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NATIONAL WATER RESEARCH INSTITUTE

INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX

THE ELECTRONIC COMPILATION OF GEOLOGICAL AND HYDROGEOLOGICAL DATA FROM THE SMITHVLLE, ONTARIO SITE: DATA MANAGEMENT SYSTEM DOCUMENTATION V.1

N. Marenco, P. Lapcevic and L. Davidson

NWRI Contribution Number 00-055

THE ELECTRONIC COMPILATION OF GEOLOGICAL AND HYDROGEOLOGICAL DATA FROM THE SMITHVILLE, ONTARIO SITE: DATA MANAGEMENT SYSTEM DOCUMENTATION V.1

by:

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January 2000

NWRI Cont. # 00-55

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MANAGEMENT PERSPECTIVE

Conservation of biodiversity in healthy ecosystems. Priority ecosystems are conserved and restored

Since 1995, the Groundwater group at NWRI has been involved in an extensive field and laboratory hydrogeological research program at the Smithville PCB site in Smithville, ON. The data from our research studies as well as that from other researchers and MOE monitoring programs was compiled and verified into an electronic data management system. This compilation includes Microsoft Access® databases, rock core photographs, geophysical sondes and scanned maps. The project has been completed in collaboration with a private consulting firm. This report is intended to serve as summary documentation and user's guide for the data management system. The database is currently being used by modellers and consultants responsible for assessing the viability of various remediation alternatives for the site. Additionally, having the various data sets in a single coherent system will aid in further interpretations of the data. This electronic compilation will allow to us to better use research data to further our understanding of the hydrogeology of heterogeneous rock systems and improve our ability to predict and prevent the environmental effects of toxic substances in groundwater and help to conserve and restore priority ecosystems in the Great Lakes Basin.

The bulk of the work on this study has been completed. Much of the Smithville Project data has been included in the electronic compilation. This compilation represents a unique data set which will be amenable to further interpretations in the years to come. We will continue to provide updates to the databases and intend to use the databases as we continue work on modelling studies and prepare journal articles on the work that has been carried out.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Conservation de la biodiversité dans des écosystèmes sains. Les écosystèmes prioritaires sont conservés et remis en état.

Depuis 1995, le groupe de l'INRE responsable des eaux souterraines a participé à un vaste programme de recherche hydrogéologique *in situ* et en laboratoire sur le site de stockage de BPC de Smithville, en Ontario. Les données provenant de nos recherches et des programmes de surveillance du MEO ainsi que celles obtenues d'autres chercheurs ont été compilées et vérifiées dans un système électronique de gestion des données. Cette compilation englobe des bases de données Access® de Microsoft, des photographies de carottes de roches, des sondes géophysiques et des cartes scannées. Ce projet a été réalisé en collaboration avec un bureau de conseil technique privé. Ce rapport vise à servir de documentation sommaire et de guide de l'utilisateur du système de gestion des données. Cette base de données est actuellement utilisée par des modélisateurs et des consultants chargés d'évaluer la viabilité de diverses options de restauration visant le site. En plus, le regroupement des divers ensembles de données dans un seul système cohérent facilitera l'interprétation ultérieure des données. Grâce à cette compilation électronique, nous pourrons mieux utiliser les données de recherche pour accroître notre compréhension de l'hydrogéologie des systèmes rocheux hétérogènes; améliorer notre capacité de prévoir et de prévenir les incidences environnementales des substances toxiques dans les eaux souterraines et être plus en mesure de conserver et de rétablir les écosystèmes prioritaires dans le bassin des Grands Lacs.

La plus grande partie du travail lié à cette étude est terminée. La plupart des données du projet de Smithville ont fait l'objet d'une compilation électronique. Cette dernière représente un ensemble de données tout particulier qui se prêtera à des interprétations ultérieures dans les années à venir. Nous continuerons à mettre à jour ces bases de données et avons l'intention de nous en servir tout en poursuivant nos études de modélisation et en préparant des articles scientifiques pour en rendre compte.

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RÉSUMÉ

À la fin des années 70 et au début des années 80, des déchets et des solvants contaminés ont été entreposés au site de la Chemical Waste Management Ltd. (CWML) à Smithville, en Ontario. En 1985, le ministère de l'Environnement de l'Ontario (MEO) a assumé la gestion du site après qu'on ait découvert des solvants dans une lagune de surface et constaté la contamination des eaux souterraines sous-jacentes. On a entrepris un programme d'assainissement, en quatre étapes, visant à contenir la contamination et à dépolluer la roche-mère sous-jacente. Au cours des 15 dernières années, le MEO, des consultants privés, des chercheurs universitaires et gouvernementaux ont produit, sur le terrain et en laboratoire, des données décrivant la subsurface et les panaches aqueux et non aqueux, au moyen d'activités de caractérisation du site et de programmes de surveillance constante. Le système de gestion des données géologiques de Smithville visait à assembler numériquement, à normaliser et à vérifier les données géoscientifiques recueillies au site même et aux alentours durant les 15 dernières années et à les disposer sous une forme logique, gérable et facilement accessible. On voulait ainsi faciliter l'accès à l'ensemble des données existantes et garder la souplesse nécessaire pour pouvoir intégrer de nouvelles données sur le site, le cas échéant. Le rapport décrit la structure, le contenu et la présentation du système de gestion des données et fournit un guide d'utilisation.

ABSTRACT

During the late 1970s and early 1980s, contaminated wastes and solvents, were stored at the Chemical Waste Management Ltd. (CWML) site in Smithville, Ontario. In 1985, the Ontario Ministry of the Environment (MOE) assumed management of the site after the discovery of solvents in a surface lagoon and subsurface contamination of the groundwater underlying the site. A four-phase remediation program, with the objective of containing and remediating the contamination in the bedrock underlying the site, was initiated. Over the last 15 years, field and laboratory data characterizing the subsurface, aqueous, and non-aqueous plumes have been generated through site characterization activities and on-going monitoring programs by the MOE, private consultants, university, and government researchers. The aim of the Smithville geological data management system was to digitally assemble, standardize, and verify the available geoscience data collected in and around the site over the last 15 years into a logical, manageable, and easily accessible format. This was intended to provide easy access to the existing data set, and be flexible to incorporate new site data when available. This report describes the structure, content, and format of the data management system, and provides a guide to using it.

1.0 INTRODUCTION

During the late 1970s and early 1980s, contaminated wastes and solvents, including polychlorinated biphenyl (PCB), were stored at the Chemical Waste Management Ltd. (CWML) site in Smithville, Ontario. After discovery of solvents in a surface lagoon, the Ontario Ministry of the Environment (MOE) assumed management of the site and undertook a four-phase program to remediate the waste on the surface and underlying soil, bedrock, and groundwater systems. During Phases I to III, clean-up of the surface waste and contaminated overburden was undertaken, various hydrogeological investigations were conducted, and much of the available PCB wastes underwent on-site destruction (Golder Associates Ltd., 1995). In May 1989, a "pump-and-treat" system consisting of 8 wells (RWS1-RWS8) pumping from the shallow bedrock was initiated and continues to the present time. The principal aims of Phase IV of this program, now ongoing, are to contain and remediate the contamination in the bedrock underlying the CWML site.

The characterization of the subsurface at the site has been extensive. Over 200 boreholes and monitoring wells have been installed in and around the waste site during the last 15 years. These monitoring wells have been used to measure the level of contamination of various compounds in the aqueous plume (e.g. TCE, TCB, and PCB) at various depths in the subsurface. Between 1995 and 1999, researchers at the National Water Research Institute (NWRI) along with various sub-contractors have been conducting laboratory and field experiments to study the dolostone underlying the site, and the regional hydrogeology with the goal of developing a conceptual model for groundwater flow and aqueous transport in the dolostone (Novakowski et al., 1999). The carbonate bedrock below the site has been characterized in detail at a number of different scales. Measurements of hydraulic head have been obtained to determine the groundwater flow regime in the overburden and underlying rock units both at the regional scale (km) and local scale (m). The physical and chemical properties of the fractured rock have been characterized through field and laboratory measurements. Much of the data from this study is included in the data management system discussed in this report. Complimentary data, such as climatic measurements from nearby weather stations, have been included to aid in the interpretations. In addition to the site characterization work, the Ontario Clean Water Agency (OCWA) has routinely collected groundwater samples for the analysis of contaminant constituents in numerous monitoring wells around the source area for over 10 years. OCWA has also maintained continuous hydraulic head measurements in several monitors using transducers and data loggers. Overall, the different types of data have been collected and interpreted by various different groups including the MOE, private consultants, university, and government researchers. Collectively, the data sets generated from various studies over the last decade in and around the CWML site make this a uniquely studied contaminated groundwater site.

The objective of this project was to compile, standardize, and verify site characterization, monitoring program and other related data from various workers into a manageable and easily accessible format. The data management system is intended to provide both researchers and decision-makers with a tool to easily access and use the existing data set. Additionally, the data management system is intended to be flexible in order that new site data, when available, can be easily incorporated to the existing databases.

This report outlines the electronic compilation and data management system developed for the hydrogeological data collected at the Smithville site. The documentation describes the structure, content, and format of the data management system, and provides a step-by-step guide to using the databases, both to view and export existing data, and to append user-specific data.

2.0 DATA MANAGEMENT SYSTEM STRUCTURE AND CONSTRUCTION

The Smithville geological data management system is a digital compilation of the available geoscience data collected in and around the CWML site from approximately 1987 to the present. The structure of the data management system was designed by Earthfx Inc., and VIEWLOG® Systems between 1996 and 1998. At this time, much of the pre-1995 data was assembled into the database tables. In 1998 and 1999, much of the data obtained through the detailed studies, post-1995 monitoring program data (chemistry, and hydraulic head measurements), and other relevant data sets were added to the data management system by NWRI and Earthfx Inc.. Data from field and lab research studies carried out by NWRI, McMaster University, and University of Utah researchers under the EPA study on capture zones in carbonate rock were also included.

2.1 Structure

The Smithville data management system is assembled using Microsoft Access® 97, a relational SQL (Structured query language) compliant database software package that provides rapid electronic access to site data. Included in the Microsoft Office Pro®

package, Access® is a user-friendly, readily available software that can store vast amounts of information without loss of speed. Its "querying power", derived from the relationships between the various database tables, makes Access® ideal for manipulating and comparing large data sets.

The data management system is comprised of 3 separate databases: (a) DATA (Smv_data.mdb); (b) USER (Smv_user.mdb); and (c) MENU (Smv_menu.mdb). "Smv_data.mdb" contains data compiled in a family of 24 tables. "Smv_menu.mdb" is linked to "Smv_data.mdb", and is an automated database offering several tools to browse and view the data through forms. "Smv_user.mdb" is also linked to "Smv_data.mdb", and is intended for users wishing to develop their own queries. The divided structure permits independent updates of either the viewing tools or the data. The three databases currently occupy approximately 120 Mb of hard-drive space, and require a minimum P200 computer with 32 Mb RAM.

Additionally, there are 3 other components within the data management system that are not stored within the database software. These include: (a) core photographs; (b) CAD-style base maps; and (c) borehole geophysics. Figure 1 shows all the components of the data management system. The core photographs are indexed in "Smv_data.mdb" and can be viewed with VIEWLOG® or any software that reads "*.bmp" files (e.g. Corel PhotoPaint®). The CAD-style base maps, and borehole geophysics are best viewed with VIEWLOG®. Instructions to install the system are provided in Appendix B.

2.2 Data Model

The data model used to assemble "Smv_data.mdb" is based on the relationship between "borehole" and "monitor". The vast majority of data obtained from site investigations can be referenced to originate from either a borehole (e.g. rock core properties, lithological descriptions), or from a monitoring interval (e.g. water level measurements, chemical constituents). The different types of monitors and boreholes installed at the Smithville site are described in detail in Section 3.14. All data measurements or descriptions are referenced to either a borehole or monitor, which have spatial co-ordinates (UTM northing and easting) and can be located on a map or plan view. Data from non-borehole sources are referenced to other forms of "monitor". For example, precipitation data would be referenced to a climate "station", which can be located spatially but does not extend into the subsurface. The links between the tables resulting from the data model are shown in Figure 2.

2.3 Database Table Structure

Most tables in "Smv_data.mdb" have been assembled according to the requirements of the second or third normal form (2NF or 3NF). This means that the tables are "orthogonal" or normalized, with each record devoted to a specific data point. An example of this format is shown in Figure 3. Although this may not be an intuitive format for reviewing data, it offers advantages for database searching and storage. More conventional tables can be constructed using Access® query and report capabilities or by exporting to spreadsheet software. Detailed information on database principles and structure can be found in O'Neil (1994).

2.4 Units

Numerous units are used within the data management system, because of the wide range of measurements obtained during site investigations. Most tables contain one or several fields displaying units of the data. The SI system is used throughout the data management system, with the exception of the core photographs, each of which shows a measuring tape, in inches and feet beside the core. In most cases, measurements of depth have been converted to metres above sea level (masl) to avoid ambiguities related to the reference point (ground surface or top of casing), particularly in inclined holes.

2.5 Data Sources and Qualifiers

In several tables, additional fields have been added to identify sources of the data as well as any relevant "qualifiers". These include: (a) the original source file name; (b) the corporate source; (c) compilation dates; and (d) method detection (MDL) or reporting limits (RL). Other qualifiers included provide information on the original format of the data (e.g. some hydraulic head measurements were entered into the database as water levels [depth to water in metres] and converted, while others were processed by the originator and entered as hydraulic head [masl]).

3.0 DATA MANAGEMENT SYSTEM CONTENT

This section contains a description of the contents of each table in "Smv_data.mdb", as well as information on the 3 other data management system components. Data sources and references are also included. Table 1 provides a list of all tables in "Smv_data.mdb". The definition of each field in all tables is included in Appendix A. In broad terms, the contents of the data management system are:

- Borehole logs
- Monitor details
- Major geological descriptions (stratigraphic contacts)

- Minor geological descriptions (core features)
- Water level data
- Water sample data
- Permeability testing data
- Rock property data

Data available to "Smv_data.mdb", but not stored within Access® include:

- Core photographs (Boreholes 54, 58, 62, 64, and 65)
- CAD-style base maps
- Borehole geophysics

3.1 Tables in "Smv_data.mdb"

3.1.1 Borehole

(1) Description

For the purpose of this data management system, a "borehole" generally refers to an open, uncompleted drilled hole in the overburden or rock. In some instances, pre-1995 monitoring well clusters are referred to as boreholes to maintain referential integrity in the database (e.g. borehole 5 refers to the "site" containing 5S11, 5S14, 5D19, 5D25, etc.). Between 1995 and 1998, NWRI installed 18 boreholes intersecting the length of the Lockport dolostone and completed with a steel casing (grouted in) through the overburden. Boreholes may contain one or more monitors, which isolate measurement zones either temporarily or permanently within the borehole. All subsurface groundwater measurements are associated with a monitor, which in turn are associated with a borehole (the details of all monitors are included in a separate table "Monitor"). The "Borehole" table outlines the details of the boreholes installed in and around the

CWML site. Included are drilling details (e.g. drilling contractors, drill type, drilling start and end dates, etc.), UTM co-ordinates, and borehole azimuth and plunge. Data on the 8 pumping wells are included in this table. Borehole details on several boreholes (OW-series) installed in the region by Terraqua Investigations Ltd. for another unrelated study are also included as they are part of the currently ongoing water level monitoring program. In this case, the monitor and borehole are identical. Both vertical and inclined boreholes have been installed at the site. Figure 4 illustrates a typical installation of an inclined borehole.

(2) Data Sources

Golder Associates Ltd., Terraqua Investigations Ltd., NWRI, Phase IV.

(3) Data References

Golder Associates Ltd., Clean-up of abandoned PCB storage facility, Smithville, Ontario: Results of geological and hydrogeological investigations and contaminated plume delineation study, 1987, Ref. 871-1156, 1988.

Golder Associates Ltd., Hydrogeological Data Compilation and Assessment CWML Site, Smithville, Ontario, Golder Associates Ltd., Project No. 94-106, 1995.

Pentney, A., and B. Blackport, Rock St. closed landfill site, Smithville, Ontario, Terraqua Investigations Ltd., Ref. No. TA463, 1994.

(4) Comment

The "Borehole" table is necessary for database functionality, because the borehole name or number acts as a "primary key field". Because this table also contains the UTM co-ordinates, it is necessary to locate monitors and associated data on a map or cross-section. "Nested" monitors are assumed to have the same UTM co-ordinates. In some cases, the borehole and monitor are identical (e.g. pumping wells RWS1-RWS8, and the OW-series).

3.1.2 BoreholeTests

(1) Description

This table is a compilation of the results of hydraulic testing in various boreholes and monitors used in this study. A large component of this data set is transmissivity (T) and equivalent single fracture aperture ($2b_{eq}$) measurements determined through constant-head injection tests (CHITs) conducted in boreholes 34C, 37C, 54A-D, and 55 to 65 by NWRI (Novakowski et al., 1999). The principle behind a CHIT is to inject or withdraw water at a constant hydraulic head into an isolated portion of the borehole and measure the flow-rate at steady-state conditions. The ratio of measured flow rate to change in head is related to the permeability of the isolated zone. The tests conducted by NWRI in this study used a system of 5 tanks of varying diameter (Figure 5). The effective range of transmissivity that can be measured with this particular system is 10^{-10} to 10^{-2} m^2/s. Several different test interval lengths were used to characterize the vertical distribution of transmissivity in the Lockport dolostone underlying the site. Equivalent single fracture apertures ($2b_{eq}$) were calculated using the T of a given zone and the cubic law. It is important to note that $2b_{eq}$ is a calculated number and should not be taken to suggest that each testing zone contains only one fracture. Fracture frequency or magnitude cannot be determined from the results of hydraulic testing since a single large fracture may have an equivalent transmissivity of several smaller fractures. Further details on CHIT methodology can be found in Novakowski (1988) and Lapcevic et al. (1998). Hydraulic tests were also completed over the length of boreholes 11, 12, and 21 by Golder Associates Ltd.. These tests used a test interval of approximately 3 metres, and the testing system had an effective range of 10^{-8} to 10^{-3} m^2/s.

