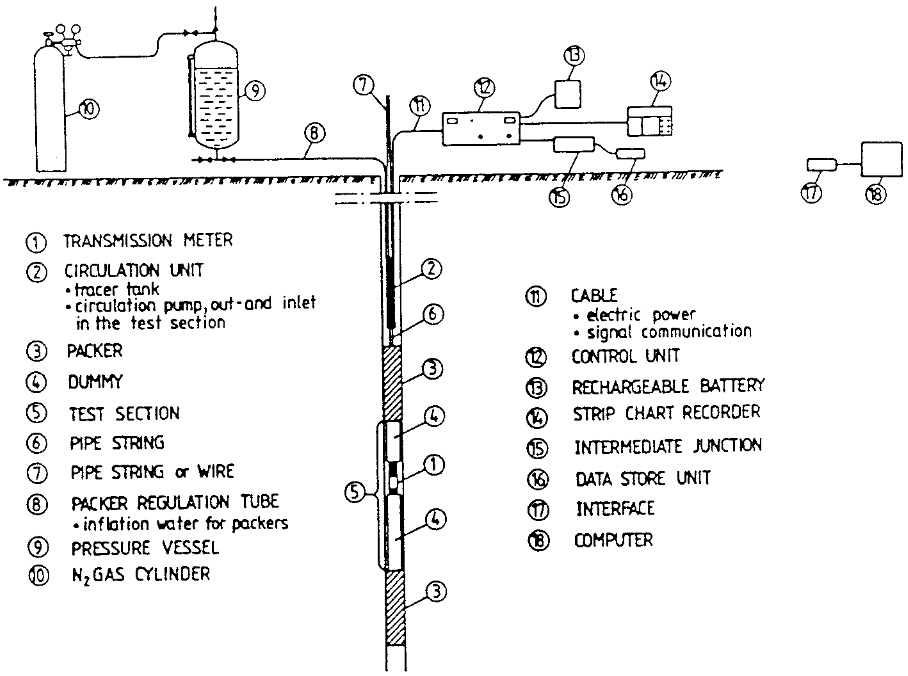

Figure 3-1 Borehole point dilution equipment

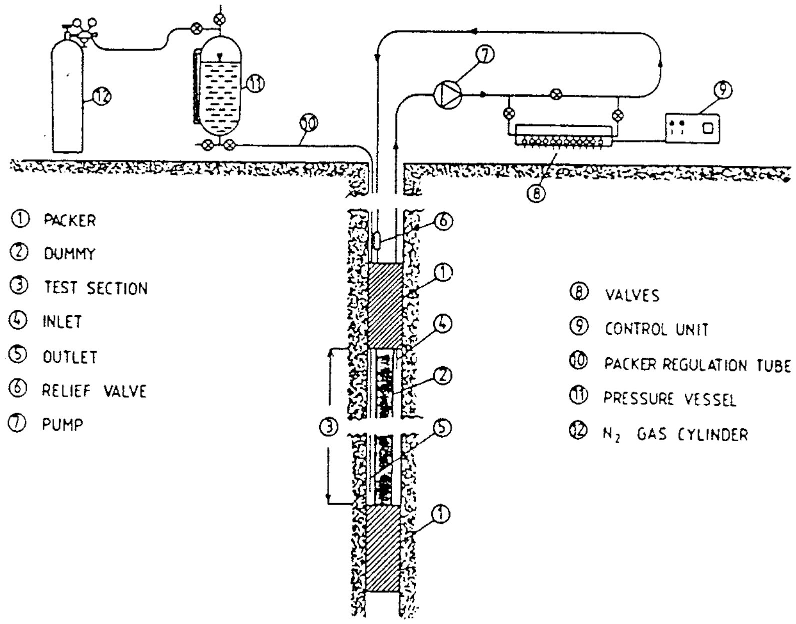

Figure 3-2 Surface sampling dilution equipment

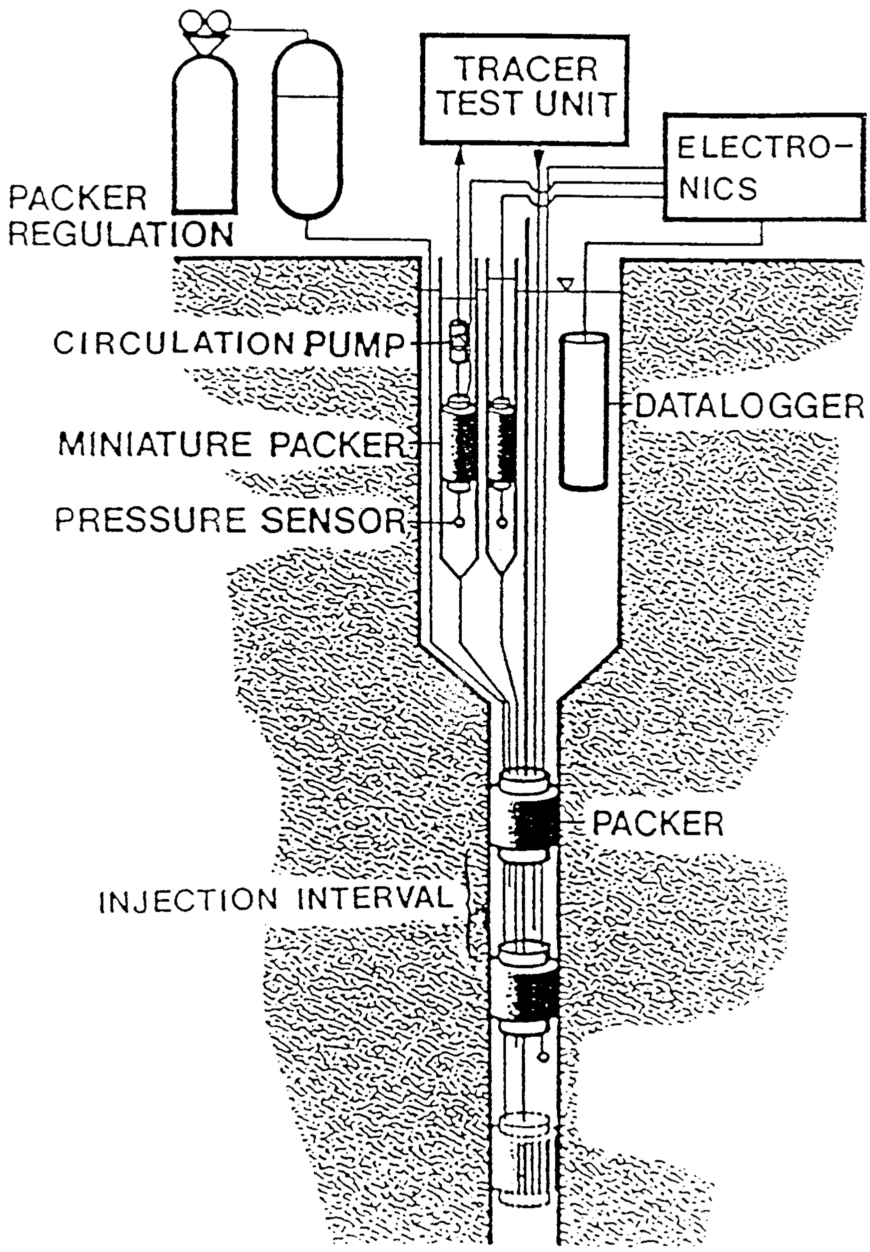

Figure 3-3 Multipacker system for telescope boreholes; principle design for hydraulic head monitoring and tracer dilution measurements.