This table also includes groundwater velocities measured in single fractures calculated from point dilution experiments conducted in 1996 and 1998 in boreholes 37C, 54A, 56, and 59. Additionally, storativity and hydraulic conductivity data from pumping tests (3, 24, and 72 hour tests) performed from 1987 to 1989 in boreholes MW2, 23, and 14 are included.

(2) Data Sources

Golder Associates Ltd., NWRI.

(3) Data References

Golder Associates Ltd., Summary of Packer Test Results, 1998 (internal Phase IV file from Golder Associates Ltd.; no specific report reference available).

Golder Associates Ltd., Report on: Hydrogeologic data compilation and assessment CWML site Smithville, Ontario, Project No. 94-106, 52pp., 1995.

Radcliffe, A., Determination of Groundwater Velocities in Discrete Fractures using Point Dilution Methods, University of Waterloo, B. Sc. Thesis, Department of Earth Sciences, 1997.

Uhlman, W., J. Voralek, and P. Lapcevic, The Use of Point-Dilution Techniques for Determining Groundwater Velocity in Fractured Bedrock, Smithville, Ontario, NWRI Contribution No. 99-202., 29pp., 1999.

3.1.3 ChemData & 3.1.4 ChemData QA samples

(1) Description

These tables include the results of the chemical analyses of groundwater samples from various monitors in and around the Smithville site. The chemical analyses for non-groundwater samples (e.g. rock, soil, grass, and surface water) can be found in tables "RockProperty", and "OtherChem". The "ChemData" table includes both analyses for organic contaminants to delineate and monitor the various plumes, as well as analyses of groundwater samples for background inorganic constituents and stable isotopes. The bulk of the measurements included in this table consist of the chemical constituents determined from the groundwater samples obtained from the characterization of the aqueous plumes (1987 onwards) and ongoing monitoring efforts in selected monitors (Smithville Phase IV, 1996). Additionally, analysis of the groundwater from the "pump-and-treat" well system is included in this table. Measurements of inorganic constituents (e.g. anions, metals, conductivity, temperature, dissolved oxygen, and alkalinity) were obtained from 3 surveys of groundwater samples acquired in 1997 from Westbay® monitoring zones (boreholes 53, 60-63, and 65), and deep multilevel monitors (boreholes 11, 12, and 21). Stable isotope measurements (^{18}O, ^{2}H, and ^{3}H) were also obtained in most of these monitors (Zanini et al., 1997, and 1998). Some additional inorganic measurements as well as CFC-12 and stable isotopes were obtained from selected shallow monitors and Westbay® monitoring zones as part of research studies conducted by University of Utah workers (Utah, 1999). In 1997, a study examining TCE, TCB, and degradation product concentrations in discrete features was carried out in open boreholes using temporary sampling intervals (Brown et al., 1997). The data from this study also included some analyses of the groundwater samples for standard inorganic constituents. Both the organic and inorganic results of this work are included in this table. A list of chemical parameters is shown in Table 2 (also see Section 3.1.17). In some instances, the values obtained from the analyses are "qualified" or require an explanation. A list of qualifier codes and their definition is included in Table 3. The "ChemData QA samples" table includes MDL, control and reporting limits (RL), as well as surrogate recovery values for organic constituents.

(2) Data Sources

University of Utah, Phase IV, NWRI, OCWA, MOEE.

(3) Data References

Brown A., P. Lapcevic, K. Novakowski, S. Lesage, S. Brown, K. Millar, J. Voralek, and L. Zanini, Characterization of Trichloroethylene Contamination in the fractured bedrock at the Smithville, Ontario Site, NWRI Contribution No. 97-140, 1997.

K. Solomon, and A. Sheldon, University of Utah, personal communication.

Smithville Phase IV Program, A critical Review of the Monitoring Program at the Former CWML site in Smithville, Ontario, Internal Report, 80 pp., 1996.

Zanini, L., K. Novakowski, and P. Lapcevic, Inorganic Geochemistry of the Groundwater at the Smithville Site: Phase I Investigation, NWRI Contribution No. 97-123, 39 pp., 1997.

Zanini, L., K. Novakowski, P. Lapcevic, G. Bickerton, J. Voralek, and C. Talbot, Regional groundwater flow in the fractured carbonate aquifer underlying Smithville, Ontario, inferred from combined hydrogeological and geochemical measurements, J. Groundwater, 1998 (In press).

Zanini, L., K. Novakowski, P. Lapcevic, G. Bickerton, J. Voralek, and C. Talbot, Inorganic Geochemistry of the Groundwater at the CWML Site, Smithville, Ontario: Phase II and III Investigation, 1997, NWRI Contribution No. 98-243, 45 pp., 1998.

3.1.5 ChemParameters

(1) Description

This table contains a listing of the chemistry parameters. It is required for graphing purposes (see Section 4.5).

3.1.6 Climate

(1) Description

This table contains measurements of temperature, precipitation (5 minutes, 1 hour, and total), and barometric pressure at several weather stations in Smithville, and other locations in the Niagara region. The location of the weather stations is described in the table "OtherMonitors". This table is not a complete record of all climatic data over the study period, but instead focuses on the time period from 1994 to 1998 to compliment hydraulic head monitoring data collected at the site as part of the Phase IV program.

(2) Data Sources

Regional Municipality of Niagara, Ontario Climate Center (Environment Canada), NWRI.

(3) Data References

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3.1.7 Corephoto

(1) Description

The 18 boreholes installed as part of the Phase IV site characterization activities (1995 to present) were diamond-drilled and cored through the entire thickness of the Lockport dolostone (~ 40 m). In eleven of the boreholes, photographs of the core

(Section 3.2.1), taken immediately after retrieval from the borehole were processed digitally and provide a complete visual record of the core. The photographic record for 5 of these boreholes (54, 58, 62, 64, and 65) was processed (Appendix B) to be accessed by the database and companion software (VIEWLOG®). This table provides a listing of the bitmap files (*.bmp) that can be combined with other data to compare the core record with other borehole measurements. The length of core included in each photograph is noted and can be converted to appropriate units (Figure 7).

(2) Data Sources

NWRI.

3.1.8 DNAPL properties

(1) Description

This table contains physical properties (solubility, density, and K_{oc}) and the chemical composition of specific DNAPLs (e.g. PCB, TCB, and TCE) identified at the Smithville site.

(2) Data Sources

Golder Associates Ltd..

(3) Data References

Golder Associates Ltd., Report on: Hydrogeologic data compilation and assessment CWML site Smithville, Ontario, Project No. 94-106, 52pp., 1995.

3.1.9 Fracture

(1) Description

This table contains the results of fracture mapping carried out by Gartner Lee Ltd. and Acres International Ltd. as part of the development of a regional geological model of the Smithville area for the Phase IV program. Included in this table are the results of fracture mapping (trace length, aperture, orientation, etc.) carried out on vertical quarry faces at the Lincoln Quarry, Vineland II pavement, and pavement at the Smithville lagoon at the CWML site. The locations of these sites are documented in the table "OtherMonitors". Further information and interpretation of this work can be found in Gartner Lee Ltd. and Acres International Ltd. (1996).

(2) Data Sources

Gartner Lee Ltd. and Acres International Ltd..

(3) Data References

Gartner Lee Ltd. and Acres International Ltd., Regional Geological Model Smithville Bedrock Remediation Program, Gartner Lee Ltd. and Acres International Ltd., Project No. 95-160, 75pp., 1996.

3.1.10 GeolMajor

(1) Description

The CWML site is underlain by 5 to 10 metres of overburden that in turn overlies the Lockport, Decew, and Rochester Formations. Locally the Lockport formation is divided into the Eramosa, Vinemount, Goat Island, and Gasport units (Figure 6). This table includes the contact depths and elevations of the stratigraphic units as determined in various boreholes in and around the site. Contacts were determined qualitatively by either visually examining rock core or drill cuttings for changes in lithology or structural features, or by the use of borehole geophysical sondes. Further information on the geology of the Smithville area can be found in Blair and McFarland (1992), Brett et al. (1995), and Gartner Lee Ltd. and Acres International Ltd. (1996).

(2) Data Sources

Golder Associates Ltd., NWRI.

(3) Data References

Golder Associates Ltd., Preliminary results of geological and hydrogeological investigations and contaminated plume delineation study: CWML abandoned PCB storage facility, Smithville, Ontario, 1987.

3.1.11 GeolMinor

(1) Description

This table contains detailed lithological descriptions from various boreholes. The description of boreholes installed before 1995 are based on drill cuttings, grab samples, and core where available. The descriptions of the boreholes installed between 1995 and 1998 are based on a field examination of the core. Both lithological features (e.g. minerals, vugs, and texture) and structural features (e.g. vertical, and bedding-plane fractures) are noted. The nomenclature used in these descriptions is summarized in Table 4. Examples of some noted features are shown in Figure 7. This data is often qualitative in nature and different geologists may refer to similar features by different names.

(2) Data Sources

NWRI, Phase IV, Golder Associates Ltd., Gartner Lee Ltd..

3.1.12 LabCodes

(1) Description

As discussed in Sections 2.5 and 3.1.3, some values obtained from chemical analyses are "qualified". This table provides a list of qualifier codes and their definition (Table 3).

3.1.13 Mass Recovered

(1) Description

In May 1989, a "pump-and-treat" system of 8 wells (RWS1-RWS8) was initiated within the confines of the CWML site. This table includes data on pumping rates (daily, and total averages), and total volume pumped between January 1992 and October 1994. Estimates of DNAPL constituents recovered as a result of this pumping are also included.

(2) Data Sources

Golder Associates Ltd..

(3) Data References

Golder Associates Ltd., Report on: Hydrogeologic data compilation and assessment CWML site Smithville, Ontario, Project No. 94-106, 52pp., 1995.

3.1.14 Monitor

(1) Description

All chemical analyses of groundwater samples and hydraulic head measurements are related to a zone of measurement. This zone is referred to as a "monitor". In this study, there are several different types of monitors. This table provides details on the monitors used at the site and links all monitors to the borehole in which they were either temporarily or permanently installed. The different groundwater monitors at the site can be classified into 5 types of monitors:

- Monitoring well, standpipe, piezometer, open borehole monitor
- Multilevel monitoring well
- Westbay® monitoring zone
- Double packer system

- Single packer system

(A) Monitoring Well, Standpipe, Piezometer, Open Borehole Monitor

In this case, each borehole is completed with only 1 monitoring zone (Figure 8). Sealing material (usually bentonite) above the screen ensures that the monitoring zone is the length of the screen. In other words, the monitoring well is only accessing the zone of the screened-off interval. Examples of this type of completion are 13S9, and 14S9. In some boreholes, steel casing has been installed and grouted to the top of the zone of interest. The monitor zone consists of open borehole below the steel casing (Figure 9). In other words, if the zone of interest is in competent rock, completing the borehole with well casing and screen is not necessary.

(B) Multilevel Monitoring Well

In this type of installation, two or more monitors are installed in a single borehole. Individual piezometers (or standpipes) are isolated from each other using a sealing material (Figure 10). Examples of this type of completion are 11A-F, 17S7, and 17S9.

(C) Westbay® Monitoring zone

The Westbay® system is a commercially available system of borehole instrumentation. It consists of water-filled packers connected by PVC casing, and specially designed pumping and measurement/sampling ports (Figure 11). Each monitoring zone refers to the length of borehole isolated by 2 packers. With this instrumentation, two or more monitoring zones are permanently installed in each borehole. Examples of this type of monitor are installed in boreholes 53, 60, 61, 62, 63, and 65. Monitoring zones are numbered from the bottom of the hole towards ground surface (Westbay® Instruments, 1996; Voralek, 1997; Black et al., 1987). Pressure data obtained with this system is used to calculate hydraulic head. Additionally, Westbay® instrumentation can be used for the collection of groundwater samples at various depths within the subsurface.

(D) Double packer system

Two or more inflatable packers can be installed in an open borehole to form one or more monitors in the borehole. The monitors are considered "temporary", because these packers are generally removable. In this case, the monitoring zone refers to the length of borehole isolated by two packers (Figure 12). In this study, different double packer set-ups were used. Some of the chemistry data and hydraulic head measurements at the Smithville site use this type of monitor. The double packer system may have one manometer extending from the zone to the surface to allow access to the zone for sampling, water level measurement, or pumping (Figure 12a). Examples of this type of monitor are 54D-TU, and 59-TL. In other instances the monitoring zone may consist of a double packer system containing a submersible pump (e.g. Grundfos® pump) (Figure 12b) (e.g. 56-12.4) or a pump above the top packer (Figure 12c) connected to the zone (e.g. 56-10.5) (Brown et al., 1997). The latter two set-ups were used to obtain groundwater samples and geochemical profiles in open holes.

(E) Single packer system

Some of the sampling carried out at the site investigated the concentration of contaminants in single fractures. To isolate these small zones and reduce the amount of water to be purged, a single packer was used (Brown et al., 1997). The single packer has a 15 cm long stainless steel plate which provides access to the groundwater in the fracture when the packer has been inflated (Figure 13). An example of this type of monitor is 56-13.1.

(2) Data Sources

Terraqua Investigations Ltd., Golder Associates Ltd., Gartner Lee Ltd., NWRI.

(3) Data References

Brown, A., P. Lapcevic, K. Novakowski, S. Lesage, S. Brown, K. Millar, J. Voralek, and L. Zanini, Characterization of Trichloroethylene Contamination in the fractured bedrock at the Smithville, Ontario Site, NWRI Contribution No. 97-140, 1997.

Gartner Lee Ltd., Draft Discussion: hydrogeologic study - stage 1, Chemical Waste Management Ltd., Smithville, Ontario, 1986.

Golder Associates Ltd., Clean-up of abandoned PCB storage facility, Smithville, Ontario: Results of geological and hydrogeological investigations and contaminated plume delineation study, 1988 and 1989, 1989.

Golder Associates Ltd., Hydrogeological Data Compilation and Assessment CWML Site, Smithville, Ontario, Golder Associates Ltd. Project No. 94-106, 1995.

Pentney, A., and B. Blackport, Rock St. closed landfill site, Smithville, Ontario, Terraqua Investigations Ltd., Ref. No. TA463, 1994.

Voralek, J. W., Westbay® Completion Report for MP38 Monitoring Wells, No. 63 and 65, NWRI, 1997.

Westbay Instruments Inc., Westbay® Completion Report for MP38 Monitoring Wells No. 53, 60, 61, 62 Smithville Site, Project No. WB761-96, 1996.

(4) Comment

Similar to the "Borehole" table, the "Monitor" table is necessary for database functionality, because the monitor name or number acts as a primary key field. Note that monitors may be "permanent" or "temporary".

3.1.15 OtherChem

(1) Description

This table contains the results of chemical analyses of surface water, soil, and grass samples from various "other monitors" in and around the Smithville site collected primarily during Phase I to III investigations. The details on these monitors can be found in the table "OtherMonitors". The results of the chemical analyses of core samples are found in the table "RockProperty". More information on the samples can be found in the "SampleDetails" table.

(2) Data Sources

Gartner Lee Ltd., NWRI, MOE.

(3) Data References

Gartner Lee Ltd., Draft Discussion: hydrogeologic study - stage 1, Chemical Waste Management Ltd., Smithville, Ontario, 1986.

Ministry of the Environment, PCB concentrations in soil and grass samples in the vicinity of Chemical Waste Management, Smithville – 1985, 1986.

3.1.16 OtherMonitors

(1) Description

This table contains location co-ordinates for all non-borehole "monitors" that are not included in the "Monitor" table, such as: a) soil sample sites; b) grass sample sites; c) surface water sampling sites; d) the Smithville lagoon; e) climate stations; f) the Lincoln Quarry; g) other quarries; and (h) domestic wells. In cases where UTM co-ordinates are not available, non-borehole monitors are spatially located with site descriptions.

3.1.17 ParameterFormula

(1) Description

This table contains a listing of the chemical parameters and their corresponding formulas.

3.1.18 References

(1) Description

This table contains a bibliographical index of all the available theses, reports, and papers pertaining to the Smithville site.

3.1.19 RockProperty

(1) Description

This table contains the results of various analyses of the physical and chemical properties of rock core samples. These include an analysis of the chemical composition of samples from various units underlying the site, gravimetric porosity measurements, and the results of diffusion experiments on rock core disks. The results of isotope analyses (^{18}O, and ^{13}C) on rock core samples obtained from borehole 54A are also included (McMaster, 1997). Information on the rock core samples studied can be found in the "SampleDetails" table. Also included in this table are the results of mercury-injection capillary pressure measurements on samples of rock core from borehole 56. Samples were obtained from the different rock units and analyzed by Core Laboratories Canada Ltd. These measurements include wetting phase saturation, threshold pressure, median pore throat radius, porosity, and permeability (Core Laboratories, 1997).