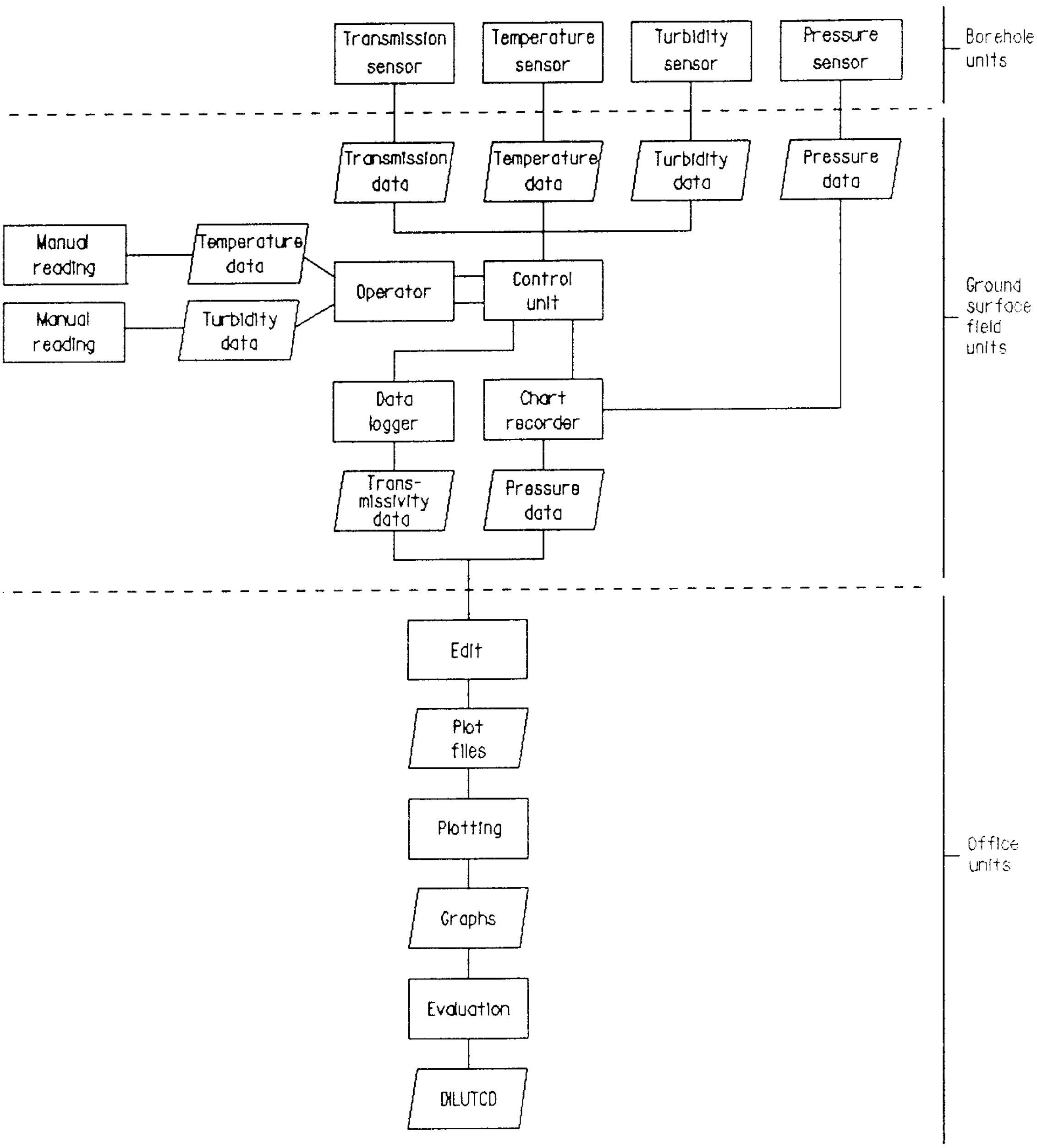

Figure 3-4 Data flow from dilution test with the point dilution equipment

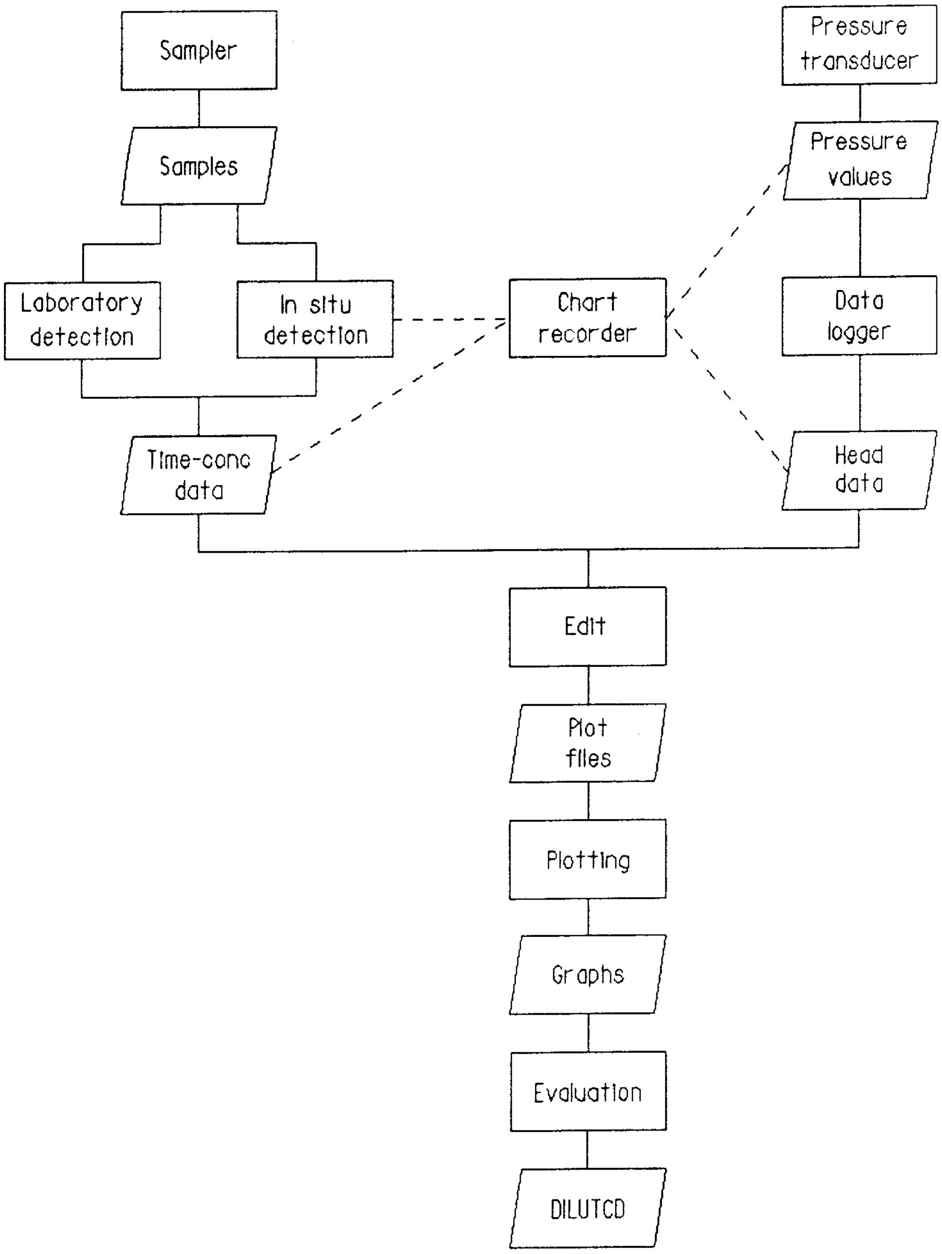

Figure 3-5 Data from dilution test with the surface sampling equipment.

4 RADIALLY CONVERGING TEST

4.1 PRINCIPLE

In a radially converging flow field, created by pumping a well or a sealed off section of a well, tracers are injected in one or several injection wells. The injection wells may be sealed off in one or more injection intervals. Sampling of the pumping well is performed with an automatic sampling equipment and tracer breakthrough curves are obtained by analyzing the samples for tracer contents. The tracer(s) are injected either as pulses or continuously. The injections can be made either by applying an excess pressure and thereby forcing the tracer into the fractures or by using the "undisturbed" method (Figure 4-1). This method implies that the tracer is introduced into the groundwater with a minimum disturbance of the "natural" groundwater flow through the injection interval. The use of this method also enables measurement of the groundwater flow through the injection interval during the injection. The radially converging test can also be used in conjunction with hydraulic interference tests. From breakthrough data, transport parameters such as dispersivity, flow porosity, hydraulic fracture conductivity, equivalent fracture aperture and, if sorbing tracers are used, retardation coefficients, may be obtained.

4.2 EQUIPMENT

Large scale tracer tests like radially converging tests and dipole tests have so far been in a developing stage in the SKB programme. This implies that the procedures and equipment for each test has been different. It is therefore difficult to describe any general type of equipment for these tests. Below, a short description of the most sophisticated equipment used so far within the SKB programme, the equipment for undisturbed tracer injection and sampling (Gustafsson et al, 1990), is given. Also, comments on possible optional equipment or procedures are given.

The injection equipment for the "undisturbed" method is designed to minimize the dispersion in the injection borehole and the disturbance of the flow field through the borehole. This is achieved by circulating the water volume in the injection interval constantly in an almost closed system using a circulation pump placed at the ground surface. The pump may also, if practically possible, be placed within the borehole. The only input to the system is a small volume of concentrated tracer solution that is injected using a precision plunger pump. In order not to create any excess pressure in the injection interval, the same volume of water has to be removed from the system. This is made through a fine precision needle valve. Filters are used to prevent damage to the injection pump and the precision needle valve caused by particles.

The more conventional way of injecting tracers is to simply inject the concentrated tracer through a tube into the borehole interval. This method was used in the earlier tests at Finnsjön (Gustafsson and Klockars, 1981; Gustafsson and Klockars, 1984). The disadvantage of this method is that the tracer is forced out into the fractures uncontrolled causing a fictive dispersion of the tracer.

The concentrated tracer solution used for continuous injections of tracers is stored at the surface in Polyethylene storage tanks. The tanks are designed to maintain anoxic conditions by nitrogen bubbling through the tracer solution.

The withdrawal of water is made with a submersible pump placed either in the open borehole or within a section of the borehole isolated by inflatable packers. The flow rate is regulated manually or automatically with a regulation valve coupled to a mass flow meter and the water is discharged at a distance of at least 100 m from the withdrawal well. An example of the withdrawal equipment is shown in Figure 4-2.

The sampling at the withdrawal borehole is made with an automatic sampler.

4.3 DATA FLOW

The primary parameter measured during a radially converging tracer test is the concentration of tracer in the discharged water. The concentration may either be directly measured in situ or by taking samples and analyzing at the site or in the laboratory. The sampling is generally made with an automatic time controlled sampler at regular intervals. In the early parts of the test at short intervals (1-2 hours) and then at successively increasing intervals. The results are manually entered on a PC and data files with concentration versus date and time of the sampling are stored as DOS files. The DOS files are then listed and corrected and the data is transferred into files containing relative concentration (C/C_o) versus time after start of tracer injection. The relative concentration of tracer is also corrected for any occurring background readings. These files are then plotted and the graphs are used for evaluation of transport parameters such as; tracer first arrival, mean residence time, dispersivity, flow porosity and hydraulic conductivity. The data flow is presented in Figure 4-3.

There are also a number of other parameters being registered during a radially converging tracer test. The number of parameters may differ between different tests but the typical parameters of interest for the evaluation of a radially converging test are;

- hydraulic head of pumping, injection, and observation wells
- pumping/injection flow rates
- electrical conductivity of the pumped water
- oxidation-reduction potential (Eh) of the pumped water
- temperature of the pumped water

These data are either directly registered and stored in a computer or manually registered and entered on a PC. When data are directly stored on a field computer, manual readings are also made as a check. The data are in general plotted using the same time axis as for the tracer breakthrough data. The reason for this is to facilitate comparisons between the different parameters and to make comparisons directly with the tracer breakthrough data.

Lastly, a text file called the "log of events" is created. This file contains all events during the test which, in any way, has affected the results. Typically, the "log of events" contains information like pump stops, power failures, sampling problems, etc.

The data from the earlier tests performed at Finnsjön (Gustafsson and Klockars, 1981, 1984) were mostly collected manually while during the later tests more and more data are collected automatically using flow meters, transducers etc. connected to data loggers.

4.5 RADIALLY CONVERGING DATA IN GEOTAB

The flyleaf data and result data from the radially converging tests are stored in following tables (a detailed description of the data tables is found in Appendix 1):

RADCONF1	Flyleaf 1	- Company, person(s) responsible, reference to report,archive and data storage
RADCONF2	Flyleaf 2	- Pumping data
RADCONF3	Flyleaf 3	- Tracer and injection data
RADCONF4	Flyleaf 4	- Comment table

RADCOTEM	Data table - Temperature of the pumped water
RADCOCON	Data table - Electrical conductivity of the pumped water
RADCONEH	Data table - Oxidation/reduction potential
RADCOGEO	Data table - Geometry in borehole section
RADCONQD	Data table - Water flow rate
RADCOCD1	Calculated data table no 1
RADCOCD2	Calculated data table no 2
RADCOCD3	Calculated data table no 3
RADCOCD4	Calculated data table no 4

In the main group HYDROLOGY containing hydrological and meteorological measurements, groundwater level data are stored in the table:

GRWBSD	Manual ground water head measurements

Ground water pressure data registered by pressure transducer are stored on magnetic tapes at SKB Stockholm and a notation of the data file is made in the table RADCONF1.