(2) Data Sources

NWRI, Golder Associates Ltd., Corelabs, McMaster University, Phase IV.

(3) Data References

Bickerton, G. S., Chemical and Mineralogical Composition of the Lockport and Rochester Formations, Smithville, Ontario, NWRI Contribution No. 97-130, 1997.

Core Laboratories Canada Ltd., Advanced Rock Properties Study: Borehole 56, Smithville Site, Report to NWRI, No 52132-97-1116, 32pp., 1998.

Golder Associates Ltd., Matrix Diffusion Testing Eramosa Dolostone Samples, Golder Associates Ltd., 1996.

McMaster University, Department of Geography, Karst Investigations Deliverable 13: Isotopic patterns in CWML core #54, Project No. 96451/2/3 – MCM, 1997.

Novakowski, K., P. Lapcevic, G. Bickerton, J. Voralek, L. Zanini and C. Talbot, The development of conceptual model for contaminant transport in the dolostone underlying Smithville, Ontario, National Water Research Institute, Burlington, Ontario, Canada, 245pp., 1999.

Zanini, L., K. S. Novakowski, and G. Bickerton, The radial diffusion method applied to dolostone core samples from the Lockport Formation, Smithville, Ontario: Phase II, NWRI Contribution No. 99-203, 1999.

3.1.20 SampleDetails

(1) Description

This table contains information (e.g. sample type, dimensions, description, sampled formation, sampling agency, etc.) on the non-groundwater samples collected from in and around the Smithville site, including core samples obtained for isotope analysis and diffusion cell experiments. Each sample is referenced to a borehole, monitor, or "other" monitor. Location co-ordinates and/or site descriptions are available in the tables "Borehole", and "OtherMonitors".

(2) Data Sources

McMaster University, NWRI, Golder Associates Ltd., Phase IV.

(3) Data References

Bickerton, G., Chemical and mineralogical composition of the Lockport and Rochester Formations, Smithville, Ontario, NWRI Contribution No. 97-130, 1997.

Golder Associates Ltd., Matrix Diffusion Testing Eramosa Dolostone Samples, Golder Associates Ltd., 1996.

McMaster University, Department of Geography, Karst Investigations Deliverable 13: Isotopic patterns in CWML core #54, Project No. 96451/2/3 – MCM, 1997.

Zanini, L., K. S. Novakowski, and G. Bickerton, The radial diffusion method applied to dolostone core samples from the Lockport Formation, Smithville, Ontario: Phase II, NWRI Contribution No. 99-203, 1999.

3.1.21 SiteHistory

(1) Description

This table contains a chronological description of events regarding the CWML site from its beginnings in the early-1970's to the present day.

(2) Data Sources

Golder Associates Ltd., NWRI, OCWA, MOEE.

(3) Data References

Gartner Lee Ltd., Draft Discussion: hydrogeologic study - stage 1, Chemical Waste Management Ltd., Smithville, Ontario, 1986.

Golder Associates Ltd., Clean-up of abandoned PCB storage facility, Smithville, Ontario: Results of geological and hydrogeological investigations and contaminated plume delineation study, 1987, Ref. 871-1156, 1988.

Golder Associates Ltd., Report on: Hydrogeologic data compilation and assessment CWML site Smithville, Ontario, Project No. 94-106, 52pp., 1995.

Groundwater Remediation Project, Smithville Phase IV Program Site Characterization Field Activities January-March 1996, NWRI Internal Progress Report, 1996.

Groundwater Remediation Project, Results of Hydraulic Testing Program at Smithville Phase IV Site: Nov 1995-Dec 1996, NWRI, Report to Smithville Phase IV, 56pp., 1997.

Lapcevic, P. A., K. S. Novakowski, G. Bickerton, and J. Voralek, Preliminary results of the Fall 1995 drilling and hydraulic testing program at the Smithville Phase IV Bedrock Remediation Site, NWRI Contribution No.96-50, 36 pp., 1996.

Westbay Instruments Inc., Westbay® Completion Report for MP38 Monitoring Wells No. 53, 60, 61, 62 Smithville Site, Project No. WB761-96, 1996.

Voralek, J. W., Westbay® Completion Report for MP38 Monitoring Wells, No. 63 and 65, NWRI, 1997.

3.1.22 SurveyData

(1) Description

This table contains the elevation of the reference point for each of the monitors. The reference point is used to relate water level measurements, and other depth measurements that require correction to a geodetic datum. In most cases, this reference point is the top of the casing (TOC) above ground surface. It is not unusual for this reference point to change (e.g. casing broken off, shifting of ground surface, etc.). This table incorporates any changes to monitor reference points by noting the date range for which the survey is valid. In cases where the monitors have been re-surveyed (e.g. monitors instrumented in boreholes 11, 12, 21, and the OW-series), two sets of date ranges are included.

(2) Data Sources

NWRI, Golder Associates Ltd..

(3) Data References

Golder Associates Ltd., Hydrogeological Data Compilation and Assessment CWML Site, Smithville, Ontario, Golder Associates Ltd. Project No. 94-106, 1995.

3.1.23 WaterLevel & 3.1.24 WaterLevelDay

(1) Description

These tables contain over 10 years of water level measurements and calculated hydraulic heads for various monitors in and around the Smithville site. Groundwater or water pressure levels in the field have been measured on this project in a number of different ways: (1) water level measurements with measuring tapes; (2) in-situ pressure readings with the Westbay® system; and (3) water level measurements with submersible pressure transducers and data loggers. Standard water level meters are used to measure the distance from the surface to the groundwater level in standpipes or manometer type monitors (Figures 8, 9). The Westbay® system measures the water pressure in the monitoring zone through the measurement probe (Figure 14). The pressure difference between the inside of the casing (where the casing is completely filled with water) (P_{in}) and the outside in each zone (P_{out}), is then used to calculate hydraulic head (h) with the following equation (Figure 15):

$$h = TOC - (P_{in}-P_{out})*0.7032 \text{ (m/psi)}$$

where TOC is the elevation of the casing top in metres above sea level (masl).

In the third case, a pressure transducer is installed in a monitoring well, and the pressure above the transducer is measured at a given time interval and recorded electronically with a datalogger. The voltage signals from the datalogger are later converted to hydraulic head. The table "WaterLevel" contains all head data from the site including datalogger files. In some cases the electronic measurement of head was carried out at intervals of 10 minutes or less creating huge files. The table "WaterLevelDay" condenses the data by including a daily average for monitors in which there are more than one reading on any given day.

(2) Data Sources

OCWA, Phase IV, Golder Associates Ltd., NWRI, McMaster University, University of Utah.

(3) Data References

Golder Associates Ltd., Hydrogeological Data Compilation and Assessment CWML Site, Smithville, Ontario, Golder Associates Ltd. Project No. 94-106, 1995.

Lortie, S., Analysis of the Hydraulic Head Trends at Smithville, Ontario, University of Waterloo, Department of Earth Sciences, 1996.

Letter from Mr. R. Binek (OCWA) to Mr. D. Ketcheson (Phase IV) dated April 17, 1997 and March 27, 1997

3.2 Other Components

3.2.1 Core Photographs

From 1995 to the present, core samples from 11 boreholes installed as part of the Phase IV site characterization activities were photographed after retrieval from the borehole. Digitally processed and included in this package, these core photographs provide a visual record of the core, which can be accessed by the database, VIEWLOG®, or other software. The "Corephoto" table (see Section 3.1.7) provides a listing of the bitmap files (*.bmp) for 5 boreholes for which digital core photographs were processed for use with this data management system. Detailed instructions for processing core photographs are provided in Appendix B.

3.2.2 Maps

A variety of AutoCAD® (*.dwg), and VIEWLOG® (*.map) figures are available for use with the Smithville databases. The files are found in the "Map" sub-directory. The VIEWLOG® files were converted from the original AutoCAD® drawings from Golder Associates Ltd., and Jagger Hims and are UTM-referenced and fully layered. These files can be exported from VIEWLOG® back into "*.dxf" format, or used within VIEWLOG® and linked to the database to take full advantage of the VIEWLOG® features. Several of the original AutoCAD® files are also included, providing alternate site and sub-regional maps. Some of these maps use a site-specific co-ordinate system and cannot be linked to the database without a transformation.

3.2.3 Borehole Geophysics

As part of the Phase IV characterization activities, standard geophysical sondes were collected in 15 boreholes. In 1995, boreholes 34C, 37C, 53, 54A, 54B, 54C, and 55 were surveyed by Gartner Lee Ltd.. The boreholes were logged with 2-axis inclinometer, temperature, electromagnetic induction, natural gamma, and calliper tools. Boreholes 56, 57, 58, 59, 60, 61, and 62 were logged by Hyd-Eng Geophysics Inc. in July and August of 1996. In these boreholes, natural gamma, temperature, resistivity, and calliper logs were collected. In addition, a natural gamma log was completed in 54B. The data from these borehole geophysical logs are available for use with the databases. The logs are available in VIEWLOG® format, in 3 data sub-directories within the "Well Log" directory. The "NWRI Logs" directory contains the final VIEWLOG® files used to prepare the composite borehole logs presented in Appendix B of Novakowski et al.,

1999. They can be used at any time (with a database connection) to regenerate similar logs. The "VIEWLOG" directory contains working copies of the VIEWLOG® files that can be used to create custom well logs. These working copies may require scale and depth corrections. The "Raw" directory contains a self unzipping file of the raw geophysical logs outlined above recorded in the field and processed by the geophysical logging contractors in VIEWLOG® format. These files would require normal corrections. Details of the two geophysical logging programs can be found in Gartner Lee Ltd. (1996), and Hyd-Eng Geophysics Inc. (1997).

4.0 QA/QC PROGRAM

One of the final steps in preparing "Smv_data.mdb" was an error trapping process. The error trapping was designed to identify two types of error: (a) error resulting from the manipulation of the data from its original form (usually digital) into the database; and (b) potential errors in the original data leading to anomalous values. Because much of the data provided for incorporation into "Smv_data.mdb" was compiled by others, subtle errors that did not result in anomalous data points were impossible to identify. As a result, error trapping only addressed the relative accuracy of the data. Error trapping included the following steps:

- Filtering the data through queries
- Creating queries to display maximum and minimum values
- Creating cross-referencing queries
- Generating hydrographs
- Plotting chemistry parameter values

4.1 Scanned Data

A large portion of the historical chemistry data was only available in hard copy and was scanned by VIEWLOG® Systems in 1997. The scanned data was filtered through 27 queries to identify and flag anomalies in dates, monitor names, and decimal point locations. Flagged data was either corrected or deleted.

4.2 Max-Min Check

Database tables were queried to display maximum and minimum values for dates and values. Where raw data was available, the maximum and minimum values were compared to the raw data (particularly for data provided by NWRI) to ensure no errors developed during the process of merging the data into "Smv_data.mdb". A comparison of the number of records was also carried out to ensure records were neither accidentally lost nor created.

4.3 Cross-Reference

Cross-referencing queries were generated to ensure that measurements were within the borehole depth. For example, packer intervals cannot be below the base of the borehole.

4.4 Hydrographs

Temporal graphs of hydraulic head were printed for visual review. Anomalous data was noted, and if possible corrected.

4.5 Chemistry Data

To verify chemistry data, an interactive graphing engine to display chemical parameters by monitoring location on a time – concentration graph was prepared.

5.0 DATA ACCESS

This section describes the process for retrieving, and viewing data from "Smv_data.mdb".

5.1 Automation Tools

"Smv_menu.mdb" provides automation tools to search, display, print, and/or export hydrographs and time - concentration graphs from "Smv_data.mdb". Screen forms are also provided to display borehole and monitor construction details.

5.2 Graphing

"Smv_menu.mdb" has been prepared with utilities to rapidly generate hydrographs and time-concentration graphs, as well as enable browsing of the borehole/monitor construction data. The utilities are available through the main toolbar of this database, and offer the following menu bar choices:

- View data
- Manage samples
- Enter data
- About
- Window

(1) File

The "File" menu contains standard "Windows" features.

(2) View data

The "View data" menu offers a choice of:

- Water level graphs
  - By monitor
  - By borehole
  - By geological unit
- Time - concentration graphs
- Borehole Data

The geological unit hydrograph makes use of an internal query that assigns each monitoring interval to the appropriate stratigraphic unit by locating the stratigraphic unit that hosts the majority of the monitoring interval. Depending on the permeability contrast between the adjacent stratigraphic units, this approach may not be hydrogeologically valid.

When using the time - concentration graph, a data calibration point will appear on the graph. This is an arbitrary data point, assigned to the date of January 1, 1990, with a value of 1, for all compounds.

(4) Enter Data

This menu is used to enter new data or correct existing data related to the construction of boreholes and monitors.

(5) About

This menu provides a brief description of the database and its inherent limitations.

(6) Window

The "Window" menu contains standard "windows" features. Listed below, for example, are the steps required to generate a hydrograph in "Smv_menu.mdb":

- Open by double clicking on "Smv_menu.mdb"
- Select "View data" from the main tool bar
- Select "Water level"
- Select "Water level vs. time (by borehole)"
- A graph will appear defaulting to BH11
- Select the borehole drop down box, and select the required borehole
- Click on the graph to activate the re-graphing process
- Print the graph by selecting "Print"
- Export data by selecting "Export"

5.3 VIEWLOG®

The capabilities of the data management system are enhanced by VIEWLOG®, a separate software product used to present the data as maps, cross-sections, borehole logs, and to complete detailed analyses using interactive "picking" tools, and "krigging". The VIEWLOG® software retrieves data from queries developed by the user and stored in "Smv_user.mdb" (Figure 1). An example of a borehole geophysical log created using VIEWLOG® and "Smv_data.mdb" can be found in Appendix B of Novakowski et al. (1999). VIEWLOG® is not provided with this package, but can be obtained from VIEWLOG® Systems.

6.0 SUMMARY

This report is intended as a manual and reference guide for users wishing to familiarize themselves with the Smithville data management system. It provides details on the structure and content of the data management system, a description of each database table, and a short summary of the 3 other components included. Sources of the data, and data references are included for referral and consultation. To resolve any ambiguities associated with the abbreviation of field names and data entries, a detailed description of each field within "Smv_data.mdb" is included, as well as definitions of nomenclature employed. Documentation on data loading, accessing, retrieving, and manipulating are intended to facilitate the use of the system. Further details on data interpretation can be obtained from referenced reports.

7.0 ACKNOWLEDGEMENTS

This project was funded by the Ontario Provincial Government through the auspices of the Smithville Phase IV Bedrock Remediation Program. Funding management, technical assistance, and kind advice were provided by Ted O'Neill, and Gregg Zwiers of the Phase IV team. The detailed site characterization study of the carbonate dolostone, carried out by NWRI, which generated a large portion of field and laboratory data included in this database system was led and directed by Kent Novakowski currently at Brock University. John Voralek, Greg Bickerton, Lavinia Zanini, and Charles Talbot of NWRI, Amy Sheldon and Kip Solomon of the University of Utah, and Steve Worthington of McMaster University assisted by providing compiled, yet often unpublished data for inclusion in the database. Software assistance, and technical support were provided by Dirk Kassenaar, of VIEWLOG® Systems. Bryan

Smith of the Ontario Climate Center, and Ian D. Smith of the Regional Municipality of Niagara provided climate data. Additional data was obtained from OCWA, MOE, Gartner Lee Ltd., Golder Associates Ltd., Hyd-Eng Inc., and Terraqua Investigations Ltd..

8.0 REFERENCES

Bickerton, G., Chemical and mineralogical composition of the Lockport and Rochester Formations, Smithville, Ontario, NWRI Contribution No. 97-130, 1997.

Black, W. H., H. R. Smith, and F. D. Patton, Multiple-level groundwater monitoring with the MP system, In: Proceedings NWWA-AGU Conf. Surface and Borehole Geophysical Methods and Groundwater Instrumentation, NWWA, Dublin, Ohio, 1987.

Blair, R., and S. McFarland, Regional correlation of the Middle and Lower Niagara Escarpment Area, proceedings of the 1992 Conference of the Canadian National Chapter, International Association of Hydrogeologists, Hamilton Ontario, 659-696, 1992.

Brett, C. E., D. H. Tepper, W. M. Goodman, S. T. LoDuca, and B. H. Eckert, Revised Stratigraphy and Correlations of the Niagaran Provincial Series (Medina, Clinton and Lockport Groups) in the Type Area of Western New York, U.S. Geological Survey Bulletin 2086, U.S. Government Printing Office, Washington, D.C., 66pp., 1995.

Brown A., P. Lapcevic, K. Novakowski, S. Lesage, S. Brown, K. Millar, J. Voralek, and L. Zanini, Characterization of Trichloroethylene Contamination in the fractured bedrock at the Smithville, Ontario Site, NWRI Contribution No. 97-140, 1997.

Core Laboratories Canada Ltd., Advanced Rock Properties Study: Borehole 56, Smithville Site, Report to NWRI, No 52132-97-1116, 32pp., 1998.

Gartner Lee Ltd. and Acres International Ltd., Regional geologic model: Smithville Bedrock Remediation Program, Gartner Lee Ltd. and Acres International Ltd., Project No. 95-160, 75pp., 1996.

Gartner Lee Ltd., Geophysical Report for Project 95-426 Borehole Geophysics-Geology, 1996.