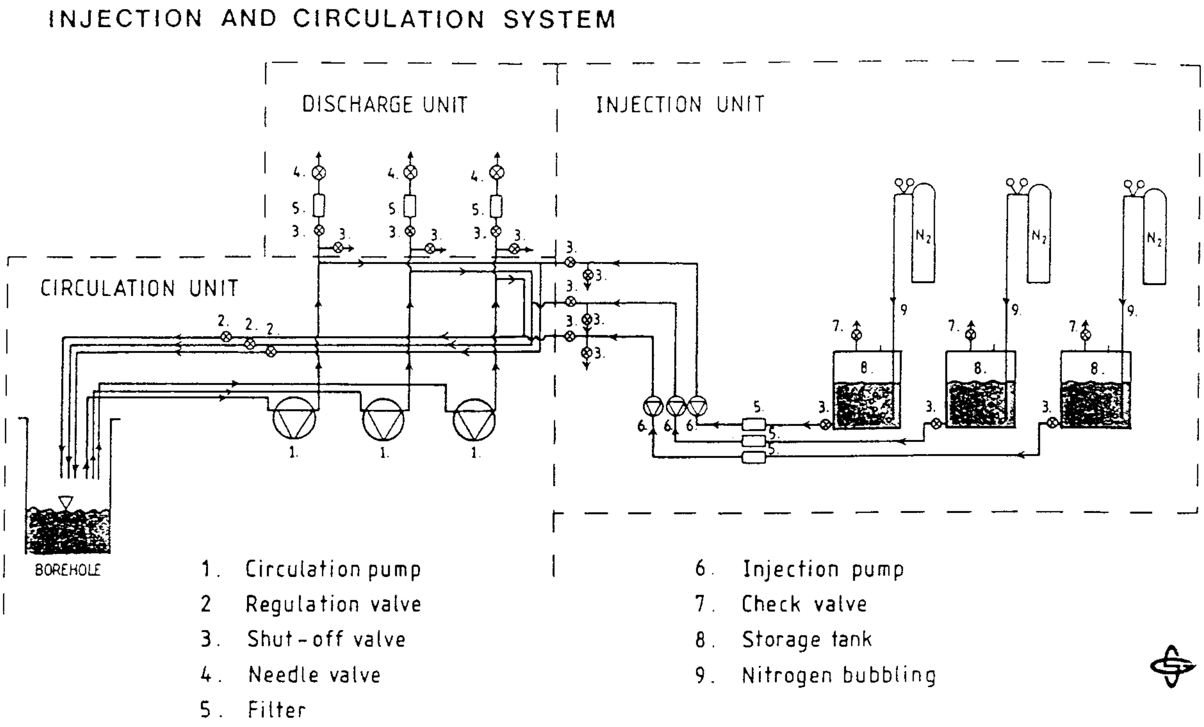

Figure 4-1 Injection and circulation system

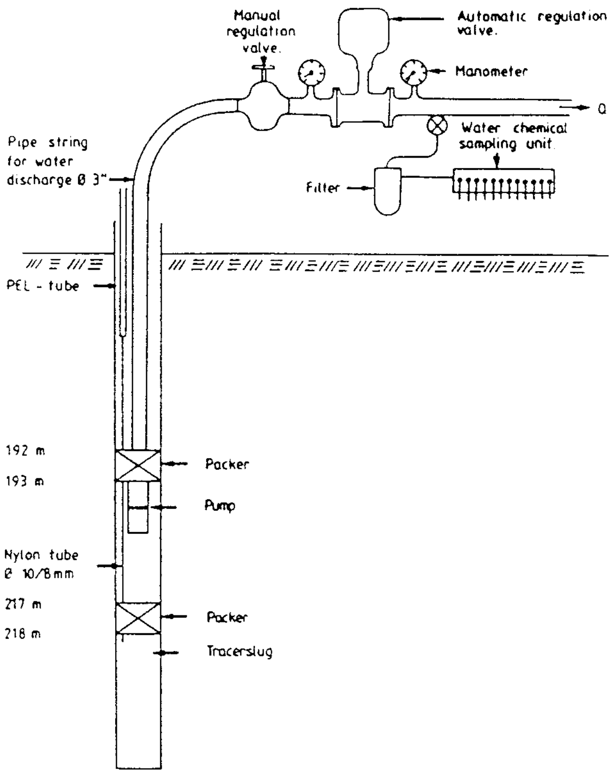

Figure 4-2 Withdrawal equipment for the radially converging tracer experiment

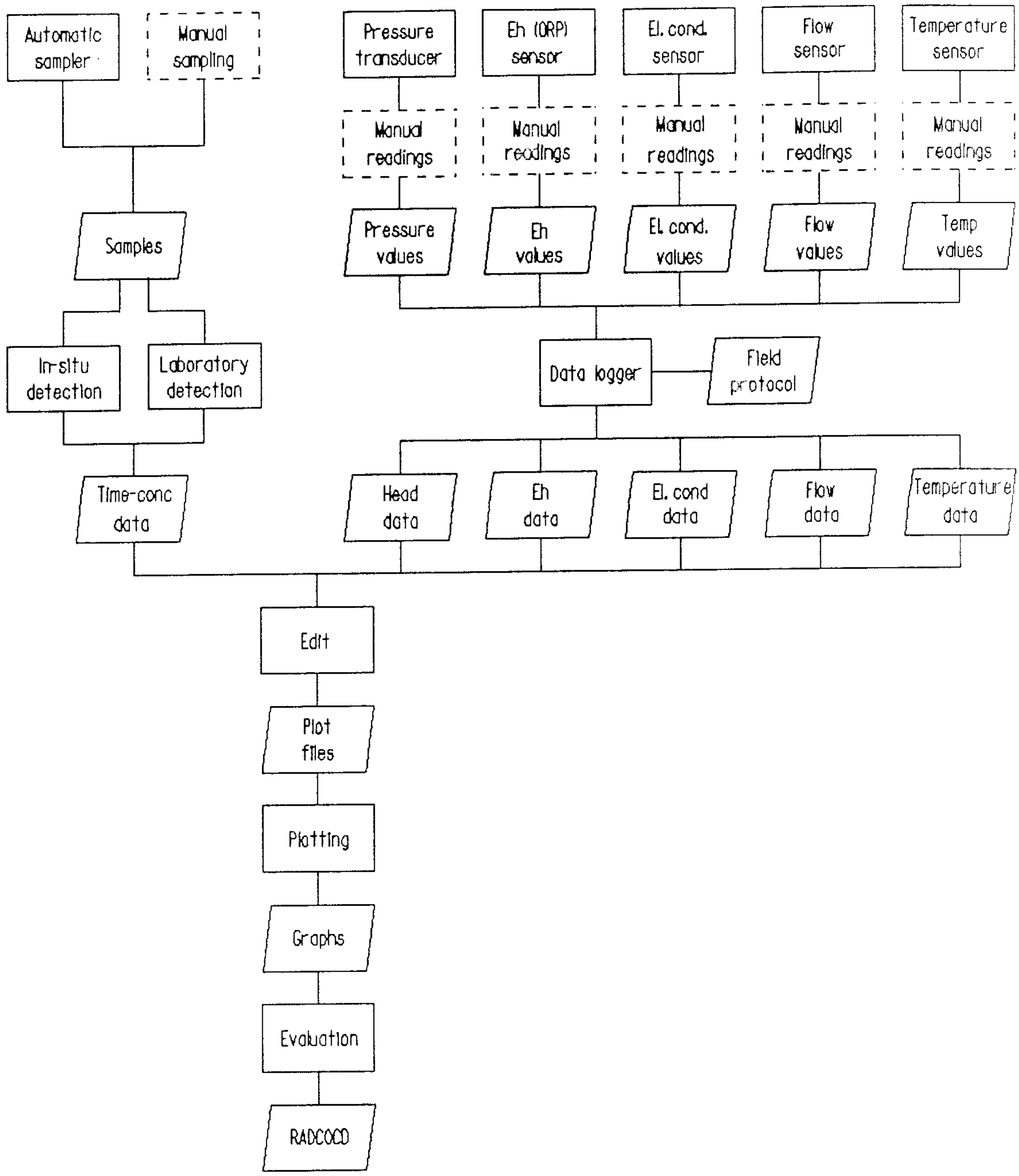

Figure 4-3 Data from radially converging test.

5 RADIALLY DIVERGING TEST

5.1 PRINCIPLE

In a radially diverging flow field, created by injecting water in a borehole or a sealed off section of a borehole, tracers are added. Sampling is performed in one or several detection boreholes or sealed off sections of the boreholes. From the tracer breakthrough data the following parameters can be obtained:

- time of first arrival
- the tracer solute mean residence time
- dispersion
- retardation due to sorption and matrix diffusion

The residence time as well the dispersion is determined from fitting procedures with theoretical solutions, analytical or numerical. Retardation and sorption also by fitting to theoretical solutions and by comparisons of breakthrough curves of nonsorbing, non diffusing and sorbing tracers.

From the residence times the following transport parameters can be calculated:

- hydraulic fracture conductivity
- flow porosity
- equivalent fracture aperture

5.2 EQUIPMENT

The radially diverging test may, as well as the other different types of tracer test , be performed in many different ways using more or less sophisticated equipment. So far only two radially diverging tracer tests have been performed within the SKB programme (Andersson and Klockars, 1985; Gustafsson et al, in prep). Both tests were performed in a small scale at the Stripa mine. The equipment described below is the one used for these Stripa tests.

In the radially diverging test the tracer is forced into the aquifer by applying an excess pressure. In the Stripa tests this was made by applying a constant head using compressed nitrogen (Figure 5-1). The injection flow rate was measured with float type flow meters and also by manual redings of the level in the tracer tanks.

The tracers were detected in several boreholes radially distributed around the injection borehole. Sampling was made by constantly circulating the water in the borehole through an automatic sampler, see Figure 5-1. The samples were then analysed at the laboratory and time-concentration data was determined.

5.3 DATA FLOW

The parameters measured during a radially diverging test are much the same as in the radially converging and the dipole tests. However, the radially diverging tests at Stripa did not focus on the chemical parameters so apart from the tracer breakthrough data, only the injection flow rates and the head distribution was measured. The data flow for the radially diverging test is presented in Figure 5-2 below.

5.4 RADIALLY DIVERGING DATA IN GEOTAB

The flyleaf data and result data from the radially converging tests are stored in following tables (a detailed description of the data tables is found in Appendix 1):

RADDIVF1	Flyleaf 1	- Company, person(s) responsible, reference to report,archive and data storage
RADDIVF2	Flyleaf 2	- Injection data
RADDIVF3	Flyleaf 3	- Tracer data
RADDIVF4	Flyleaf 4	- Comment table
RADDIGEO	Data table	- Geometry in borehole section
RADDIVIP	Data table	- Injection pressure
RADDIVIQ	Data table	- Injection capacity
RADDICD1	Calculated data table no 1	
RADDICD2	Calculated data table no 2	
RADDICD3	Calculated data table no 3	
RADDICD4	Calculated data table no 4	

In the main group HYDROLOGY containing hydrological and meteorological measurements, groundwater level data are stored in the table:

GRWBSD Manual ground water head measurements

Ground water pressure data registered by pressure transducer are stored on magnetic tapes at SKB Stockholm and a notation of the data file is made in the table RADDIVF1.

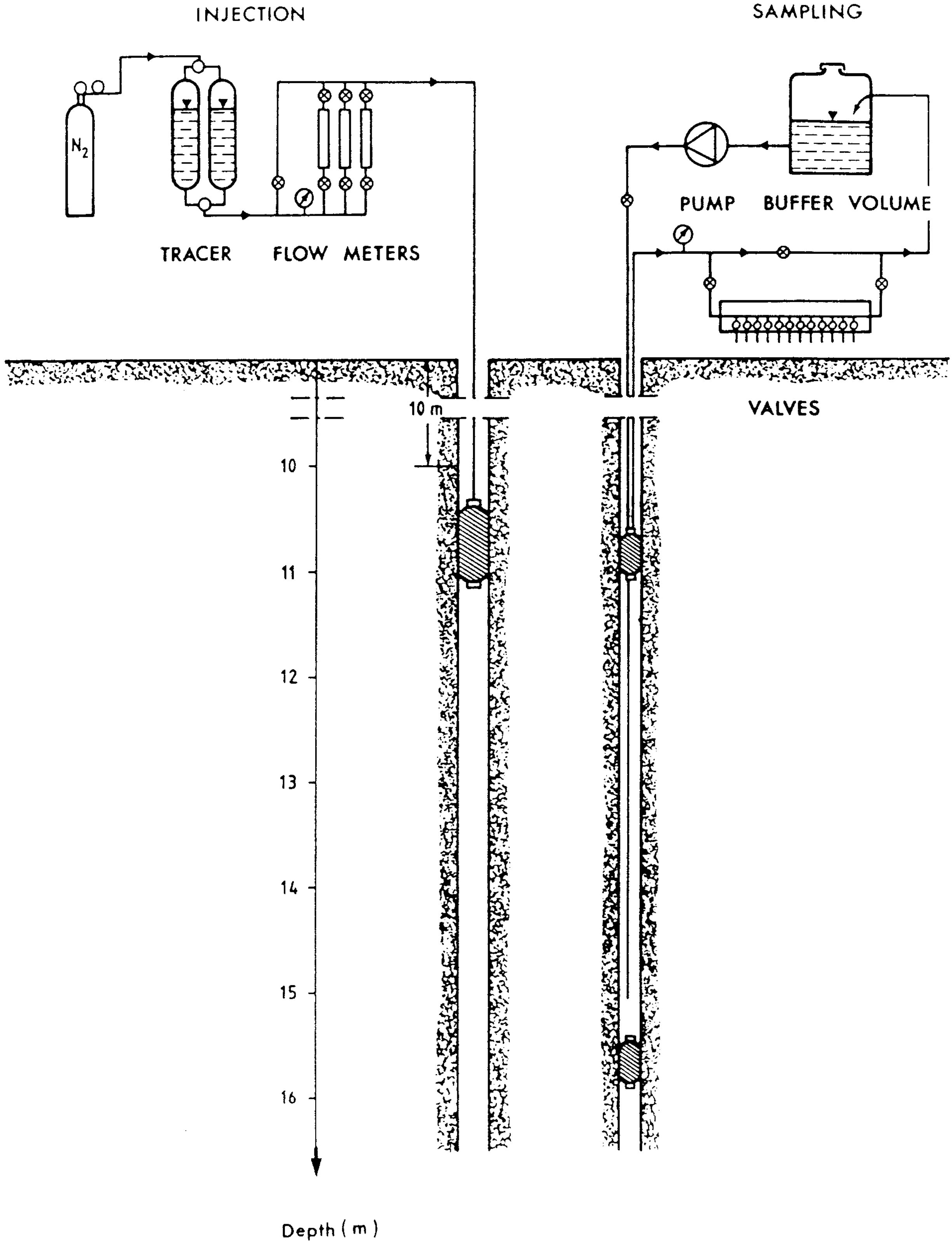

Figure 5-1 Injection and sampling equipment for radially diverging tracer test.