Gartner Lee Ltd., Draft Discussion: hydrogeologic study - stage 1, Chemical Waste Management Ltd., Smithville, Ontario, 1986.

Golder Associates Ltd., Clean-up of abandoned PCB storage facility, Smithville, Ontario: Results of geological and hydrogeological investigations and contaminated plume delineation study, 1987, Ref. 871-1156, 1988.

Golder Associates Ltd., Clean-up of abandoned PCB storage facility, Smithville, Ontario: Results of geological and hydrogeological investigations and contaminated plume delineation study, 1988 and 1989, 1989.

Golder Associates Ltd., Matrix Diffusion Testing Eramosa Dolostone Samples, Golder Associates Ltd., 1996.

Golder Associates Ltd., Preliminary results of geological and hydrogeological investigations and contaminated plume delineation study: CWML abandoned PCB storage facility, Smithville, Ontario, 1987.

Golder Associates Ltd., Report on: Hydrogeologic data compilation and assessment CWML site Smithville, Ontario, Project No. 94-106, 52pp., 1995.

Golder Associates Ltd., Summary of Packer Test Results, 1998 (internal Phase IV file from Golder Associates Ltd.; no specific report reference available).

Groundwater Remediation Project, Results of Hydraulic Testing Program at Smithville Phase IV Site: Nov 1995-Dec 1996, NWRI, Report to Smithville Phase IV, 56pp., 1997.

Groundwater Remediation Project, Smithville Phase IV Program Site Characterization Field Activities January-March 1996, NWRI Internal Progress Report, 1996.

Hyd-Eng Geophysics Inc., 1996 Geophysical Borehole Surveys at the Smithville Phase IV Site Smithville, Ontario, Project I10 for Environment Canada, 1997.

K. Solomon, and A. Sheldon, University of Utah, personal communication.

Lapcevic, P. A., K. S. Novakowski, and E. A. Sudicky, Groundwater flow and solute transport in fractured media, In: Groundwater Engineering, Ed: J. Delleur, CRC Press, 17-1-17-39, 1998.

Lapcevic, P. A., K. S. Novakowski, G. Bickerton, and J. Voralek, Preliminary results of the Fall 1995 drilling and hydraulic testing program at the Smithville Phase IV Bedrock Remediation Site, NWRI Contribution No.96-50, 36 pp., 1996.

Letter from Mr. R. Binek (OCWA) to Mr. D. Ketcheson (Phase IV) dated April 17, 1997 and March 27, 1997

Lortie, S., Analysis of the Hydraulic Head Trends at Smithville, Ontario, University of Waterloo, Department of Earth Sciences, 1996.

McMaster University, Department of Geography, Karst Investigations Deliverable 13: Isotopic patterns in CWML core #54, Project No. 96451/2/3 – MCM, 1997.

Ministry of the Environment, PCB concentrations in soil and grass samples, in the vicinity of Chemical Waste Management, Smithville – 1985, 1986.

Novakowski, K. S., Comparison of fracture aperture widths determined from hydraulic measurements and tracer experiments, In Proc: 4th Canadian/American Conference on Hydrogeology, Ed: B. Hitchon and S. Bachu, Nat. Water Well Assoc., Dublin, Ohio, 68-80, 1988.

Novakowski, K., P. Lapcevic, G. Bickerton, J. Voralek, L. Zanini and C. Talbot, The development of conceptual model for contaminant transport in the dolostone underlying Smithville, Ontario, National Water Research Institute, Burlington, Ontario, Canada, 245pp., 1999.

O'Neil, P., Database - Principles, Programming, Performance, San Francisco, USA: Morgan Kaufmann Publishers, Inc., 873pp., 1994.

Pentney, A., and B. Blackport, Rock St. closed landfill site, Smithville, Ontario, Terraqua Investigations Ltd., Ref. No. TA463, 1994.

Radcliffe, A., Determination of Groundwater Velocities in Discrete Fractures using Point Dilution Methods, University of Waterloo, B. Sc. Thesis, Department of Earth Sciences (Thesis), 1997.

Smithville Phase IV Program, A critical Review of the Monitoring Program at the Former CWML site in Smithville, Ontario, Internal Report, 80 pp., 1996.

Uhlman, W., J. Voralek, and P. Lapcevic, The Use of Point-Dilution Techniques for Determining Groundwater Velocity in Fractured Bedrock, Smithville, Ontario, NWRI Contribution No. 99-202, 29pp., 1999.

Voralek, J. W., Westbay® Completion Report for MP38 Monitoring Wells, No. 63 and 65, NWRI, 1997.

Voralek, J. W., Westbay® Completion Report for MP38 Monitoring Wells, No. 34C, 37C, 64, 66, and 67, NWRI Internal Report, 1999.

Westbay Instruments Inc., Westbay® Completion Report for MP38 Monitoring Wells No. 53, 60, 61, 62 Smithville Site, Project No. WB761-96, 1996.

Worthington S.R.H. and D.C. Ford, Chemical Hydrogeology of the Carbonate Bedrock at Smithville, McMaster University, Report to Smithville Phase IV, 169pp.,1999.

Zanini, L., K. Novakowski, and G. Bickerton, The radial diffusion method applied to dolostone core samples from the Lockport Formation, Smithville, Ontario: Phase II, NWRI Contribution No. 99-203, 1999.

Zanini, L., K. Novakowski, and P. Lapcevic, Inorganic Geochemistry of the Groundwater at the Smithville Site: Phase I Investigation, NWRI Contribution No. 97-123, 39 pp., 1997.

Zanini, L., K. Novakowski, P. Lapcevic, G. Bickerton, J. Voralek, and C. Talbot, Regional groundwater flow in the fractured carbonate aquifer underlying Smithville, Ontario, inferred from combined hydrogeological and geochemical measurements, J. Groundwater, 1998 (In press).

Zanini, L., K. Novakowski, P. Lapcevic, G. Bickerton, J. Voralek, and C. Talbot, Inorganic Geochemistry of the Groundwater at the CWML Site, Smithville, Ontario: Phase II and III Investigation, 1997, NWRI Contribution No. 98-243, 45 pp., 1998.

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Email: Pat.Lapcevic@cciw.ca

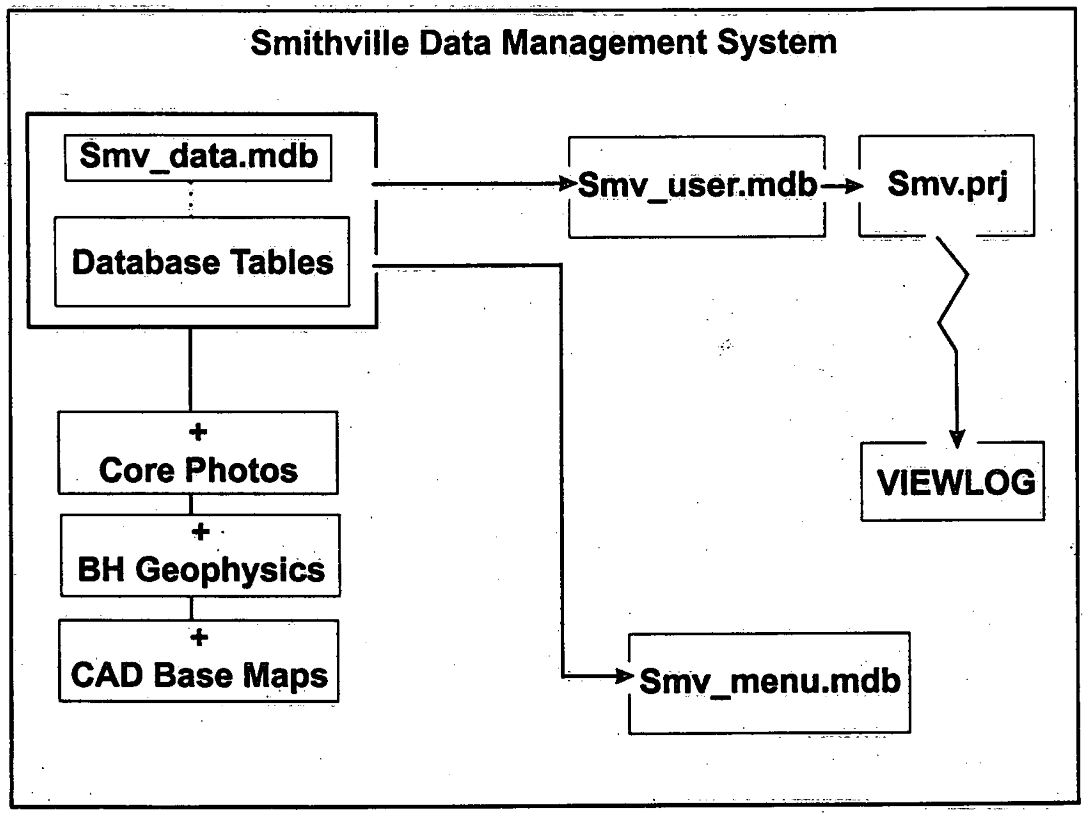

Figure 1. Schematic diagram illustrating the different components of the data management system.

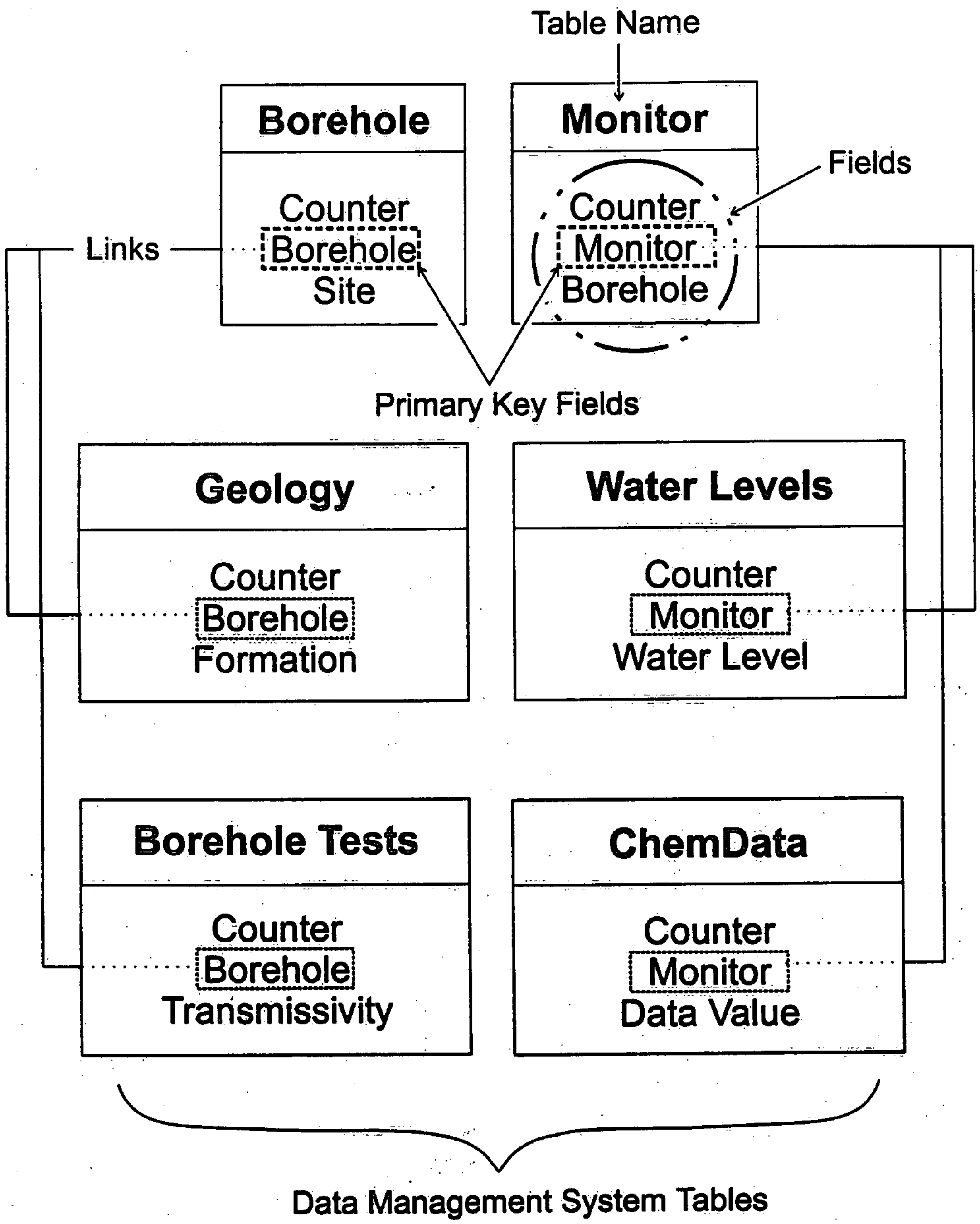

Figure 2. Schematic diagram illustrating the links between the "Smv_data.mdb" database tables.

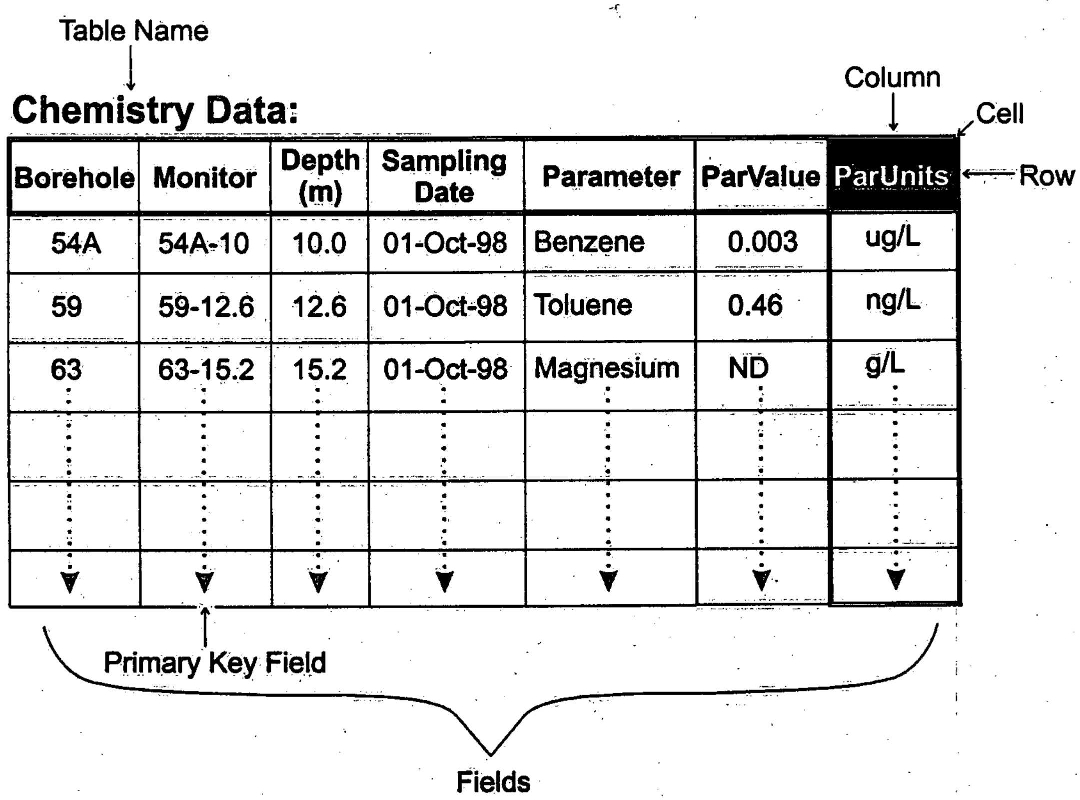

Figure 3. Schematic diagram illustrating the orthogonal format of an "Smv_data.mdb" database table.

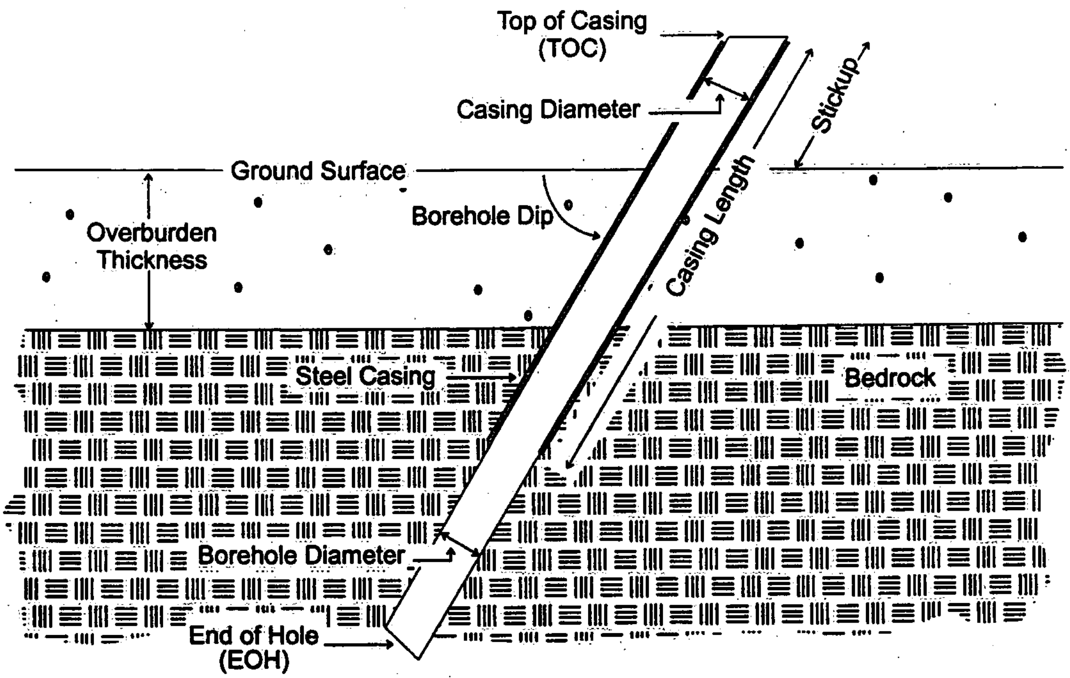

Figure 4. Schematic diagram of an inclined borehole installation.