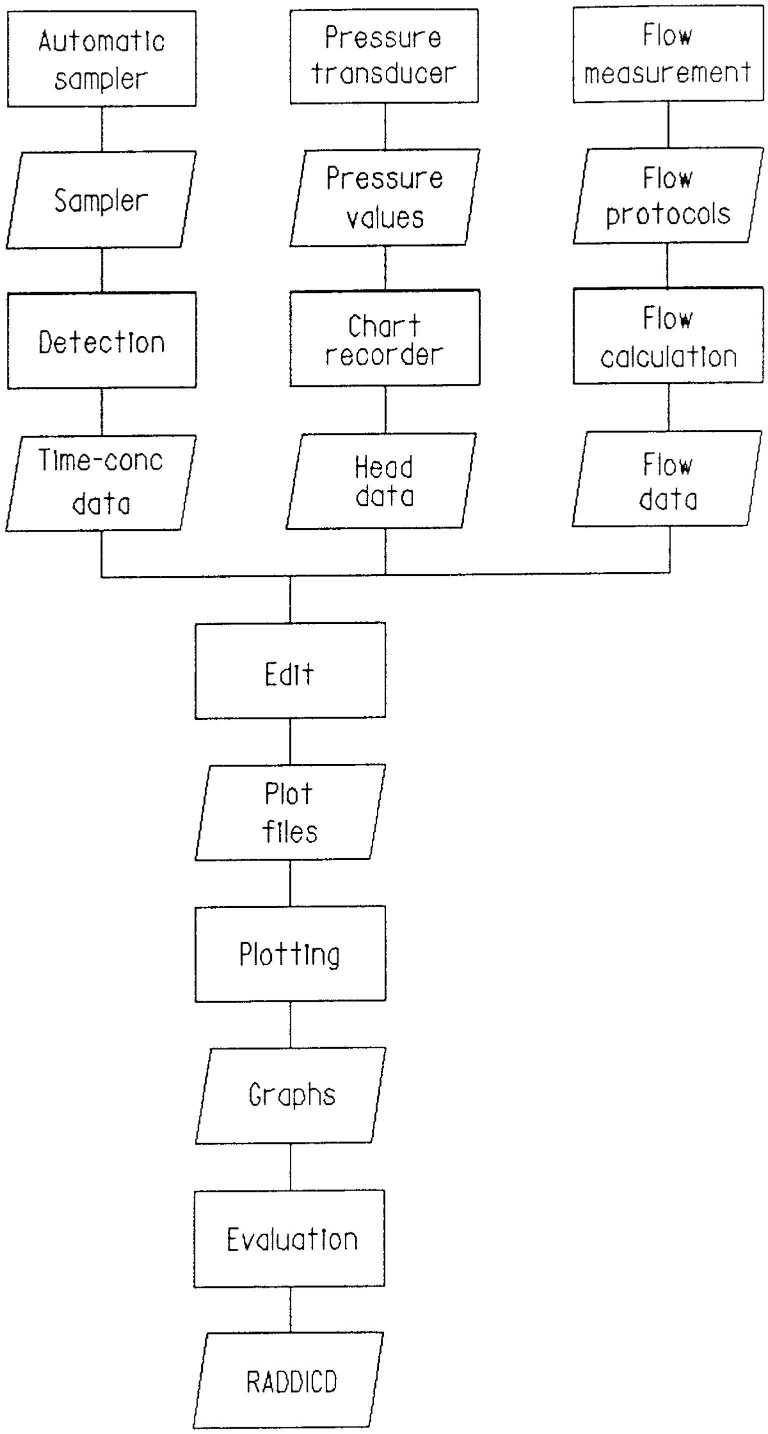

Figure 5-2 Data flow from radially diverging test.

6 DIPOLE TEST

6.1 PRINCIPLE

The dipole test, also referred to as the doublet or two-well test, is performed by creating a dipole flow field between a pump well and an injection well. The flow field is created either by recirculating the water withdrawn from the pump well, back into the injection well or by injecting and discharging water without recirculation. In an ideal dipole, the injection and discharge rates are equal but in some cases, they differ. Tracers are in general injected into the injection well as pulses and sampling of the discharged water is made to determine the tracer breakthrough curves. Within the dipole field breakthrough of tracers may also be registered in one or several observation boreholes. As an option tracers may also be injected in one or more of the observation boreholes.

As an example, the dipole flow field of the dipole test at Finnsjön (Andersson et al. 1990) is shown in Figure 6-1. This test is so far the only dipole test performed within the SKB programme.

6.2 EQUIPMENT

The dipole tracer tests performed within the SKB programme so far have been made in a recirculating flow field in a isolated interval of a major fracture zone at Finnsjön (Andersson et al, 1990). The equipment used is shown in Figure 6-1. The recirculation of the water withdrawn from the pumping well implies that only one pump is needed to create the dipole flow field. Tracers were injected as pulses with short duration using a metering pump and sampling was made with automatic samplers both in the pumping well and in other boreholes within the investigated area. In addition, equipment for detection of radioactive tracers was used. Other important parameters such as hydraulic head, electrical conductivity, temperature and oxidation-reduction potential of the pumped water was continuously registered.

6.3 DATA FLOW

The parameters measured during a dipole test are the same as for the radially converging test, see Section 4-3. The only difference is that some of the parameters are measured both in the pumped water and in the injected water. Also the data flow is the same, see

Figure 4-2.

6.4 DIPOLE DATA IN GEOTAB

The flyleaf data and result data from the dipol tests are stored in following tables (a detailed description of the data tables is found in Appendix 1):

DIPOLF1	Flyleaf 1	- Company, person(s) responsible, reference to report,archive and data storage
DIPOLF2	Flyleaf 2	- Pumping data
DIPOLF3	Flyleaf 3	- Tracer and injection data
DIPOLF4	Flyleaf 4	- Comment table
DIPOLTEM	Data table	- Temperature of the pumped water
DIPOLCON	Data table	- Electrical conductivity of the pumped water
DIPOLEH	Data table	- Oxidation/reduction potential
DIPOLGEO	Data table	- Geometry in borehole section
DIPOLQD	Data table	- Pumping rate
DIPOLCD	Calculated data table	

In the main group HYDROLOGY containing hydrological and meteorological measurements, groundwater level data are stored in the 30

GRWBSD Manual ground water head measurements

Ground water pressure data registered by pressure transducer are stored on magnetic tapes at SKB Stockholm and a notation of the data file is made in the table DIPOLF1.

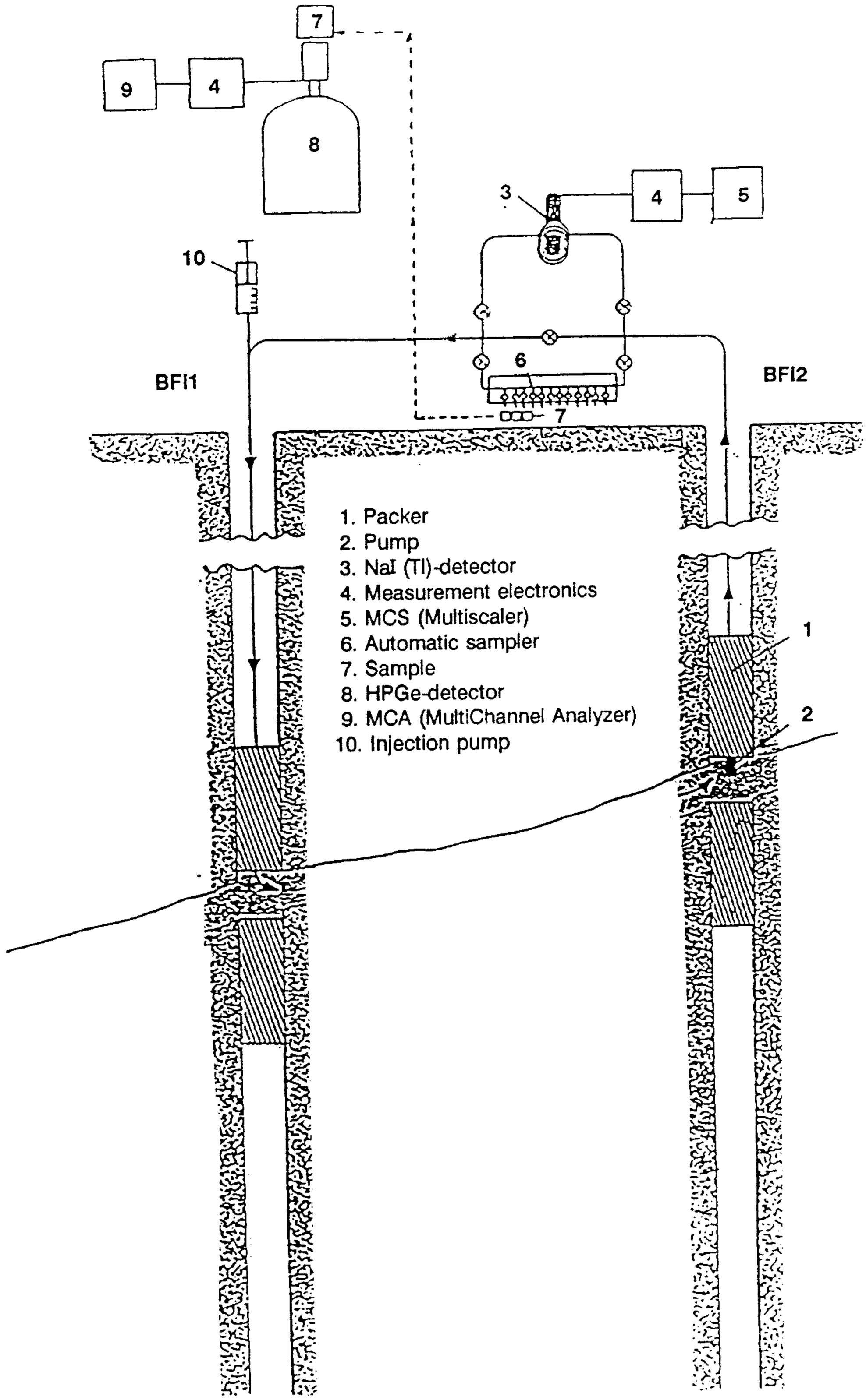

Figure 6-1 Experimental design om the dipole experiment

7 FLUSHING WATER TEST

7.1 PRINCIPLE

During drilling of cored boreholes, flushing water is used in order to cool the drill bit and to flush out the drilling debris. The water is continuously pumped from a water supply well into a storage tank where it is labelled with a tracer, i e the fluorescent dye Uranine (sodium fluorescein). The primary aim of the method is to establish if the drilled borehole and the supply well are hydraulically connected. This is made by sampling the water from the supply well before and after tracer labelling. Prior to drilling, samples for background readings of tracer are taken in the water supply well.