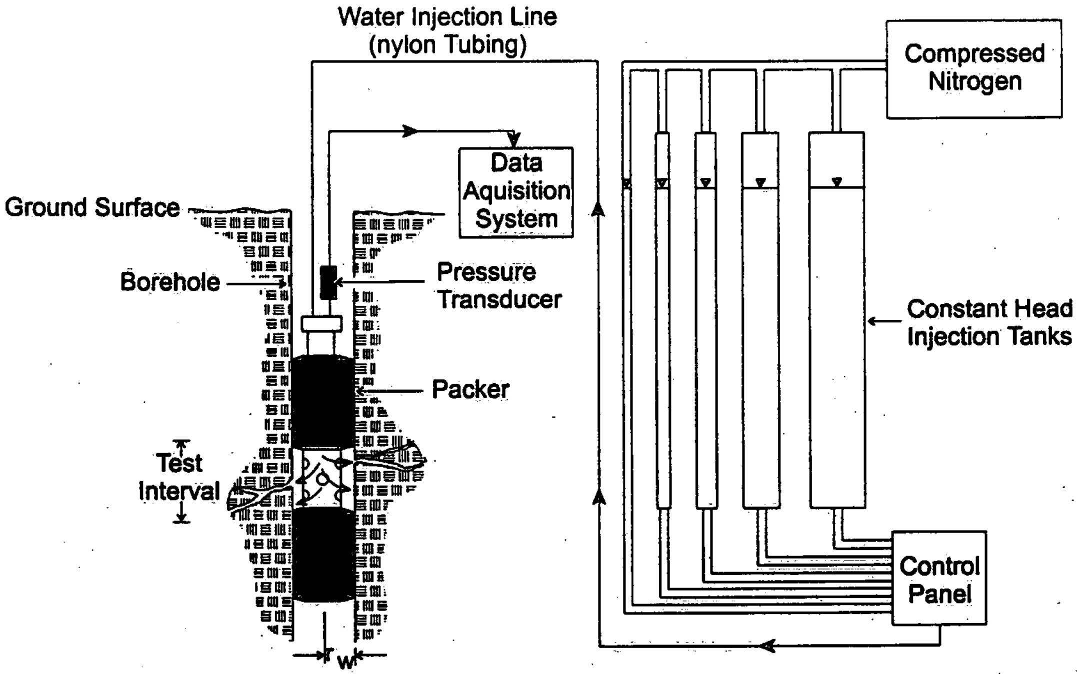

Figure 5. Schematic diagram of a typical constant-head injection testing (CHIT) system.

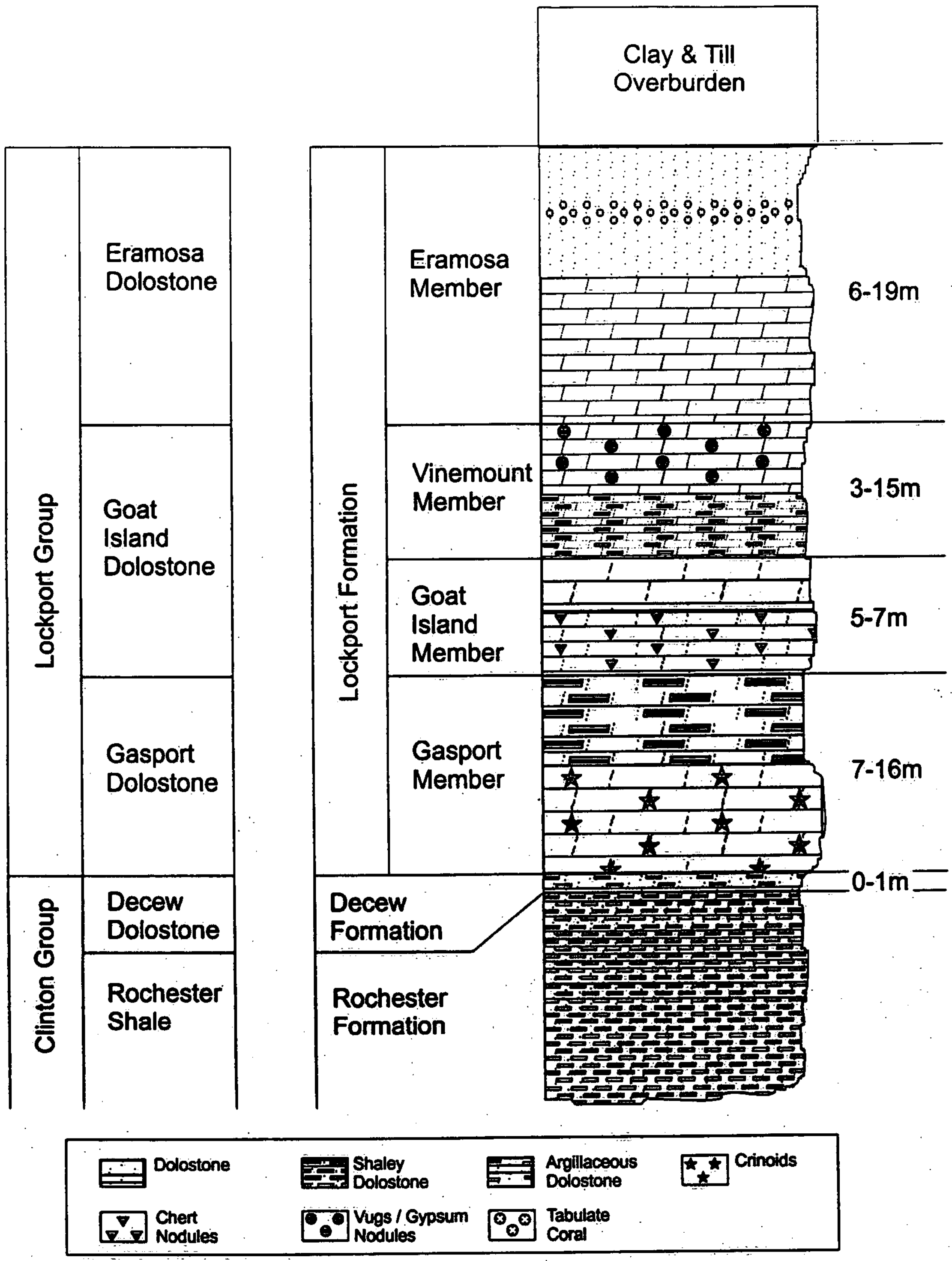

Figure 6. Stratigraphic column of the Lockport Dolostone Formation.

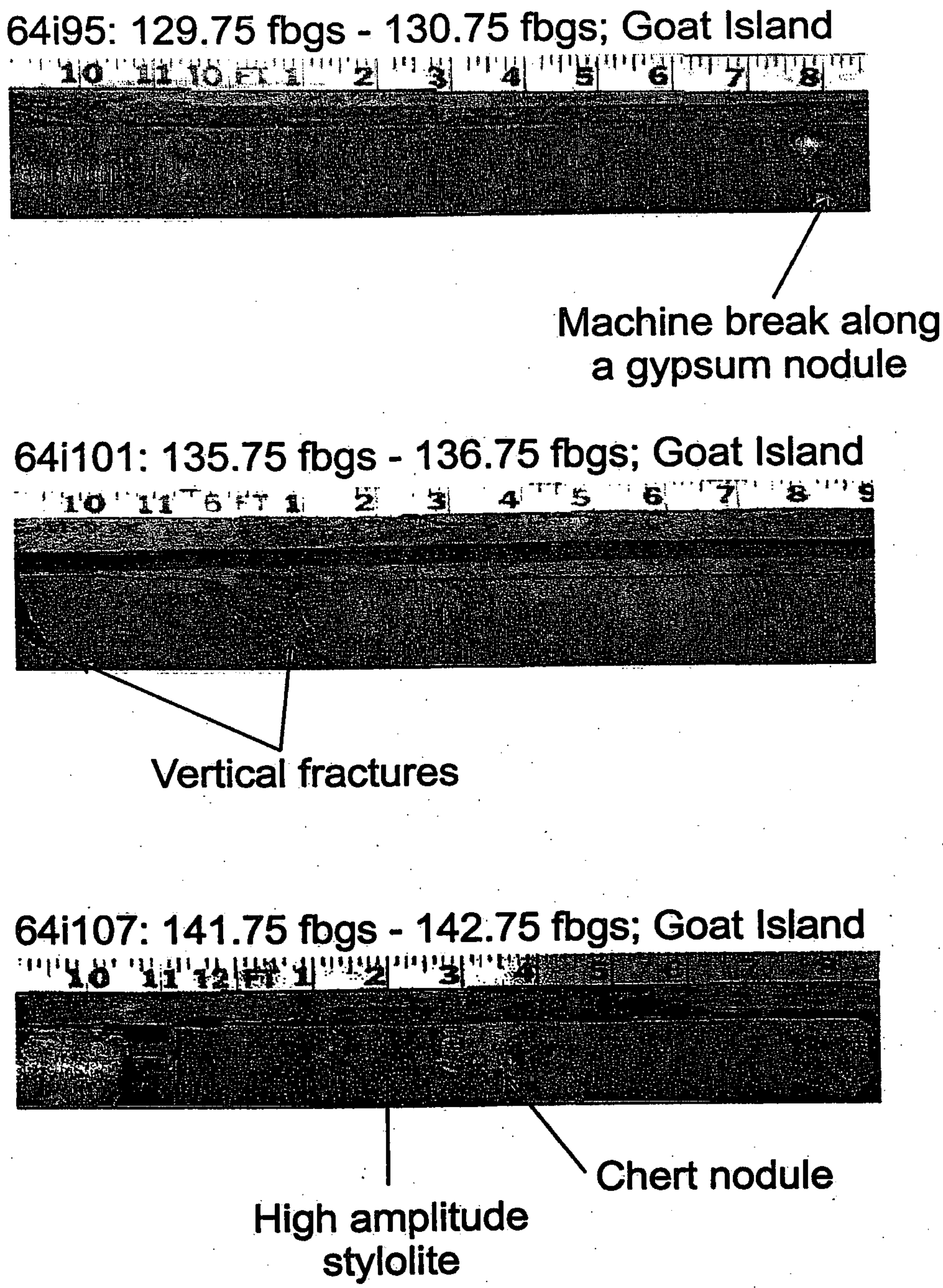

Figure 7. Examples of some features identified in rock core.

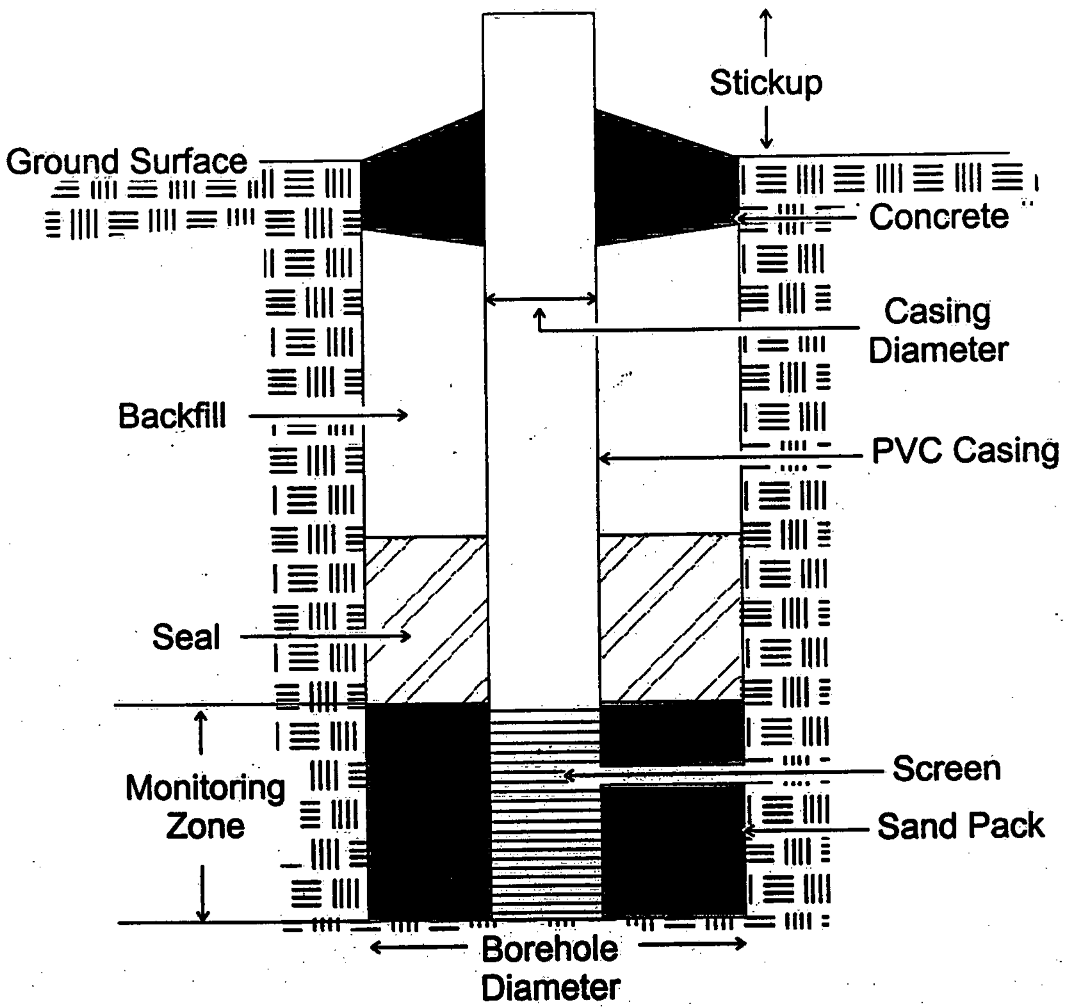

Figure 8. Schematic diagram of a conventional standpipe piezometer.

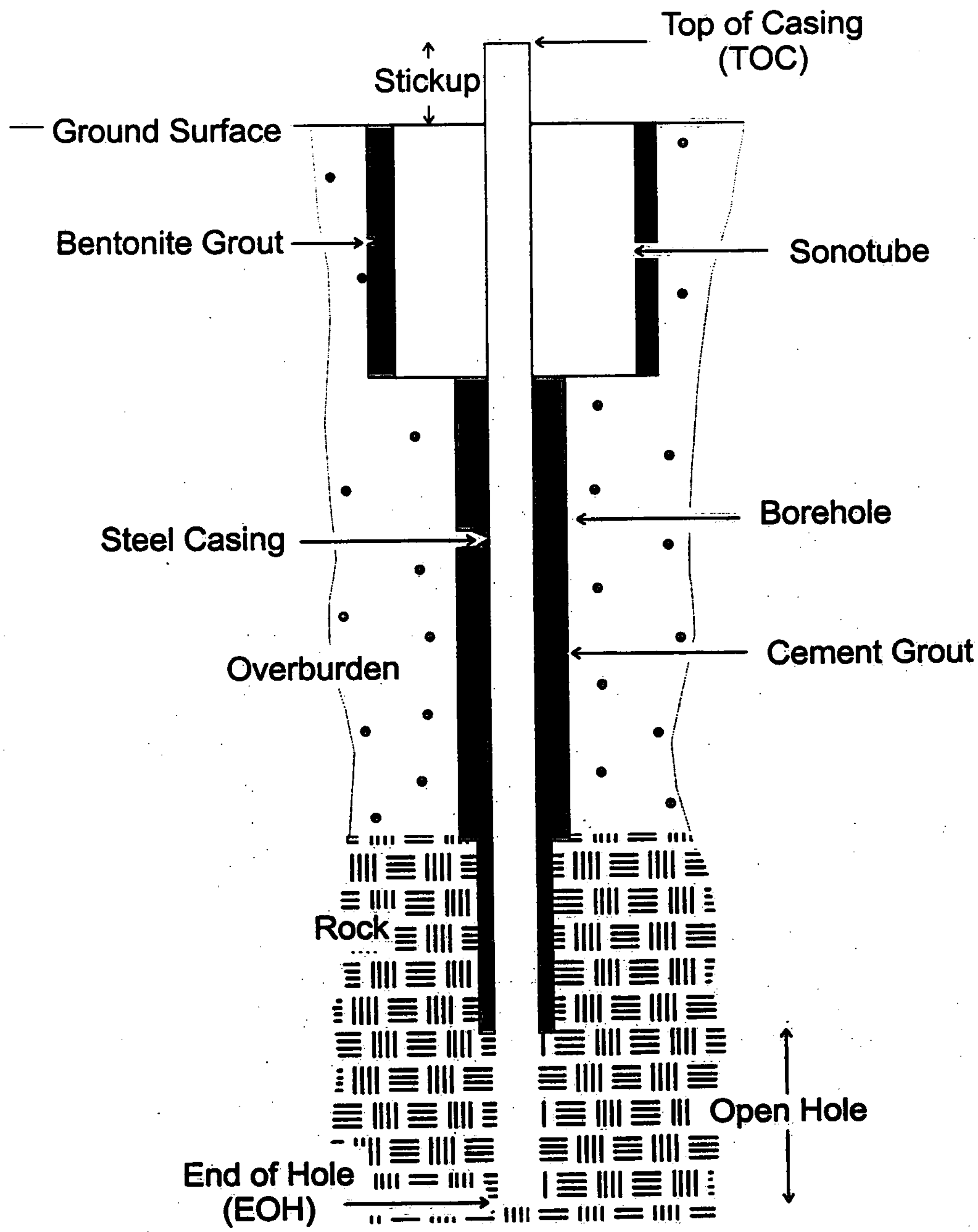

Figure 9. Schematic illustration of an open hole monitor.

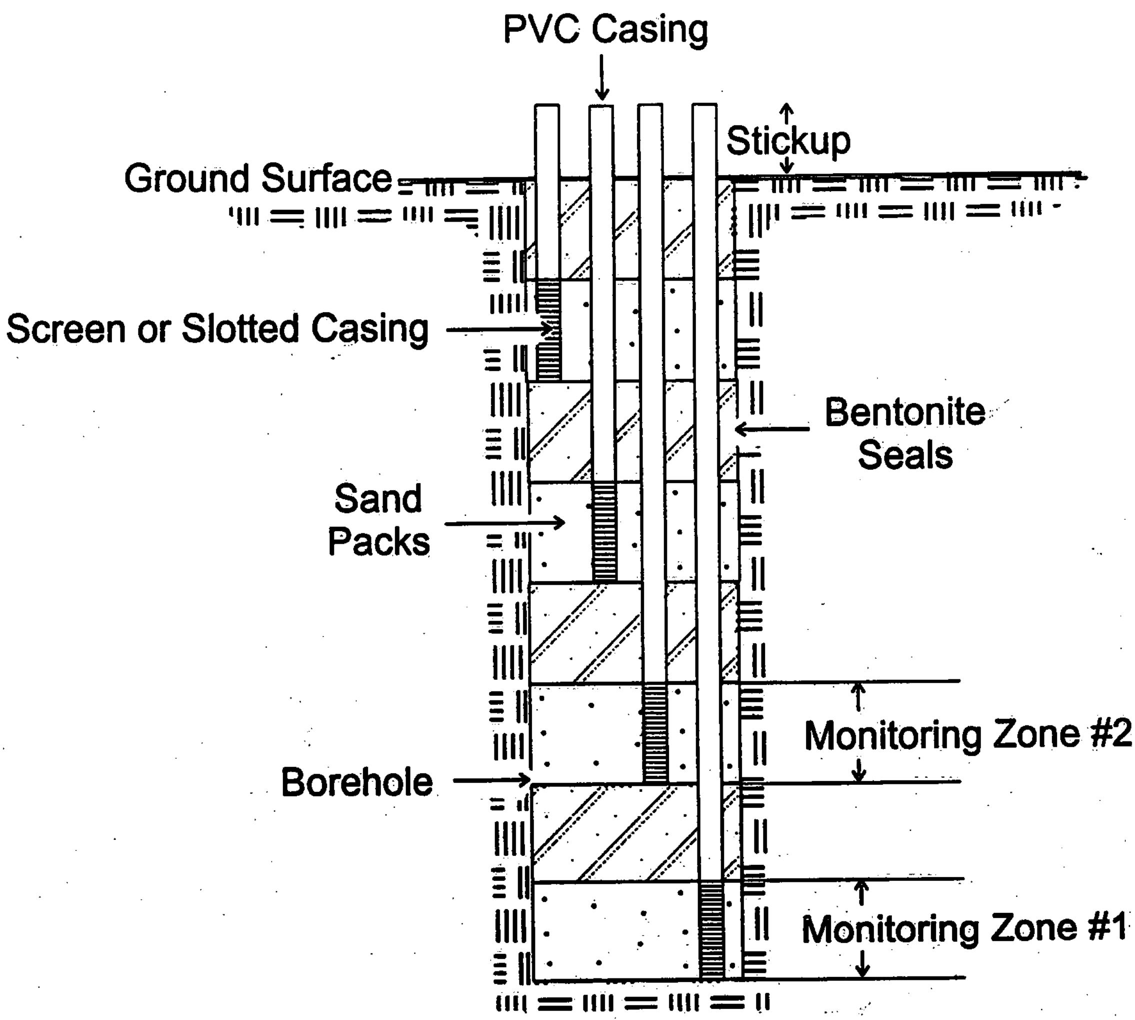

Figure 10. Multilevel monitoring zones installed in a single borehole with individual seals between each monitoring level.

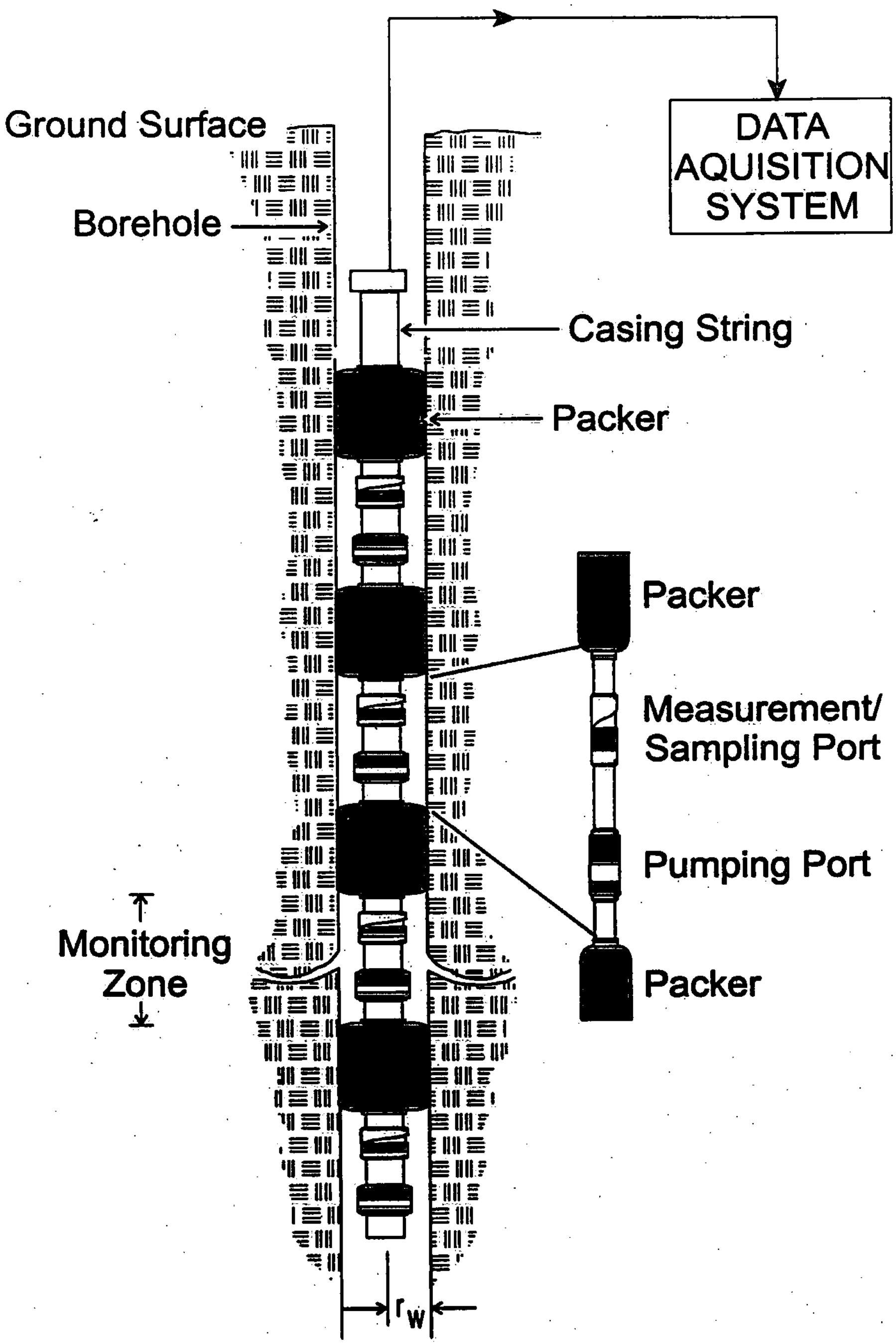

Figure 11. Schematic diagram of Westbay® instrumentation downhole.

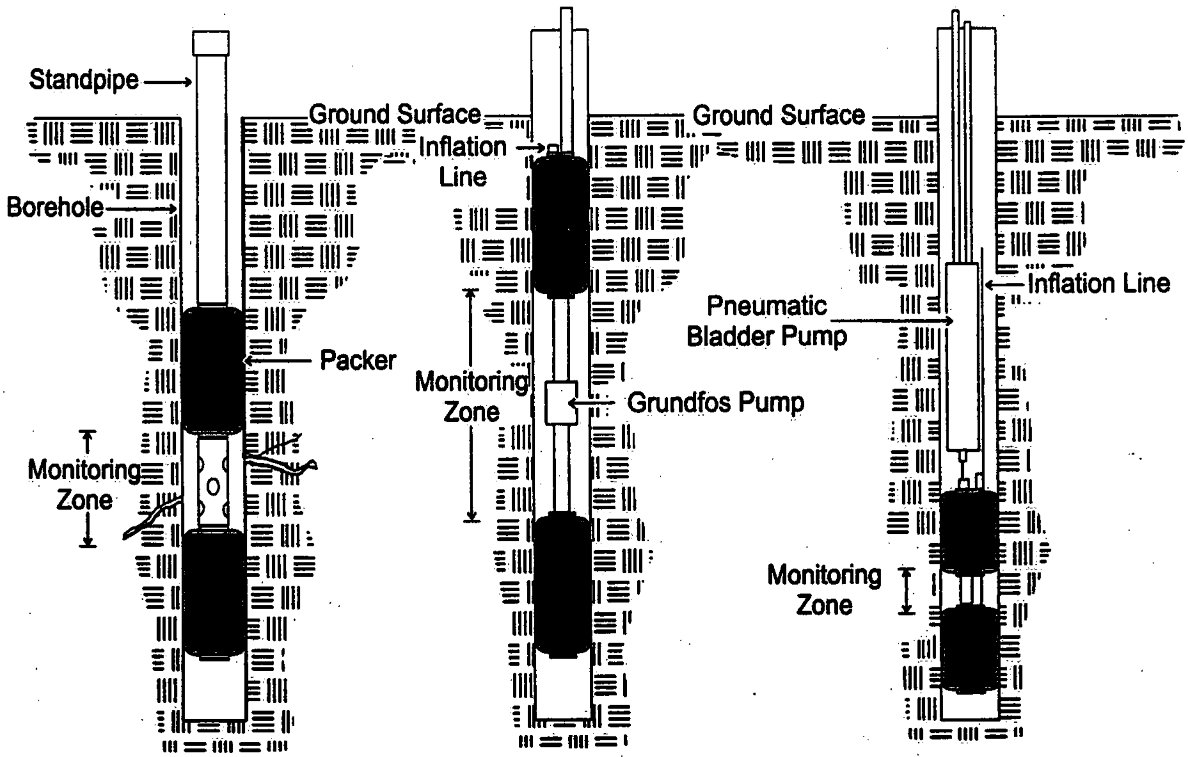

Figure 12. Temporary monitors set up in an open borehole using packers: (a) standpipe packer system; (b) submersible pump system; (c) double packer sampler.

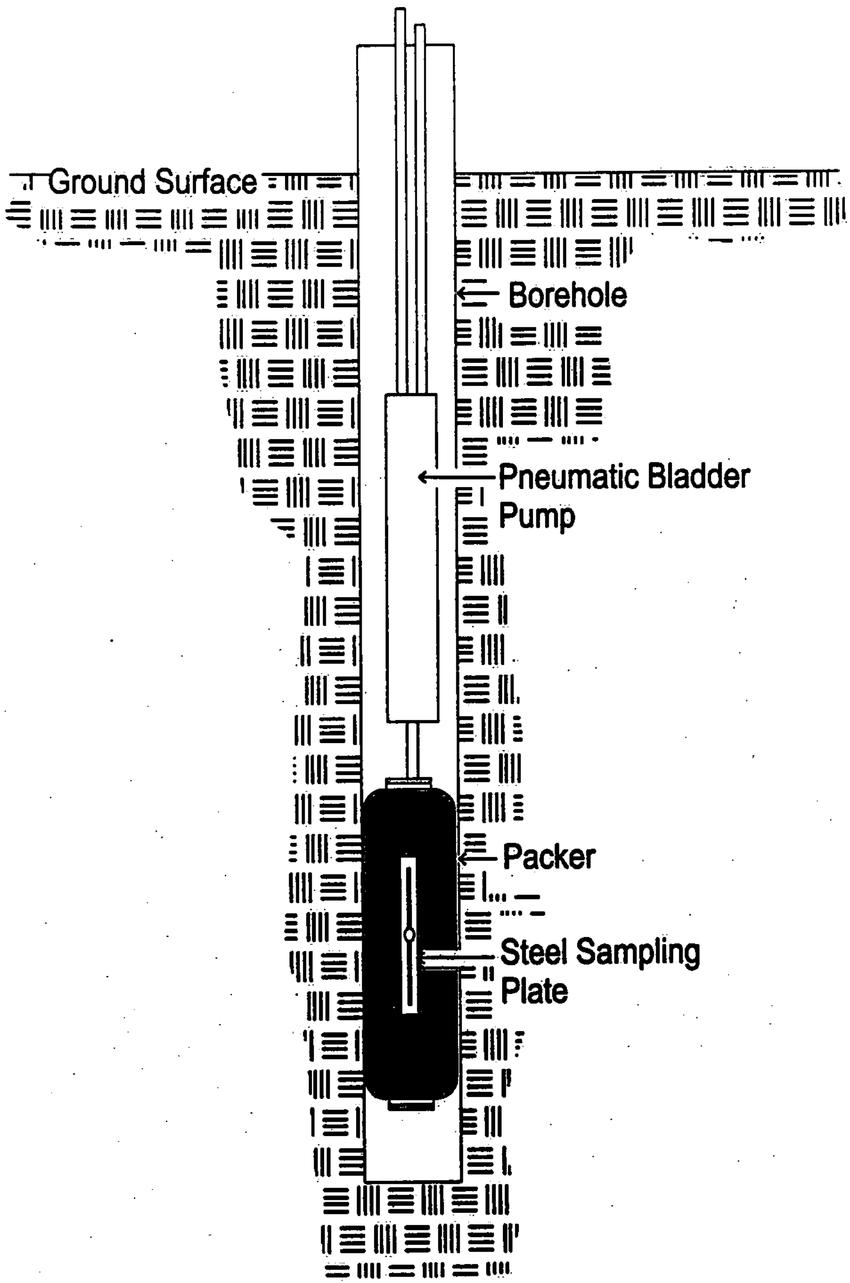

Figure 13. Schematic illustration of a single sampling packer system downhole.

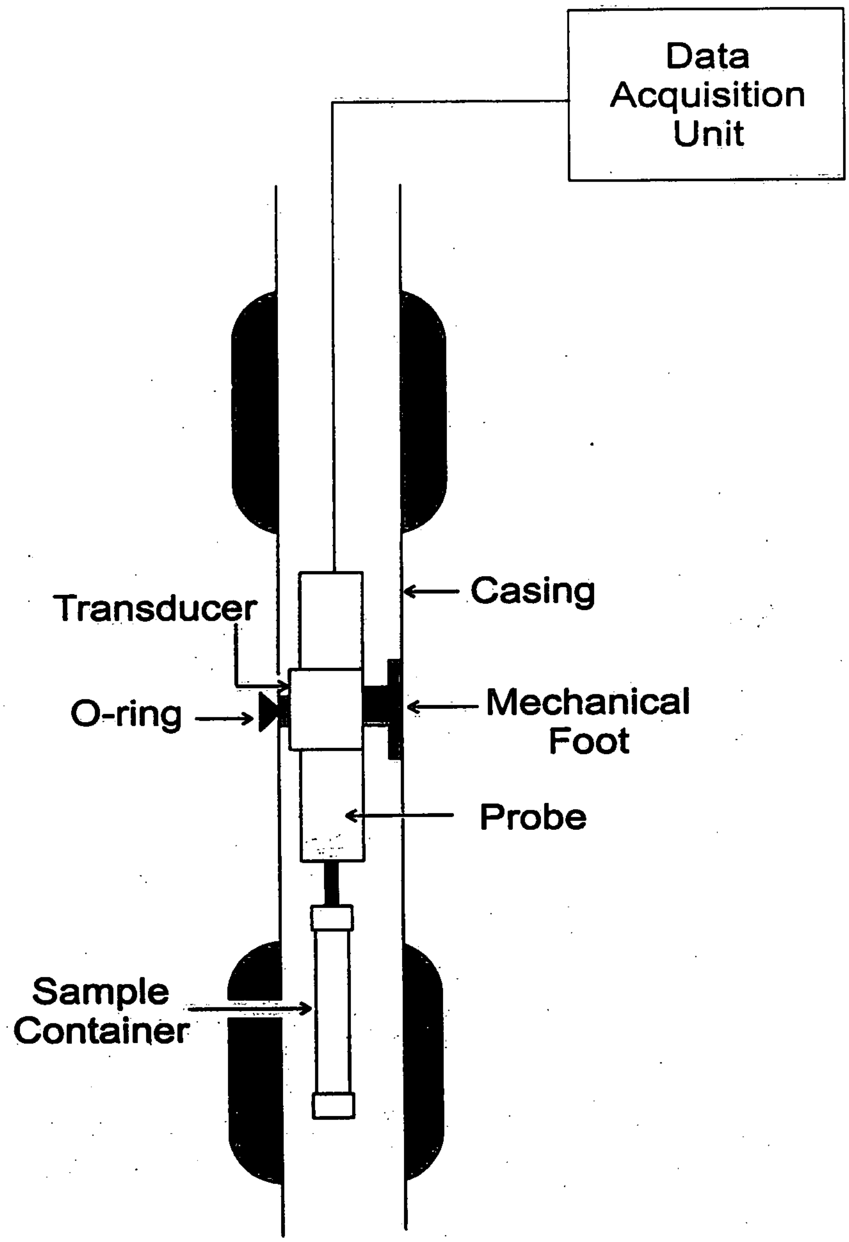

Figure 14. Schematic illustration of the Westbay® measurement probe. The probe is positioned on a measurement port and activated from the surface to obtain access to the zone outside the casing.