The method can provide valuable information about hydraulic connections with a minimum of effort. Estimates of hydraulic parameters like hydraulic conductivity and porosity can be made. However, the lack of control of the radius of injection and the governing flow regime may cause errors that have to be considered.

7.2 EQUIPMENT

A schematic diagram showing the design of the flushing water test is shown in Figure 7-1. The tests performed so far within the SKB programme has been made without any sophisticated injection or sampling devices. This is also of the basic idea behind the test, to be simple and possible to perform at a small cost and with a small effort. The only equipment needed for the test is a pump for sampling and to create a drawdown in the observation well and flow meters to determine the injection and withdrawal rates. However, the test may of course be supported by data from ongoing groundwater level registrations, etc.

The tracer labelling is made by pouring a small amount of concentrated tracer solution into the flushing water supply tank and stiring to achieve a good mixing. During the drilling, records of the volume of injected water versus time are kept. Sampling for any eventual tracer breakthrough is made manually in the water withdrawn from the water supply well. The samples are analyzed at the laboratory.

7.3 DATA FLOW

The primary data from a flushing water test is the breakthrough data for the tracer in the observation borehole. The data is entered manually to a PC, stored as DOS-files and converted into relative concentration (C/C_o) versus time. The drilling operator also keeps records of the injected amounts of tracer labelled water and the amounts of water withdrawn from the supply well. These data are also entered manually to a PC and stored as DOS-files. The data flow is presented in Figure 7-2. Additional data collected may be head data from the withdrawal borehole and other boreholes in the area.

7.4 ACCURACY

The flushing water test may provide data which can be used to determine both hydraulic and transport parameter of the aquifer. However, there are large uncertainties in the data due to the lack of control of the test. Firstly, the injection of flushing water into the aquifer is difficult to control and secondly, the governing flow regime for the transport between the injection well and the water supply well is difficult to establish.

The transport parameters determined from the flushing water test should therefore be seen as rough estimates which can be used for the design of more controlled tracer tests.

7.5 FLUSHING WATER DATA IN GEOTAB

The flyleaf data and result data from the flushing water tests are stored in following tables (a detailed description of the data tables is found in Appendix 1):

FLUSHF1	Flyleaf 1	- Company, person(s) responsible, reference to report,archive and data storage
FLUSHF2	Flyleaf 2	- Pumping and drilling data
FLUSHF3	Flyleaf 3	- Tracer data
FLUSHF4	Flyleaf 4	- Comment table
FLUSHTEM	Data table	- Temperature of the pumped water
FLUSHCON	Data table	- Electrical conductivity of the pumped water
FLUSHEH	Data table	- Oxidation/reduction potential

FLUSHGEO Data table - Geometry in borehole section

FLUSHQD Data table - Pumping rate
FLUSHCD1 Calculated data table no 1

FLUSHCD2 Calculated data table no 2

In the main group HYDROLOGY containing hydrological and meteorological measurements, groundwater level data are stored in the table:

GRWBSD Manual ground water head measurements

Ground water pressure data registered by pressure transducer are stored on magnetic tapes at SKB Stockholm and a notation of the data file is made in the table FLUSHF1.

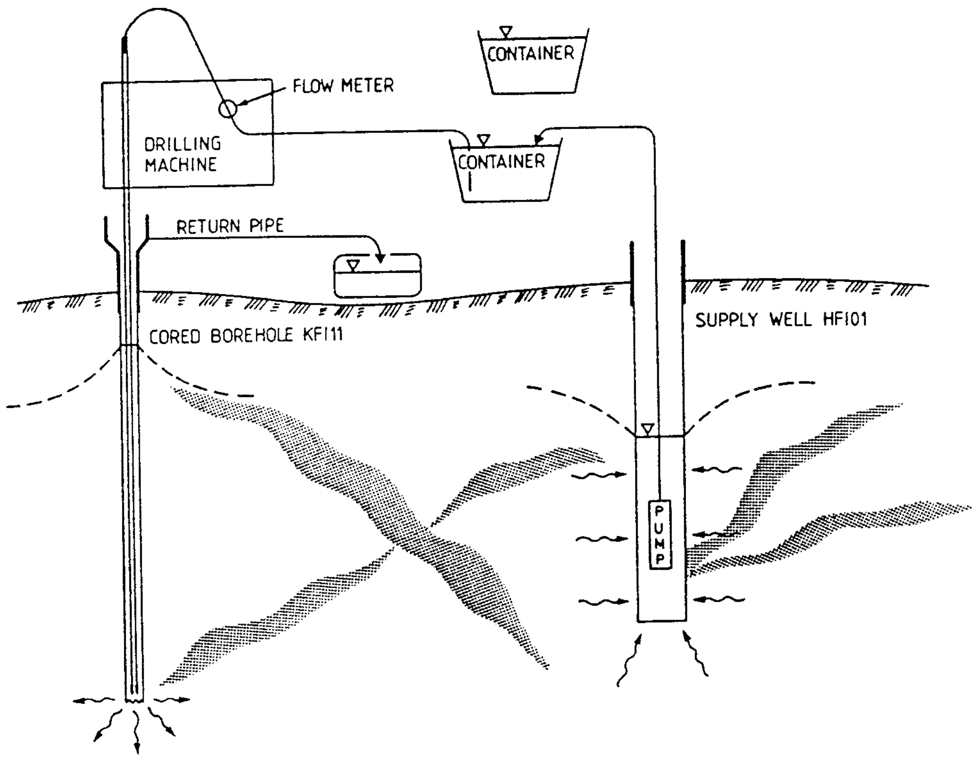

Figure 7-1 Principle of the flushing water test.

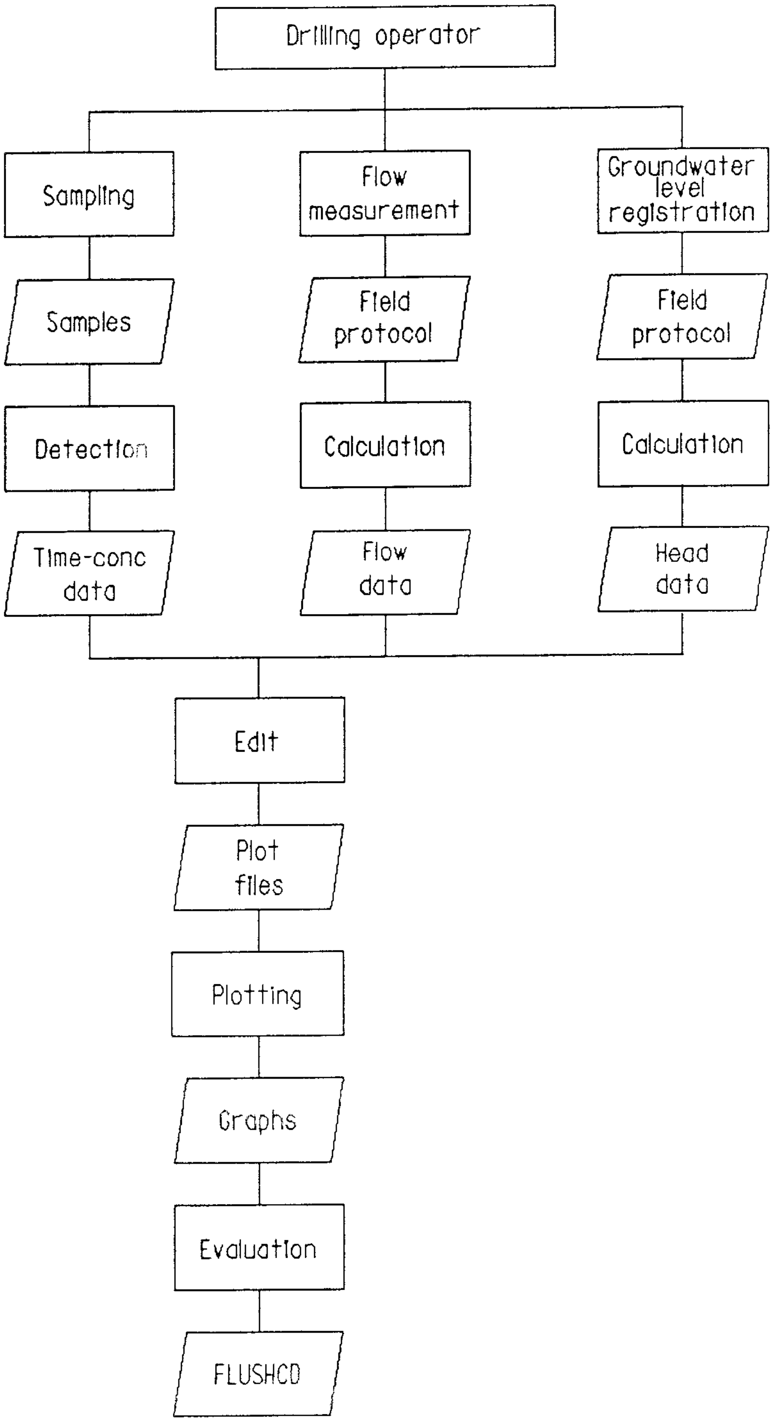

Figure 7-2 Data flow from flushing water test.

8 CHECK TABLES

8.1 CHECK TABLES FOR TRACERS

During radially converging and radially diverging tests, different tracers can be used during one test where start date, injection or detection borehole and upper and lower limit of test section are the same. Then it is necessary to use the tracer name as a search criteria in order separate calculated data from the same test, which only differs in tracer name.

The check table for tracer contains a column, TRCODE, with a shortname for tracer, a column ,TRNAME, with the whole tracer name and a column, TRTYPE, containing the two types; nonradioactive and radiotracer (Appendix 2).

8.2 CHECK TABLES FOR INJECTION TYPES

In the same manner as for tracer types, a check table is made for different types of injections.

The check table for injection types contains a column, INJCODE, with a shortname for injection and a column, INJNAME, containing injection type in text en clair (Appendix 2).

9 REFERENCES

Andersson, P., Klockars, C-E,1985: Hydrogeological investigations and tracer tests in a well-defined rock mass in the Stripa mine.
SKB TR 85-12

Andersson, P., Eriksson, C-O, Gustafsson, E., Ittner, T., 1990: Dipole tracer experiment in a low-angle fracture zone at Finnsjön. Experimental design and preliminary results. The Fracture Zone Project - Phase 3.
SKB AR 90-24

Ergodata, 1990: GEOTAB: Users' Guide Version 1.8.2
SKB TR 90-34

Eriksson, E., Sehlstedt, S., 1989: Description of background data in the SKB database GEOTAB.
SKB TR 89-02

Gentzschein, B.,1986: Description of hydrogeological data in SKB's database GEOTAB.
SKB TR 86-22

Gustafsson,E., 1986: Bestämning av grundvattenflödet med utspädningsteknik. Modifiering av utrustning och kompletterande fältmätningar.
SKB AR 86-21

Gustafsson, E., Andersson, P., Eriksson, C-O., Nordqvist, R., 1990: Radially converging tracer experiment in a low angle fracture zone at the Finnsjön site, central Sweden. The Fracture Zone Project - Phase 3.
SKB AR 90-27

Gustafsson, E., Klockars, C-E., 1981: Studies on groundwater transport in fractured crystalline rock under controlled conditions using non-radioactive tracers.
SKB TR 81-07

Gustafsson, E., Klockars, C-O., 1984: Study of strontium and cesium migration in fractured crystalline rock.
SKB TR 84-07

Sehlstedt, S., 1988: Description of geophysical data in the SKB database GEOTAB.
SKB TR 88-05

Stark, T., 1988: Description of geological data in SKBs database GEOTAB.
SKB TR 88-06

10 APPENDIX 1

Description of Tracer Test tables in GEOTAB.

Method Dilution Test

DILUTF1 : Dilution Test - Flyleaf 1

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of activity in section (yymmdd)
GRWHOLES		CHAR(50)	IDCODES	boreholes where grwhead is measured
COMPANY		CHAR(30)	COMP	name of company performing test
RESP1		CHAR(20)	PERSON	person responsible for test
RESP2		CHAR(20)	PERSON	person responsible for evaluation
REPORT		CHAR(30)	REPORT	reference to report
ARCHIVE		CHAR(50)	ARCHIVE	reference to archive
DATASTO		CHAR(79)	DATASTO	data storage
COM50		CHAR(50)	COM50	comments
SIGN		CHAR(5)	SIGN	signature of person responsible for input of data
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTF2 : Dilution Test - Flyleaf 2

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of activity in section (yymmdd)
TIME		CHAR(6)	TIME	start time of activity in section (hhmmss)
SECVOL		NUM (7,5)	SECVOL	section volume (m**3)
PDBDATE		CHAR(6)	DATE	pem packer deflation date before measurement (yymmdd)
PDBTIME		CHAR(6)	DATE	pem packer deflation time before measurement (hhmmss)
PIBDATE		CHAR(6)	DATE	pem packer inflation date before measurement (yymmdd)
PIBTIME		CHAR(6)	TIME	pem packer inflation date before mesurement (hhmmss)
CSTART		CHAR(6)	DATE	start circulation date (yymmdd)
CTIME		CHAR(6)	TIME	start circulation time (yymmdd)
INJDATE		CHAR(6)	DATE	start date of injection of tracer (yymmdd)
INJTIME		CHAR(6)	TIME	start time of injection of tracer (hhmmss)
CSTOPDAT		CHAR(6)	DATE	stop circulation date (yymmdd)
CSTOPTIM		CHAR(6)	TIME	stop circulation time (hhmmss)
CINJTIME		NUM (6)	INJTIME	calculated injction time (s)
RINJTIME		NUM (6)	INJTIME	real injection time (s)
MEASTIME		NUM (8)	MEASTIME	measurement time (s)
PDADATE		CHAR(6)	DATE	packer deflation date after measurement (yymmdd)
PDATIME		CHAR(6)	TIME	packer deflation time after measurement (hhmmss)
PIADATE		CHAR(6)	DATE	packer inflation date after measurement (yymmdd)
PIATIME		CHAR(6)	TIME	packer inflation time after measurement (hhmmss)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTF3 : Dilution Test - Flyleaf 3 Tracer Information

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of activity in section (yymmdd)
TRCODE		CHAR(7)	TRCODE	tracer code
INJVOL		NUM (8,6)	INJVOL	injected volume (m**3)
INJAMO		NUM (6,4)	WEIGHT	injected amount tracer (g)
T		NUM (3,*)	TRANSM	transmissivity in section (m**2/s)
ANMETHOD		CHAR(50)	COM50	chemical analysis method
CB		NUM (7,5)	CONC	background concentration of tracer (ppm)

CO	NUM (7,5)	CONC	initial concentration (ppm)
COMMENT	CHAR(79)	COMMENT	comments
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTF4 : Dilution Test - Flyleaf 4 Comment Table

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of activity in section (yymmdd)
LINENO	*	NUM (4)	LINENO	line number
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTF5 : Dilution Test - Flyleaf 5 Instrumentation

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of activity in section (yymmdd)
CAPPUMP		NUM (4,*)	FLOW	capacity of circulation pump (m**3/s)
LOCPUMP		CHAR(50)	COM50	location of circulation pump
TEQUIP		CHAR(79)	TEQUIP	test equipment
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTD : Dilution Test - Data Table

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of test (yymmdd)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
C		NUM (7,5)	CONC	concentration of tracer (ppm)
CCO		NUM (7,3)	KVOT	C/Co
LNCCO		NUM (4,*)	LNKVOT	elogaritm of C/Co
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DILUTCD : Dilution Test - Calculated Data

Column	Key	Type	Domain	Text
IDCODE	*	CHAR(5)	IDCODE	borehole idcode
SECUP	*	NUM (6,2)	LENGTH	length to test section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to test section, lower limit (m)
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
QW		NUM (4,*)	FLOW	groundwater flow rate through injection section (m**3/s)
RET		NUM (3,*)	RET	retardation coefficient (dim.less)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

METHOD RADIALLY CONVERGING TEST

RADCONF1: Radially Converging Test - Flyleaf 1

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	idcode for area
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PUMPWELL	*	CHAR(5)	IDCODE	idcode of pumpwell
COMPANY		CHAR(30)	COMP	name of company performing test
INJHOLES		CHAR(50)	IDCODES	injection holes
DETHOLES		CHAR(50)	IDCODES	detection holes
GRWHOLES		CHAR(50)	IDCODES	boreholes where grwhead is measured
RESP1		CHAR(20)	PERSON	person responsible for test
RESP2		CHAR(20)	PERSON	person responsible for evaluation
REPORT		CHAR(30)	REPORT	reference to report
ARCHIVE		CHAR(50)	ARCHIVE	reference to archive
DATASTO		CHAR(79)	DATASTO	data storage
SIGN		CHAR(5)	SIGN	signature of person responsible for input of data
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCONF2: Radially Converging Test - Flyleaf 2 Pumping Flyleaf

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
T		NUM (3,*)	TRANSM	transmissivity of the pumped section
QMEAN		NUM (4,*)	FLOW	mean measured water flow rate (m**3/s)
TEQUIP		CHAR(79)	TEQUIP	equipment in pumpwell
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCONF3: Radially Converging Test - Flyleaf 3 Tracer and Injection Data

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	injection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section, upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section, lower limit (m)
DIST		NUM (5,1)	RADSEC	distance between pumpwell and injection section (m)
TRCODE		CHAR(7)	TRCODE	tracer code
INJCODE		CHAR(5)	INJCODE	type of injection
INJVOL		NUM (8,6)	INJVOL	injected volume (m**3)
AMOTRAC		NUM (6,4)	WEIGHT	amount of tracer in injection solution (g)
INJAMO		NUM (6,4)	WEIGHT	injected amount of tracer (g)
ANMETHOD		CHAR(50)	COM50	chemical analysis methode
CB		NUM (7,5)	CONC	background concentration of tracer (ppm)
C00		NUM (7,5)	CONC	measured injection concentration (ppm)
INJQ		NUM (4,*)	FLOW	injection pump capacity; mean value (m**3/s)
OUTQ		NUM (4,*)	FLOW	injection discharge; mean value (m**3/s)
CIRQ		NUM (4,*)	FLOW	circulation pump capacity (m**3/s)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCONF4: Radially Converging Test - Flyleaf 4 Comments

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
LINENO	*	NUM (4)	LINENO	line number
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOTEM: Radially Converging Test - Temperature of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
TEMP		NUM (6,*)	TEMPG	temperature of the pumped water (oC)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOCON: Radially Converging Test - Electrical Conductivity of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (yymmdd)
ECOND		NUM (5,1)	ECOND	electrical conductivity of the pumped water (mSiemens/h)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCONEH: Radially Converging Test - Oxidation/Reduction Potential

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
EH		NUM (3)	EH	redox potential (mV)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCONQD: Radially Converging Test - Water Flow Rate

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
FLOW		NUM (4,*)	FLOW	measured water flow rate (m**3/s)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOCD1: Radially Converging Test - Calculated Data Table No 1

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
EESFQL		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from pump capacity, linear flow model (m)
EESFQWL		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QW, linear flow model (m)

EESFTOL	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from TO, linear flow model (m)
EESFQR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from pump capacity, radiall model (m)
EESFQWR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QW, radiall model (m)
EESFTOR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from TO, radiall model (m)
EM	NUM (6,*)	EM	mass balance fracture aperture (m)
HETTF	NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer first arrival (s/m**2)
HETTO	NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer mean residence time (s/m**2)
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOCD2: Radially Converging Test - Calculated Data Table No 2

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
TQL		NUM (3,*)	STRANSC	fracture transmissivity calculated from pump capacity (m**2/s);linear model
TQWL		NUM (3,*)	STRANSC	fracture transmissivity calculated from QW (m**2/s); linear model
TTOL		NUM (3,*)	STRANSC	fracture transmissivity calculated from TO (m/s); linear model
TML		NUM (3,*)	STRANSC	fracture transmissivity calculated from EM (m**2/s); linear model
TQR		NUM (3,*)	STRANSC	fracture transmissivity calculated from pump capacity (m**2/s); radiall model
TQWR		NUM (3,*)	STRANSC	fracture transmissivity calculated from QW (m**2/s); radiall model
TTOR		NUM (3,*)	STRANSC	fracture transmissivity calculated from TO (m**2/s); radiall model
TMR		NUM (3,*)	STRANSC	fracture transmissivity calculated from EM (m**2/s); radiall model
PECLET		NUM (3,*)	PECNUM	peclet number (dim.less)
RET		NUM (3,*)	RET	retardation coefficient (dim.less)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOCD3: Radially Converging Test - Calculated Data Table No 3

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
TF		NUM (7)	TF	tracer first arrival (s)
TO		NUM (7)	TF	tracer mean residence (s)
REC		NUM (5,2)	TRAREC	tracer recovery (%)
DELTAH		NUM (6,2)	DELTAH	head difference injection-sampling (mean) (m)
QW		NUM (4,*)	FLOW	groundwater mean flow rate through injection section (m**3/s)
KESFQL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from pump capacity, linear flow model (m/s)
KESFQWL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QW, linear flow model (m/s)
KESFTOL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO; linear flow model (m/s)
KESFQR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from pump capacity, radiall model (m/s)
KESFQWR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QW, radiall model (m/s)
KESFTOR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO, radiall model (m/s)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADCOCD4: Radially Converging Test - Calculated Data Table No 4

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
FIQL		NUM (3,*)	FPORC	flow porosity calculated from pump capacity (dim.less); linear model
FIQWL		NUM (3,*)	FPORC	flow porosity calculated from QW (dim.less); linear model
FITOL		NUM (3,*)	FPORC	flow porosity calculated from TO (dim.less); linear model
FIML		NUM (3,*)	FPORC	flow porosity calculated from mass balance dim.less); linear model
FIQR		NUM (3,*)	FPORC	flow porosity calculated from pump capacity (dim.less); radiall model
FIQWR		NUM (3,*)	FPORC	flow porosity calculated from QW (dim.less); radiall model
FITOR		NUM (3,*)	FPORC	flow porosity calculated from TO (dim.less); radiall model
FIMR		NUM (3,*)	FPORC	flow porosity calculated from mass balance (dim.less); radiall model
DISPL		NUM (3,*)	DISP	longditudinal dispersivity (m)
DISPT		NUM (3,*)	DISP	transverse dispersivity (m)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

MEHTOD RADIALLY DIVERGING TEST

RADDIVF1: Radially Diverging Test - Flyleaf 1

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	idcode for area
START	*	CHAR(6)	DATE	start date of test (yymmdd)
INJHOLE	*	CHAR(5)	IDCODE	injection borehole
COMPANY		CHAR(30)	COMP	name of company performing test
DETHOLES		CHAR(50)	IDCODES	detection holes
GRWHOLES		CHAR(50)	IDCODES	boreholes where grwhead is measured
RESP1		CHAR(20)	PERSON	person responsible for test
RESP2		CHAR(20)	PERSON	person responsible for evaluation
REPORT		CHAR(30)	REPORT	reference to report
ARCHIVE		CHAR(50)	ARCHIVE	reference to archive
DATASTO		CHAR(79)	DATASTO	data storage
SIGN		CHAR(5)	SIGN	signature of person responsible for input of data
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDIVF2: Radially Diverging Test - Flyleaf 2