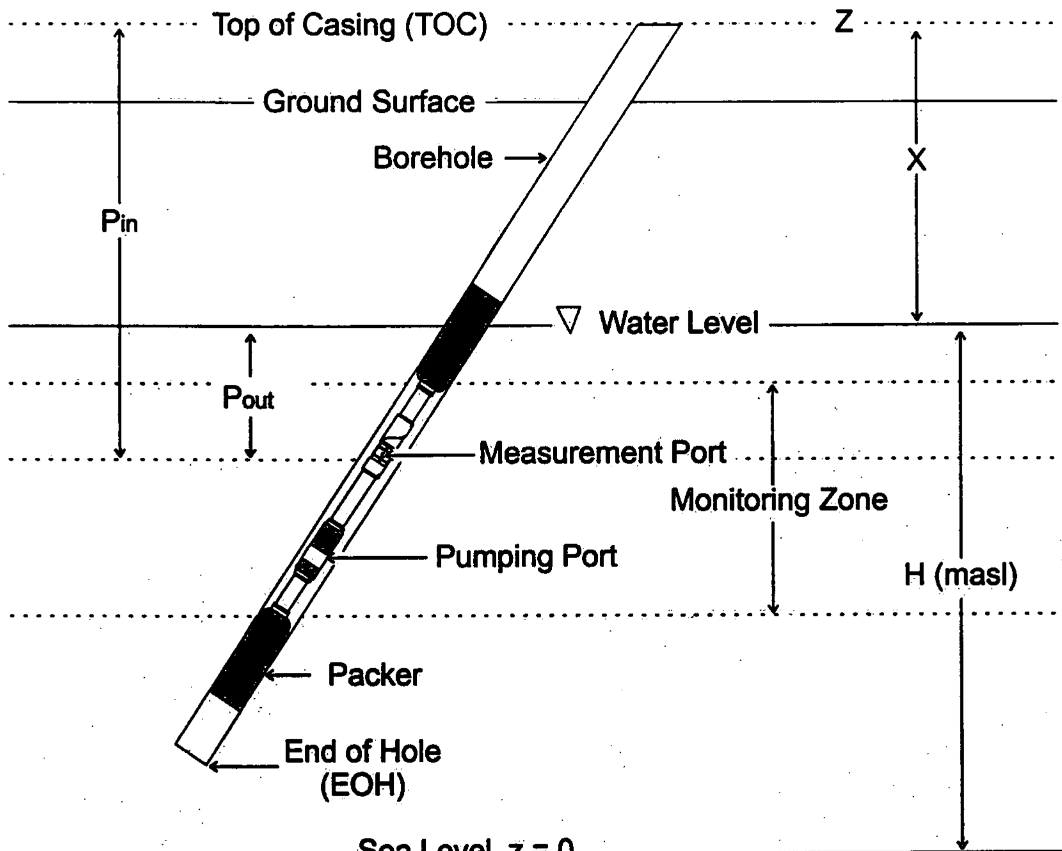

Figure 15. Schematic diagram of an inclined borehole with Westbay® instrumentation illustrating P_{in} and P_{out} measurements.

Table 1. List of all tables included in "Smv_data.mdb".

Table No.	Table Name	Time Span of Data	No. of Records[1]
1	Borehole	1969 – 1998	172
2	BoreholeTests	1987 – 1998	1,567
3	ChemData	1987 – 1998	152,662
4	ChemData QA samples	1996 – 1998	1,667
5	ChemParameters	NA[2]	94
6	Climate	1994 – 1998	40,142
7	Corephoto	NA	717
8	DNAPL properties	NA	18
9	Fracture	NA	2,478
10	GeolMajor	NA	529
11	GeolMinor	NA	10,951
12	LabCodes	NA	46
13	Mass Recovered	NA	91
14	Monitor	1986 – 1998	289
15	OtherChem	1985 – 1997	198
16	OtherMonitors	NA	102
17	ParameterFormula	NA	32
18	References	NA	499
19	RockProperty	1995 – 1998	2,544
20	SampleDetails	NA	904
21	SiteHistory	1966 – 1998	166
22	SurveyData	1986 – present	331
23	WaterLevel	1987 – 1999	301,767
24	WaterLevelDay	1987 – 1999	16,393

[1] The number of records is included as a guide only and is subject to change as data is added or removed from "Smv_data.mdb".
[2] Not applicable

Table 2. Chemical parameters.

Parameter
1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethene
1,2,3,4-Tetrachlorobenzene
1,2,3,5-Tetrachlorobenzene
1,2,3-Trichlorobenzene
1,2,4,5-Tetrachlorobenzene
1,2,4-Trichlorobenzene
1,2-dibromoethane
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloropropane
1,3,5-Trichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
18-O
2,3,6-Trichlorotoluene
2,4,5-Trichlorotoluene
2,6,a-Trichlorotoluene
2,6-dichlorobenzyl chloride
Alkalinity (as CaCO3)
Aluminum
Ammonia (Nitrogen)
Barium
Benzene
Berylium
Boron
Bromodichloromethane
Bromoform
Cadmium
Calcium
Carbon Tetrachloride
Chloride
Chlorobenzene
Chlorodibromomethane
Chloroethene
Chloroform

Chromium
Cis-1,2-dichloroethene
Cobalt
Conductivity
Copper
Deuterium
Dibromochloromethane
Dichlorobromomethane
Dichloromethane
Dissolved Organic Carbon
Dissolved Oxygen
Eh
Ethylbenzene
Ethylene Dibromide
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Hydrogen Sulfide
Iron
Lead
Lithium
M&p-Xylene
m-Xylene
Magnesium
Manganese
Methylene Chloride
Molybdenum
Nickel
Nitrate
o-Xylene
Octachlorostyrene
p-Xylene
PCB
Pentachlorobenzene
PH
Potassium
Silica
Sodium
Strontium

Styrene
Sulphate
Sulphide
Temperature
Tetrachloroethene
Toluene
Total Trihalomethanes
Trans-1,2-Dichloroethene
Trichlorobenzene
Trichloroethene
Trifluorochlorotoluene
Tritium
Vanadium
Vinyl chloride
Zinc
Calibration point

Table 3. Chemistry qualifier codes.

Code	Definition
!AI	Additional information available from laboratory
!AR	See attached report: no numeric result
!CS	No data: contamination suspected
!EF	No data: laboratory equipment failure
!IC	No data: improper container
!IL	No data: sample incorrectly labeled
!IM	Internal laboratory memo - for lab use only
!IV	No data: invalid sample
!LA	No data: sample spoiled in laboratory accident
!NN	No data: tests requested in lis error
!NP	No data: no appropriate procedure available
!NR	No data: sample not received at laboratory
!QU	No data: quality controls unacceptable
!RO	See attached report (no numeric result) otcs
!SM	No data: sample missing (lost in lab?)
!U	No data: unsuitable for analysis
<	Actual result is less than the reported value
<T	A measurable trace amount: interpret with caution
<TE	A measurable trace after extra diln/conc: caution
<W	No measurable response (zero): <reported value
<WE	No measurable response (diln/conc): <rep'd value
>	Actual result greater than the reported value
A>	Approx. Result: exceeded normal range limit
AIP	Analysis in progress
APL	Additional peak, large, not priority pollutant
APS	Additional peak, small, not priority pollutant
ARO	See attached report - organic trace contamination section
LCS	Laboratory control sample (method spike)
LPI	Labels probably interchanged
ND	Not detected at reporting limit
NS	Not spiked
NSS	No suitable sample
P40	Resembled mixture of aroclor 1254 and 1260
P42	PCB resembled aroclor 1242
P60	PCB resembled aroclor 1260
PS2	PCB resembled mixture of aroclor 1242, 1254, 1260
RL	Reporting limit
RMP	P&M xylene not separated

SPL	Several peaks, large, not priority pollutants
SPS	Several peaks, small, not priority pollutants
UCR	Data unreliable: could not confirm by reanalysis
UCS	Unreliable: contamination suspected
UIN	Unreliable: indeterminate interference
X1	Diluted by 10 detection limits 10 times normal
X2	Diluted by 100 detection limits 100 times normal
X3	Diluted by 1000 detection limits 1000 times normal

Table 4. Geology nomenclature.

Legend	Description
ARG	Argillaceous
BC	Broken core- possibly open
BC/MB	Broken core – mechanically broken
BC->	Frequent broken core
BP	Bedding plane
BPF	Bedding plane fractures (open or closed)
BPF/MB	Bedding plane fractures possibly associated with drilling
BPZ	Bedding plane fracture zone
C	Nodule
CA	Calcareous band, bed, or infill
CAL	Calcite infilling
CB	Coral bed
CH	Chert feature
CHZ	Chert zone
CLAY	Clay
CONTACT	Point of lithological change
CORAL	Fossil/coral zone
CRN	Crinoid(s)
EOH	End of hole
EOR	End of run
F	Feature(s)
FC	Fractured core
FOSSIL	Fossil related feature
FRACTURE	Fracture
FZ	Fracture zone
GA	Galena mineralization
GAL	Galena
GYP	Gypsum feature
GZ	Gypsum zone
LC	Lost core
MIN	Mineralization
NO COMMENT	No Comment
NOTE	Brief comment
POF	Partially open feature
PPM	Parts per million
PYR	Pyrite
PZ	Porous zone
SHALE	Shale
SPH	Sphalerite
STY	Stylolite
STYZ	Zone of more than one Stylolite
SZ	Sample zone
TOR	Top of run
TZ	Transitional zone (related to lithological contact?)
VF	Vertical fracture (degrees, rotation)
VJ	Vertical joint
VMB	Vertical machine break
VUG	Vug(s)
VUGGY	Vuggy feature
VZ	Vuggy zone

Appendix A

Table A1

Table Name:	**Borehole**		
Field	**Type**	**Description**	**Size**
BHCounter	AutoNumber (Long integer)	Borehole counter	
Borehole	Text	Number or name of borehole	255
BHCounterNWRI	Number (Double)	NWRI borehole counter	8
Site	Text	Project site	255
Area	Text	Sub-region of site	255
GndElev	Number (Double)	Ground elevation of borehole	8
DrillBy	Text	Drillers of borehole	255
DrillType	Text	Drilling method	255
DrillDateSt	Date/Time	Start date of drilling	
DrillDateEd	Date/Time	End date of drilling	
Tddepth	Number (Double)	Depth to base of hole	8
DepthUnit	Text	Units of depth	255
Tdelev	Number (Double)	Elevation of base of hole	8
Bhdia	Number (Double)	Borehole diameter	8
BedrockContactDepth	Number (Double)	Depth to bedrock	8
BedrockContactElev	Number (Double)	Elevation of bedrock contact	8
BRUnits	Text	Units of bedrock contact	255
CasingLength	Number (Double)	Length of casing	8
CasingDia	Number (Double)	Casing diameter	8
CasingUnit	Text	Units of casing length & diameter	255
BH Casing Stickup	Number (Double)	Casing stickup	8
SUunit	Text	Units of casing stick up	255
Bhdip	Number (Double)	Dip of borehole	8
Bhaz	Number (Double)	Borehole azimuth	8
BhutmE	Number (Double)	UTM easting of borehole	8
BhutmN	Number (Double)	UTM northing of borehole	8
Comments	Text	Miscellaneous comment	255
Source	Text	Data source	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
datafile	Text	Original file location/name	255

Table A2

Table Name:	BoreholeTests		
Field	**Type**	**Description**	**Size**
Borehole	Text	Number or name of borehole	255
Monitor	Text	Number or name of monitor	50
TestType	Text	Type of test performed	255
TestNum	Text	Optional test number	50
Date	Date/Time	Date of test	
DepthTop	Number (Double)	Depth to top of test zone	8
DepthBot	Number (Double)	Depth to base of test zone	8
DepthUnit	Text	Units of depth	50
ElevTop	Number (Single)	Elevation of top of test zone	4
ElevBot	Number (Single)	Elevation of base of test zone	4
Depth Source	Number (Single)	1 = original format of data as elevation; 2 = original format of data as depth (elevation calculated by database)	4
HydroStratUnit	Text	Responding stratigraphic unit	50
Parameter	Text	Parameter name	50
ParameterCode	Text	Parameter modifier	255
ParmValue	Number (Double)	Parameter value	8
ParmUnit	Text	Units of parameter value	255
Ap>	Text	Single fracture aperture modifier	255
FractAptur	Number (Double)	Calculated single fracture aperture	8
FractApturUnits	Text	Units of single fracture aperture	255
Source	Text	Data source	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	50
Comment1	Text	Miscellaneous comment	64
Comment2	Text	Miscellaneous comment	64

Table A3

Table Name:	**ChemData**		
Field	**Type**	**Description**	**Size**
SampleNum	Text	Sample number	50
Monitor	Text	Number or name of monitor	15
Date	Date/Time	Date of sampling	
Parameter	Text	Parameter name	50
ParmValue	Number (Single)	Parameter value	4
Site	Text	Sampling site	50
Matrix	Text	Matrix sampled	50
ChemModifier	Text	Chemistry code/modifier	50
ChemUnits	Text	Units of parameter value	10
MDL	Number (Single)	Method detection limit	4
QualityCode	Text	Chemistry quality code	50
Comment	Text	Miscellaneous comment	50
Source	Text	Data source	50
Reference	Text	Data reference	50
Datafile	Text	Original file location/name	50
UpdateNWRI	Date/Time	Date of data input	

Table A4

Table Name:	**ChemData QA samples**		
Field	**Type**	**Description**	**Size**
SampleNum	Text	Sample number	50
Monitor	Text	Number or name of monitor	15
Date	Date/Time	Date of sampling	
Matrix	Text	Matrix sampled	50
Parameter	Text	Parameter name	50
ParmValue	Number (Single)	Parameter value	4
ParmValueHi	Number (Single)	Maximum of parameter value range	4
ChemModifier	Text	Chemistry code/modifier	50
ChemUnits	Text	Units of parameter value	10
MDL	Number (Single)	Method detection limit	4
MDL-Hi	Number (Single)	Maximum of MDL value range	4
QualityCode	Text	Chemistry quality code	50
Discrete Feature	Text	True = sampling zone was discrete feature; False = sampling zone was not discrete feature	50
Method	Text	Analysis method	50
Laboratory	Text	Lab performing analysis	50
Qacode	Text	Laboratory quality assurance codes	50
Comment1	Text	Miscellaneous comment	255
Comment2	Text	Miscellaneous comment	50
Source	Text	Data source	50
Reference1	Text	Data reference	50
Reference2	Text	Data reference	50
Datafile	Text	Original file location/name	50
UpdateNWRI	Date/Time	Date of data input	
Original unit	Text	Original units of parameter value	50
Original value	Number (Single)	Original parameter value	4
Original MDL	Number (Single)	Original MDL	4

Table A5

Table Name: ChemParameters

Field	Type	Description	Size
Parameter	Text	Parameter name	50
Plot	Yes/No	Check = parameter will be graphically plotted; No check = parameter will not be graphically plotted	

Table A6

Table Name:	**Climate**		
Field	**Type**	**Description**	**Size**
Location	Text	Location of climate station	255
StartTime	Date/Time	Start time of sampling	
EndTime	Date/Time	End time of sampling	
Element	Number (Long integer)	Numeric code of climatic event	
ElementName	Text	Climatic event	50
ElementValue	Number (Single)	Climatic event value	4
ElementUnits	Text	Units of climatic value	50
ElementModifier	Text	Climatic code/modifier	50
Inter-event Time	Number (Double)	Time between sampling events	8
Comment	Text	Miscellaneous comment	50
Source	Text	Data source	255
Reference	Text	Data reference	255
Datafile	Text	Original file location/name	255
Update NWRI	Date/Time	Date of data input	
Site	Text	Climatic sampling site	50

Table A7

Table Name: CorePhoto

Field	Type	Description	Size
Borehole	Text	Number or name of borehole	50
Phototopdepth	Number (Double)	Depth to top of core	8
Photobotdepth	Number (Double)	Depth to base of core	8
DepthUnits	Text	Units of depth	50
Phototopelev	Number (Single)	Elevation of top of core	4
Photobotelev	Number (Single)	Elevation of base of core	4
Photofile	Text	File name	255
Comment	Text	Miscellaneous comment	50
Source	Text	Data source	50
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	50