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	injection borehole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
ISECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
ISECLOW	*	NUM (6,2)	LENGTH	lenth to injection section lower limit (m)
T		NUM (3,*)	TRANSM	transmissivity in injection section (m**2/s)
TEQUIP		CHAR(79)	TEQUIP	equipment in injection borehole
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDIVF3: Radially Diverging Test - Flyleaf 3 Tracer and Injection Data

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	injection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
ISECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
ISECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE		CHAR(7)	TRCODE	tracer code
INJCODE		CHAR(5)	INJCODE	type of injection
INJVOL		NUM (8,6)	INJVOL	injected volume (m**3)
AMOTRAC		NUM (6,4)	WEIGHT	amount of tracer in injection solution (g)
INJAMO		NUM (6,4)	WEIGHT	injected amount of tracer (g)
ANMETHOD		CHAR(50)	COM50	chemical analysis methode
CB		NUM (7,5)	CONC	background concentration of tracer (ppm)
C00		NUM (7,5)	CONC	measured injection concentration (ppm)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDIVF4: Radially Diverging Test - Flyleaf 4 Comments

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	injection borehole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
LINENO	*	NUM (4)	LINENO	line number
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDIVIP: Radially Diverging Test - Injection Pressure

Column	Key	Type	Domain	Text

INJHOLE	* CHAR(5)	IDCODE	injhole idcode
START	* CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	* NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	* NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	* CHAR(6)	DATE	date of measurement (yymmdd)
TIME	* CHAR(6)	TIME	time of measurement (hhmmss)
INJP	NUM (7,2)	PRESS	injection pressure (kPa)
COM50	CHAR(50)	COM50	comments
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDIVIQ: Radially Diverging Test - Injection Capacity

Column	Key Type	Domain	Text
INJHOLE	* CHAR(5)	IDCODE	injhole idcode
START	* CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	* NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	* NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	* CHAR(6)	DATE	date of measurement (yymmdd)
TIME	* CHAR(6)	TIME	time of measurement (hhmmss)
INJQ	NUM (4,*)	FLOW	injection capacity (m**3/s)
COM50	CHAR(50)	COM50	comments
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDICD1: Radially Diverging Test - Calculated Data Table No 1

Column	Key Type	Domain	Text
INJHOLE	* CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	* CHAR(5)	IDCODE	idcode of detection hole
START	* CHAR(6)	DATE	start date of test (yymmdd)
SECUP	* NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	* NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	* CHAR(7)	TRCODE	tracer code
EESFQL	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from injection capacity; linear flow model (m)
EESFQWL	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QIN; linear flow model (m)
EESFTOL	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from T0; linear flow model (m)
EESFQR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from pump capacity; radiall model (m)
EESFQWR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QIN; radiall model (m)
EESFTOR	NUM (6,*)	SFAC	equivalent single fracture aperture calculated from T0; radiall model (m)
EM	NUM (6,*)	EM	mass balance fracture aperture (m)
HETTF	NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer first arrival (s/m**2)
HETTO	NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer mean residence time (s/m**2)
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDICD2: Radially Diverging Test - Calculated Data Table No 2

Column	Key Type	Domain	Text
INJHOLE	* CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	* CHAR(5)	IDCODE	idcode of detection hole
START	* CHAR(6)	DATE	start date of test (yymmdd)
SECUP	* NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	* NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	* CHAR(7)	TRCODE	tracer code
TQL	NUM (3,*)	STRANSC	fracture transmissivity calculated from injection capacity (m**2/s);linear model
TQWL	NUM (3,*)	STRANSC	fracture transmissivity calculated from QIN (m**2/s); linear model
TTOL	NUM (3,*)	STRANSC	fracture transmissivity calculated from T0 (m/s); linear model
TML	NUM (3,*)	STRANSC	fracture transmissivity calculated from EM (m**2/s); linear model
TQR	NUM (3,*)	STRANSC	fracture transmissivity calculated from

			injection capacity (m**2/s); radiall model
TQWR	NUM (3,*)	STRANSC	fracture transmissivity calculated from QIN (m**2/s); radiall model
TTOR	NUM (3,*)	STRANSC	fracture transmissivity calculated from TO (m**2/s); radiall model
TMR	NUM (3,*)	STRANSC	fracture transmissivity calculated from EM, radiall model (m**2/s); radiall model
PECLET	NUM (3,*)	PECNUM	peclet number (dim.less)
RET	NUM (3,*)	RET	retardation coefficient (dim.less)
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDICD3: Radially Diverging Test - Calculated Data Table No 3

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
TF		NUM (7)	TF	tracer first arrival (s)
TO		NUM (7)	TF	tracer mean residence (s)
REC		NUM (5,2)	TRAREC	tracer recovery (%)
DELTAH		NUM (6,2)	DELTAH	head difference injection-sampling (mean) (m)
QIN		NUM (4,*)	FLOW	tracer flow rate through sampling section (m**3/s)
KESFQL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from injection capacity; linear flow model (m/s)
KESFQWL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QIN; linear flow model (m/s)
KESFTOL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO; linear flow model (m/s)
KESFQR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from injection capacity; radiall model (m/s)
KESFQWR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QIN; radiall model (m/s)
KESFTOR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO; radiall model (m/s)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

RADDICD4: Radially Diverging Test - Calculated Data Table No 4

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	idcode of injection hole
DETHOLE	*	CHAR(5)	IDCODE	idcode of detection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to injection section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to injection section lower limit (m)
TRCODE	*	CHAR(7)	TRCODE	tracer code
FIQL		NUM (3,*)	FPORC	flow porosity calculated from injection capacity (dim.less); linear model
FIQWL		NUM (3,*)	FPORC	flow porosity calculated from QIN (dim.less); linear model
FITOL		NUM (3,*)	FPORC	flow porosity calculated from TO (dim.less); linear model
FIML		NUM (3,*)	FPORC	flow porosity calculated from mass balance (dim.less); linear model
FIQR		NUM (3,*)	FPORC	flow porosity calculated from injection capacity (dim.less); radiall model
FIQWR		NUM (3,*)	FPORC	flow porosity calculated from QIN (dim.less); radiall model
FITOR		NUM (3,*)	FPORC	flow porosity calculated from TO (dim.less); radiall model
FIMR		NUM (3,*)	FPORC	flow porosity calculated from mass balance (dim.less); radiall model
DISPL		NUM (3,*)	DISP	longditudinal dispersivity (m)
DISPT		NUM (3,*)	DISP	transverse dispersivity (m)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

METHOD DIPOLE TEST

DIPOLF1 : Dipole Test - Flyleaf 1

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	area idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
COMPANY		CHAR(30)	COMP	name of company performing test
INJHOLES		CHAR(50)	IDCODES	injection holes
DETHOLES		CHAR(50)	IDCODES	detection holes
GRWHOLES		CHAR(50)	IDCODES	boreholes where grwhead is measured
RESP1		CHAR(20)	PERSON	person responsible for test
RESP2		CHAR(20)	PERSON	person responsible for evaluation
REPORT		CHAR(30)	REPORT	reference to report
ARCHIVE		CHAR(50)	ARCHIVE	reference to archive
DATASTO		CHAR(79)	DATASTO	data storage
SIGN		CHAR(5)	SIGN	signature of person responsible for input of data
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLF2 : Dipole Test - Flyleaf 2

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
PUMPL		NUM (6,2)	LENGTH	length to pump intake along the borehole (m)
CAPPUMP		NUM (4,*)	FLOW	pump capacity (m**3/s)
TEQUIP		CHAR(79)	TEQUIP	pumping equipment
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLF3 : Dipole Test - Flyleaf 3 Tracer and Injection Data

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	injection hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
TRCODE	*	CHAR(7)	TRCODE	tracer code
INJCODE	*	CHAR(5)	INJCODE	type of injection
INJDATE	*	CHAR(6)	DATE	injection date (yymmdd)
INJTIME	*	CHAR(6)	TIME	injection time (hhmmss)
SECUP		NUM (6,2)	LENGTH	length to injection section, upper limit (m)
SECLOW		NUM (6,2)	LENGTH	length to injection section, lower limit (m)
INJVOL		NUM (8,6)	INJVOL	injected volume (m**3)
AMOTRAC		NUM (6,4)	WEIGHT	amount of tracer in injection solution (g)
INJAMO		NUM (6,4)	WEIGHT	injected amount of tracer (g)
ANMETHOD		CHAR(50)	COM50	chemical analysis methode
CB		NUM (7,5)	CONC	background concentration of tracer (ppm)
C00		NUM (7,5)	CONC	measured injection concentration (ppm)
INJQ		NUM (4,*)	FLOW	injection pump capacity; mean value (m**3/s)
OUTQ		NUM (4,*)	FLOW	injection discharge; mean value (m**3/s)
GRWQ		NUM (4,*)	FLOW	ground water flow through section (m**3/s)
CIRQ		NUM (4,*)	FLOW	circulation pump capacity (m**3/s)
DIST		NUM (5,1)	RADSEC	distance between pumpwell and injection hole
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLF4 : Dipole Test - Flyleaf 4 Comments

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	area idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
LINENO	*	NUM (4)	LINENO	line number
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLTEM: Dipole Test - Temperature of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
TEMP		NUM (6,*)	TEMPG	temperature of the pumped water (oC)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLCON: Dipole Test - Electrical Conductivity of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
ECOND		NUM (5,1)	ECOND	electrical conductivity of the pumped water (mSiemens/h)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLEH : Dipole Test - Oxidation/Reduction Potential

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
EH		NUM (3)	EH	redox potential (mV)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

DIPOLQD : Dipole Test - Pumping Rate

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
FLOW		NUM (4,*)	FLOW	measured water flow rate (m**3/s)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodate base (yymmdd)

DIPOLCD : Dipole Test - Calculated Data

Column	Key	Type	Domain	Text
INJHOLE	*	CHAR(5)	IDCODE	borehole idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
TRCODE	*	CHAR(7)	TRCODE	tracer code
TO		NUM (7)	TF	mean residence time (s)
TF		NUM (7)	TF	tracer first arrival (s)
REC		NUM (5,2)	TRAREC	recovery of tracer in pumpwell
DELTAH		NUM (6,2)	DELTAH	head difference injection-sampling (mean) (m)
DISPL		NUM (3,*)	DISP	longitudinal dispersivity (m)
PECLEN		NUM (3,*)	PECNUM	peclet number (dim.less)
RET		NUM (3,*)	RET	retardation coefficient (dim.less)
QW		NUM (4,*)	FLOW	groundwater flow rate through injection-sampling section (m**3/s)
COMMENT		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

METHOD FLUSHING WATER TEST

FLUSHF1 : Flushing Water Test - Flyleaf 1

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	areacode
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
COMPANY		CHAR(30)	COMP	name of company performing test
PUMPWELL		CHAR(5)	IDCODE	pumpwell idcode
DRILLHOL		CHAR(5)	IDCODE	idcode of drilling borehole
GRWHOLES		CHAR(50)	IDCODES	boreholes where grwhead is measured
RESP1		CHAR(20)	PERSON	person responsible for test
RESP2		CHAR(20)	PERSON	person responsible for evaluation
REPORT		CHAR(30)	REPORT	reference to report
ARCHIVE		CHAR(50)	ARCHIVE	reference to archive
DATASTO		CHAR(79)	DATASTO	data storage
COM50		CHAR(50)	COM50	comments
SIGN		CHAR(5)	SIGN	signature of person resonsible for input of data
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHF2 : Flushing Water Test - Flyleaf 2

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
STIME	*	CHAR(6)	TIME	start time of pumping (hhmmss)
PSECUP		NUM (6,2)	LENGTH	length to pumping section, upper limit (m)
PSECLOW		NUM (6,2)	LENGTH	length to pumping section, lower limit (m)
DIST		NUM (5,1)	RADSEC	distance between pumpwell and drillhole (m)
TEQUIP		CHAR(79)	TEQUIP	pumping and test equipment
EDATE		CHAR(6)	DATE	end date of pumping (yymmdd)
DDATE		CHAR(6)	DATE	start date of drilling (yymmdd)
DTIME		CHAR(6)	TIME	start time of drilling (hhmmss)
SASTART		CHAR(6)	DATE	start date of sampling (yymmdd)
SAEND		CHAR(6)	DATE	end date of sampling (yymmdd)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHF3 : Flushing Water Test - Flyleaf 3 Tracer Information

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to pumping section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to pumping section lower limit (m)
TRCODE		CHAR(7)	TRCODE	tracer code
TRCONC		NUM (7,5)	CONC	concentration of tracer in injection solution (ppm)
INJVOL		NUM (8,6)	INJVOL	injected volume (m**3)
AMOTRAC		NUM (6,4)	WEIGHT	amount of tracer in injection solution (g)
INJVOLBA		NUM (8,6)	INJVOL	injected volume back to surface (m**3)
INJAMO		NUM (6,4)	WEIGHT	injected amount of tracer (g)
ANMETHOD		CHAR(50)	COM50	chemical analysis methode
CB		NUM (7,5)	CONC	background concentration of tracer (ppm)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHF4 : Flushing Water Test - Flyleaf 4 Comments

Column	Key	Type	Domain	Text
AREAC	*	CHAR(2)	AREACODE	areacode
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
LINENO	*	NUM (4)	LINENO	line number
COMMENT		CHAR(79)	COMMENT	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHTEM: Flushing Water Test - Temperature of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
TEMP		NUM (6,*)	TEMPG	temperature of the pumped water (oC)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHCON: Flushing Water Test - Electrical Conductivity of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
ECOND		NUM (5,1)	ECOND	electrical conductivity of the pumped water (mSiemens/m)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHEH : Flushing Water Test - Oxidation/Reduction Potential of the Pumped Water

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of test (yymmdd)
PSECUP	*	NUM (6,2)	LENGTH	length to pumping section upper limit (m)
PSECLOW	*	NUM (6,2)	LENGTH	length to pumping section lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
EH		NUM (3)	EH	redox potential (mV)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHQD : Flushing Water Test - Pumping Rate

Column	Key	Type	Domain	Text
PUMPWELL	*	CHAR(5)	IDCODE	pumpwell idcode
START	*	CHAR(6)	DATE	start date of pumping (yymmdd)
SECUP	*	NUM (6,2)	LENGTH	length to pumping section upper limit (m)
SECLOW	*	NUM (6,2)	LENGTH	length to pumping section lower limit (m)
DATE	*	CHAR(6)	DATE	date of measurement (yymmdd)
TIME	*	CHAR(6)	TIME	time of measurement (hhmmss)
FLOW		NUM (4,*)	FLOW	measured water flow rate (m**3/s)
COM50		CHAR(50)	COM50	comments
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHCD1: Flushing Water Test - Calculated Data Table No 1

Column	Key	Type	Domain	Text
DRILLHOL	*	CHAR(5)	IDCODE	idcode of drilling hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
TF		NUM (7)	TF	tracer first arrival (s)
TO		NUM (7)	TF	tracer mean residence (s)
REC		NUM (5,2)	TRAREC	tracer recovery (%)
DELTAH		NUM (6,2)	DELTAH	head difference injection-sampling (mean) (m)
KESFQL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from pump capacity, linear flow model (m/s)
KESFQWL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QW, linear flow model (m/s)
KESFTOL		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO, linear flow model (m/s)
KESFQR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from pump capacity, radiall model (m/s)
KESFQWR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from QW, radiall model (m/s)
KESFTOR		NUM (3,*)	HCOND	equivalent single fracture conductivity calculated from TO, radiall model (m/s)
EESFQL		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from pump capacity, linear flow medel (m)
EESFQWL		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QW, linear flow model (m)
EESFTOL		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from TO, linear flow model (m)
EESFQR		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from pump capacity, radiall model (m)
EESFQWR		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from QW, radiall model (m)
EESFTOR		NUM (6,*)	SFAC	equivalent single fracture aperture calculated from TO, radiall model (m)
EM		NUM (6,*)	EM	mass balance fracture aperture (m)
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

FLUSHCD2: Flushing Water Test - Calculated Data Table No 2

Column	Key	Type	Domain	Text
DRILLHOL	*	CHAR(5)	IDCODE	idcode of drilling hole
START	*	CHAR(6)	DATE	start date of test (yymmdd)
TQL		NUM (3,*)	STRANSC	fracture transmissivity calculated from pump capacity (m**2/s); linear model
TQWL		NUM (3,*)	STRANSC	fracture transmissivity calculated from QW (m/s); linear model
TTOL		NUM (3,*)	STRANSC	fracture transmissivity calculated from TO (m/s); linear model
TML		NUM (3,*)	STRANSC	fracture transmissivity calculated from EM; linear model
TQR		NUM (3,*)	STRANSC	fracture transmissivity calculated from pump capacity (m**2/s); radiall model
TQWR		NUM (3,*)	STRANSC	fracture transmissivity calculated from QW (m/s); radiall model
TTOR		NUM (3,*)	STRANSC	fracture transmissivity calculated from TO (m/s); radiall model
TMR		NUM (3,*)	STRANSC	fracture transmissivity calculated from E; radiall model
FIQL		NUM (3,*)	FPORC	flow porosity calculated from pump capacity (dim.less); linear model
FIQWL		NUM (3,*)	FPORC	flow porosity calculated from QW (m/s); linear model
FITOL		NUM (3,*)	FPORC	flow porosity calculated from TO (m/s); linear model
FIML		NUM (3,*)	FPORC	flow porosity calculated from mass balance (dim.less); linear model
FIQR		NUM (3,*)	FPORC	flow porosity calculated from pump capacity (dim.less); radiall model
FIQWR		NUM (3,*)	FPORC	flow porosity calculated from QW (m/s); radiall model
FITOR		NUM (3,*)	FPORC	flow porosity calculated from TO (m/s); radiall model
FIMR		NUM (3,*)	FPORC	flow porosity calculated from mass balance (dim.less); radiall model
HETTF		NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer

			first arrival (s/m**2)
HETTO	NUM (3,*)	HETRATE	heterogeneity rate t/r**2 based on tracer mean residence time
DISPL	NUM (3,*)	DISP	longditudinal dispersivity (m)
DISPT	NUM (3,*)	DISP	transverse dispersivity (m)
PECLET	NUM (3,*)	PECNUM	peclet number (dim.less)
RET	NUM (3,*)	RET	retardation coefficient (dim.less)
INDAT	CHAR(6)	DATE	input date of data to geodata base (yymmdd)

METHOD CHECK TABLES FOR TRACER TESTS

TRACECOD: Check table for tracers

Column	Key	Type	Domain	Text
TRCODE	*	CHAR(7)	TRCODE	tracer code
TRNAME	*	CHAR(30)	TRNAME	tracer name
TRTYPE	*	CHAR(20)	TRTYPE	tracer type
COM50	*	CHAR(50)	COM50	comment
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

INJECODE: Check Tables For Injection Types

Column	Key	Type	Domain	Text
INJCODE	*	CHAR(5)	INJCODE	injection code
INJNAME		CHAR(30)	INJNAME	injection type
COMMENT		CHAR(79)	COMMENT	comment
INDAT		CHAR(6)	DATE	input date of data to geodata base (yymmdd)

11 APPENDIX 2

Table TRACECOD:

TRCODE	TRNAME	TRTYPE	COMMENT
BD2000	Blue Dextran 2000	Non radioactive	Macro molecule
Br-82	Br-82	Radiotracer	Chemical form Br(I)-
Co-58		Radiotracer	Chemical form Re(VII)O4-
Cr-51		Radiotracer	
Gd-DTPA	Gd-DTPA	Non radioactive	Metal complex
I-131		Radiotracer	Chemical form I(I)-
In-111		Radiotracer	
In-EDTA	In-EDTA	Non radioactive	Metal complex
La-140		Radiotracer	
Lu-177		Radiotracer	
Na-24		Radiotracer	
Rb-86		Radiotracer	
RdWT	Rhodamin WT	Non radioactive	Dye tracer
Re-186		Radiotracer	
TI-201		Radiotracer	
Tb-160		Radiotracer	
Tc-99m		Radiotracer	Chemical form Tc(VII)O4-
Tm-EDTA	Tm-EDTA	Non radioactive	Metal complex
Uranin	Natriumfluorecin	Non radioactive	
Yb-169		Radiotracer	

Table INJECODE:

INJCODE	INJNAME
PI	Pulse injection
CI	Continuous injection
UPI	Undisturbed pulse injection
UCI	Undisturbed continuous injection

List of SKB reports

Annual Reports

1977-78
TR 121
KBS Technical Reports 1 – 120
Summaries
Stockholm, May 1979

1979
TR 79-28
The KBS Annual Report 1979
KBS Technical Reports 79-01 – 79-27
Summaries
Stockholm, March 1980

1980
TR 80-26
The KBS Annual Report 1980
KBS Technical Reports 80-01 – 80-25
Summaries
Stockholm, March 1981

1981
TR 81-17
The KBS Annual Report 1981
KBS Technical Reports 81-01 – 81-16
Summaries
Stockholm, April 1982

1982
TR 82-28
The KBS Annual Report 1982
KBS Technical Reports 82-01 – 82-27
Summaries
Stockholm, July 1983

1983
TR 83-77
The KBS Annual Report 1983
KBS Technical Reports 83-01 – 83-76
Summaries
Stockholm, June 1984

1984
TR 85-01
Annual Research and Development Report 1984
Including Summaries of Technical Reports Issued during 1984. (Technical Reports 84-01 – 84-19)
Stockholm, June 1985

1985
TR 85-20
Annual Research and Development Report 1985
Including Summaries of Technical Reports Issued during 1985. (Technical Reports 85-01 – 85-19)
Stockholm, May 1986

1986
TR 86-31
SKB Annual Report 1986
Including Summaries of Technical Reports Issued during 1986
Stockholm, May 1987

1987
TR 87-33
SKB Annual Report 1987
Including Summaries of Technical Reports Issued during 1987
Stockholm, May 1988

1988
TR 88-32
SKB Annual Report 1988
Including Summaries of Technical Reports Issued during 1988
Stockholm, May 1989

1989
TR 89-40
SKB Annual Report 1989
Including Summaries of Technical Reports Issued during 1989
Stockholm, May 1990

Technical Reports

List of SKB Technical Reports 1991

TR 91-01
Description of geological data in SKB's database GEOTAB
Version 2
Stefan Sehlstedt, Tomas Stark
SGAB, Luleå
January 1991

TR 91-02
Description of geophysical data in SKB database GEOTAB
Version 2
Stefan Sehlstedt
SGAB, Luleå
January 1991

TR 91-03
1. The application of PIE techniques to the study of the corrosion of spent oxide fuel in deep-rock ground waters
2. Spent fuel degradation
R S Forsyth
Studsvik Nuclear
January 1991

TR 91-04

Plutonium solubilities

I Puigdomènech[1], J Bruno[2]
[1]Enviromental Services, Studsvik Nuclear, Nyköping, Sweden
[2]MBT Tecnologia Ambiental, CENT, Cerdanyola, Spain

February 1991