Table A8

Table Name:	**DNAPL properties**		
Field	**Type**	**Description**	**Size**
ChemPar	Text	Chemical name	255
Comment1	Text	Chemical composition	255
SubChemPar	Text	Chemical composition	255
Parameter	Text	Parameter name	255
ParValue	Number (Double)	Parameter value	8
ParUnits	Text	Units of parameter value	255
Comment2	Text	Miscellaneous comment	255
Source	Text	Data source	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	50

Table A9

Table Name:	Fracture		
Field	**Type**	**Description**	**Size**
Monitor	Text	Name of monitor	255
Location	Text	Face number	255
StratInterval	Text	Stratigraphic interval	255
Orientation	Number (Double)	Orientation of fracture	8
Ounits	Text	Units of orientation	255
TraceLength	Number (Double)	Trace length of fracture	8
Lunits	Text	Units of trace length	255
Area	Text	Area studied	255
AreaUnits	Text	Units of area	255
Fracture No	Text	Fracture number	255
Set	Text	Fracture set	255
Parameter	Text	Parameter name	255
ParValue-Low	Number (Double)	Minimum of parameter value range	8
ParValue-Hi	Number (Double)	Maximum of parameter value range	8
ParModifier	Text	Parameter modifier	255
ParUnits	Text	Units of parameter value	255
Comment	Text	Miscellaneous comment	255
Source	Text	Data source	255
Reference	Text	Data reference	255
Datafile	Text	Original file location/name	50

Table A10

Table Name:	**GeolMajor**		
Field	**Type**	**Description**	**Size**
Borehole	Text	Number or name of borehole	255
Site	Text	Site of borehole	255
FormationName	Text	Geological unit name	255
Description	Text	Description of geological unit	255
GMajorTopDepth	Number (Double)	Depth to top of unit	8
GmajorBotDepth	Number (Double)	Depth to base of unit	8
Depth Units	Text	Units of depth	255
GMajorTopElev	Number (Double)	Elevation of top of unit	8
GMajorBotElev	Number (Double)	Elevation of base of unit	8
Source	Text	Data source	255
Comment	Text	Miscellaneous comment	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	255

Table A11

Table Name:	**GeolMinor**		
Field	**Type**	**Description**	**Size**
Borehole	Text	Number or name of borehole	50
GminorTopElev	Number (Double)	Elevation of top of geological feature	8
GminorBotElev	Number (Double)	Elevation of base of lithological feature	8
Elevation Units	Text	Units of elevation	50
GminorTopDepth	Number (Single)	Depth to top of lithological feature	4
GminorBotDepth	Number (Single)	Depth to base of lithological feature	4
Depth Units	Text	Units of depth	50
Strike	Number (Single)	Strike of fracture	4
Dip	Number (Single)	Dip of fracture	4
GminorFeature	Text	Lithological feature	50
GminorDescription	Text	Description of lithological feature	50
Comment	Text	Comment on feature	50
Source	Text	Data source	50
Reference	Text	Data reference	50
Bhcounter	Number (Double)	Borehole counter	8
Site	Text	Site of borehole	50
Datafile	Text	Original file location/name	50

Table A12

Table Name:	**LabCodes**		
Field	**Type**	**Description**	**Size**
Code	Text	Lab chemistry code	255
Lab	Text	Laboratory using code	255
Field3	Text	Code definition	255

Table A13

Table Name:	**Mass Recovered**		
Field	**Type**	**Description**	**Size**
Borehole	Text	Number or name of borehole	255
PumpRate	Number (Double)	Pumping rate	8
PumpUnits	Text	Units of pumping rate	255
Comment1	Text	Miscellaneous comment	255
Parameter	Text	Parameter name	255
ParValue	Number (Double)	Parameter value	8
ParUnits	Text	Units of parameter value	255
Comment2	Text	Miscellaneous comment	255
Source	Text	Data source	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	255

Table A14

Table Name:	Monitor		
Field	**Type**	**Description**	**Size**
MonCounter	AutoNumber (Long integer)	Monitor counter	
MonCounterNWRI	Number (Double)	NWRI monitor counter	8
Monitor	Text	Number or name of monitor	255
Borehole	Text	Borehole in which monitor is located	255
Site	Text	Site of monitor	255
InstallStartDate	Date/Time	Start date of monitor	
MonEndDate	Date/Time	End date of monitor	
MonitorType	Text	Monitor type	255
CasingSU	Number (Double)	Monitor casing stickup	8
ReferencePoint	Text	Reference point for casing stickup	255
Suunit	Text	Units of casing stickup	255
MonitorDia	Number (Double)	Monitor diameter	8
Mdunit	Text	Units of monitor diameter	255
RespondAquifZone	Text	Responding lithological unit	255
MonMaterial	Text	Monitor material	255
ScreenTopD	Number (Double)	Depth to top of screen	8
ScreenBottomD	Number (Double)	Depth to base of screen	8
ScreenTopE	Number (Double)	Elevation of top of screen	8
ScreenBottomE	Number (Double)	Elevation of base of screen	8
MonitorTopD	Number (Double)	Depth to top of monitor	8
MonitorBottomD	Number (Double)	Depth to base of monitor	8
MonitorTopE	Number (Double)	Elevation of top of monitor	8
MonitorBottomE	Number (Double)	Elevation of base of monitor	8
SandPackMtl	Text	Sand pack material	255
SealTop1D	Number (Double)	Depth to top of first seal	8
SealBot1D	Number (Double)	Depth to base of first seal	8
SealTop1E	Number (Double)	Elevation of top of first seal	8
SealBot1E	Number (Double)	Elevation of base of first seal	8
Seal1Mtl	Text	First seal material	255
SealTop2D	Number (Double)	Depth to top of second seal	8
SealBot2D	Number (Double)	Depth to base of second seal	8
SealTop2E	Number (Double)	Elevation of top of second seal	8
SealBot2E	Number (Double)	Elevation of base of second seal	8
Seal2Mtl	Text	Second seal material	255
Units	Text	Units of depths to seal tops and bottoms	255
BackfillTopD	Number (Double)	Depth to top of backfill	8
BackfillBottD	Number (Double)	Depth to base of backfill	8
BackfillTopE	Number (Double)	Elevation of top of backfill	8
BackfillBottE	Number (Double)	Elevation of base of backfill	8
MonitorAlias1	Text	Former monitor ID	255
MonitorAlias2	Text	Former monitor ID	255
MonitorAlias3	Text	Former monitor ID	255
MonitorAlias4	Text	Former monitor ID	255
MonitorAlias5	Text	Former monitor ID	255
NWRI	Text	True = NWRI monitor; False = non-NWRI monitor	255
Comment	Text	Miscellaneous comment	255
Source	Text	Data source	255

Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	255

Table A15

Table Name:	**OtherChem**		
Field	**Type**	**Description**	**Size**
SampleNum	Text	Sample number	50
Monitor	Text	Number or name of monitor	15
Date	Date/Time	Sampling date	
Matrix	Text	Matrix sampled	50
Parameter	Text	Parameter name	50
ParmValue	Number (Single)	Parameter value	4
ParmValueHi	Number (Single)	Maximum of parameter value range	4
ChemModifier	Text	Chemistry code/modifier	50
ChemUnits	Text	Units of parameter value	10
MDL	Number (Single)	Method detection limit	4
MDL-Hi	Number (Single)	Maximum of MDL value range	4
QualityCode	Text	Chemistry quality code	50
Discrete Feature	Text	True = sampling zone was discrete feature; False = sampling zone was not discrete feature	50
Method	Text	Analysis method	50
Laboratory	Text	Lab performing analysis	50
Qacode	Text	Laboratory quality assurance codes	50
Comment1	Text	Miscellaneous comment	255
Comment2	Text	Miscellaneous comment	50
Source	Text	Data source	50
Reference1	Text	Data reference	50
Reference2	Text	Data reference	50
Datafile	Text	Original file location/name	50
UpdateNWRI	Date/Time	Date of data input	

Table A16

Table Name:	**OtherMonitors**		
Field	**Type**	**Description**	**Size**
Monitor	Text	Number or name of monitor	255
Site	Text	Site of monitor	255
Description	Text	Description of monitor/station	255
MonitorType	Text	Monitor type	255
UTM-E	Number (Double)	UTM easting of monitor	8
UTM-N	Number (Double)	UTM northing of monitor	8
UpdatedNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	255

Table A17

Table Name:	**ParameterFormula**		
Field	**Type**	**Description**	**Size**
Parameter	Text	Parameter name	255
ParFormula	Text	Parameter formula	255

Table A18

Table Name:	**References**		
Field	**Type**	**Description**	**Size**
LOC	Text	Document ID	255
Author	Text	Author	255
Title	Text	Title	255
Publishing Information	Text	Publishing information	255
Corporate Source	Text	Corporate source	255
Date	Text	Date of publication	255
Keywords	Text	Keywords	255
Notes	Text	Notes	255
Report Status	Text	Report status	255
MOEE	Text	Date approved by MOEE	255
Type	Text	Type of document	255
Datafile	Text	Original file location/name	255

Table A19

Table Name:	**RockProperty**		
Field	**Type**	**Description**	**Size**
SampleNum	Text	Sample number	50
Monitor	Text	Number or name of monitor	50
Date	Date/Time	Sampling start date	
EndDate	Date/Time	Sampling end date	
Matrix	Text	Matrix sampled (e.g. rock, soil, etc.)	50
Parameter	Text	Parameter name	50
AltParmName	Text	Alternate parameter name	50
ParmValue	Number (Single)	Parameter value	4
ParmValueHi	Number (Single)	Maximum of parameter value range	4
ChemModifier	Text	Chemistry code/modifier	50
ChemUnits	Text	Units of parameter value	20
MDL	Number (Single)	Method detection limit	4
MDL-Hi	Number (Single)	Maximum of MDL value range	4
QualityCode	Text	Chemistry quality code	50
Feature/Formation	Text	Feature/formation sampled	50
Method	Text	Analysis method	50
Laboratory	Text	Laboratory performing analysis	50
Qacode	Text	Laboratory quality assurance code	50
Comment1	Text	Miscellaneous comment	255
Comment2	Text	Miscellaneous comment	50
Source	Text	Data source	50
Reference1	Text	Data reference	50
Reference2	Text	Data reference	50
Datafile	Text	Original file location/name	50
UpdateNWRI	Date/Time	Date of data input	
Site	Text	Sampling site	50

Table A20

Table Name:	**SampleDetails**		
Field	**Type**	**Description**	**Size**
Monitor	Text	Number or name of monitor associated with sample	255
BH	Text	Number or name of borehole associated with sample	50
SamType	Text	Sample type	50
SamID	Text	Sample ID	50
SamOldID	Text	Old sample ID	50
SamDepthTop	Number (Double)	Depth to top of sampling zone	8
SamDepthBott	Number (Double)	Depth to base of sampling zone	8
SamDepthUnits	Text	Units of depth	255
SamDiam	Number (Long integer)	Diameter of rock core sample	
SamLength	Number (Long integer)	Length of rock core sample	
SamUnits	Text	Units of sample length and diameter	50
SamAgency	Text	Sampling agency	255
SamFormation	Text	Lithological formation being sampled	50
SamDescription	Text	Sample description	50
Samweight	Number (Single)	Sample weight	4
SamweightUnit	Text	Units of sample weight	50
Sammatrix	Text	Matrix sampled	50
Datafile	Text	Original file location/name	50
Source	Text	Data source	50
Reference	Text	Data reference	50
Comment1	Text	Miscellaneous comment	50
Comment2	Text	Miscellaneous comment	50
UpdateNWRI	Date/Time	Date of data input	
Site	Text	Site of sampling	50

Table A21

Table Name:	Site History		
Field	**Type**	**Description**	**Size**
Counter	Number (Double)	Counter	8
DateModifier1	Text	Date modifier	255
DateStart	Date/Time	Start date of event	
DateEnd	Date/Time	End date of event	
Description	Text	Description of event	255
Source	Text	Data source	255
Reference	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	255

Table A22

Table Name:	**SurveyData**		
Field	**Type**	**Description**	**Size**
Monitor	Text	Number or name of monitor	255
Borehole	Text	Borehole in which monitor is located	255
MonElevStartDate	Date/Time	Start date of monitor at reference point elevation	
MonElevEndDate	Date/Time	End date of monitor at reference point elevation	
MonElev	Number (Double)	Monitor elevation at reference point	8
Reference Point	Text	Reference point of survey	255
Source	Text	Data source	255
UpdateNWRI	Date/Time	Date of data input	
Datafile	Text	Original file location/name	50

Table A23

Table Name:	WaterLevel		
Field	**Type**	**Description**	**Size**
Monitor	Text	Number or name of monitor	255
WLDate	Date/Time	Sampling date	
WLelev	Number (Double)	Hydraulic head	8
WLdepth	Number (Single)	Depth to top of water level	4
DepthUnits	Text	Units of water depth	255
WLtype	Text	Water level type	50
ReadingSource	Text	1 = data received as hydraulic head; 2 = data received as water level	50
Datafile	Text	Original file location/name	50
Comment1	Text	Miscellaneous comment	255
Source	Text	Data source	255
Reference1	Text	Data reference	255
UpdateNWRI	Date/Time	Date of data input	
NWRI	Yes/No	True = NWRI monitor; False = non-NWRI monitor	
Site	Text	Site of monitor	50
BH	Text	Borehole monitor is instrumented in	50
LnaplThick	Number (Single)	Thickness of LNAPL	4
DnaplThick	Number (Single)	Thickness of DNAPL	4
Pin	Number (Single)	Pin	4
Pout	Number (Single)	Pout	4
Wldepthold	Number (Single)	Old water level depth	4

Table A24

Table Name:	**WaterLevelDay**		
Field	**Type**	**Description**	**Size**
Monitor	Text	Number or name of monitor	255
Wldate	Date/Time	Sampling date	
Wlelev	Number (Double)	Hydraulic head	8

Appendix B

1. INSTALLATION

The 3 databases in this system have been designed, and constructed using Microsoft Access® 97. If Access® is not installed, follow the Microsoft® installation steps. It is recommended to install the complete Access® 97 software package to have use of functions and tools to search, display, graph, print, and/or export data. Further information on the use of Access®, such as the assembly of queries, forms, and/or reports, is available through the help features installed with the software package. To install the Smithville database management system:

1. Copy the 3 databases (Smv_data.mdb, Smv_menu.mdb, and Smv_user.mdb) to a hard-drive directory. Note that some releases of the database may not include the "user" or "menu" databases.

2. Change the "Read only" property of each database to "no".

Using "Windows Explorer" or a similar file management tool, right click on the database file, select "Properties", and ensure that "Read only" is not checked. If it is, uncheck it. Although it might seem intuitive to set the "Smv_data.mdb" database to read only, the searching engines write to tables within this database during the querying process.

3. Relink the databases.

(A) Relink "Smv_menu.mdb" to "Smv_data.mdb".

The data tables are stored in the "Smv_data.mdb" database, and made available to "Smv_menu.mdb" and "Smv_user.mdb" through internal links. These links must be refreshed each time the "Smv_data.mdb" files are moved and/or replaced. "Smv_menu.mdb" is an autoexec file that opens "Smv_data.mdb" in its automatic mode.

To relink these databases: (a) by-pass the autoexec by holding "Shift" as the database loads; and (b) activate the "Linked table manager" by selecting "Tools", "Add-ins", and "Linked table manager". A list of the linked tables in "Smv_menu.mdb" will be displayed. Select "Select all", then "Ok". Select "Smv_data.mdb" in the directory tree. Access® will relink the tables. If "Linked table manager" is not active, it was not installed with Access®. You can either re-install Access® (using the complete installation) or manually relink the tables.

To manually relink the tables: (a) make a note of the tables in "Smv_menu.mdb" with a black arrow beside the table name (this means they are linked); (b) delete these tables; (c) select "File", "Get external data", and "Linked table"; (d) locate and select "Smv_data.mdb" in the directory tree; and (e) select the table names you deleted from "Smv_menu.mdb".

(B) Relink "Smv_user.mdb" to "Smv_data.mdb".

"Smv_user.mdb" is not an autoexec file, such that the database can be opened by selecting the file. Follow the procedures for "Smv_menu.mdb".

2. DATABASE MAINTENANCE

Fragmentation of the database can occur when data is deleted or moved within the database file causing the database file to occupy excessive hard-drive space. To alleviate this problem, the database must be "compacted". To compact the database, close any open tables, select "Tools", "Database utilities", and "Compact database". The compacted database can be saved under the same name or under a new filename.

Because the process of compacting involves writing to temporary files, a minimum free hard-drive space of 2.5 times the size of the database is recommended.

2. PROCESSING CORE PHOTOGRAPHS

Listed below are the steps required for processing core photographs for inclusion in the data management system.

- Open Corel PhotoPaint®
- Under the "File" menu, "Open" the desired core photograph
- In the "Photo CD Image" dialog box, select "Image"
- Select "Standard, 24-bit"
- Chose "Enhancement"
- Select "Gamut CD (TM)"
- Using the "Deskew Crop Tool", crop the photograph to desired size
- Under the "Image" menu, select "Rotate", and rotate photo desired amount
- Save as a bitmap

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