

**NYE COUNTY/YMP
YUCCA MOUNTAIN OVERSIGHT DRILLING PROGRAM WORK PLAN
REVISION #4
DECEMBER 2, 1994**

INTRODUCTION AND OVERVIEW

The DOE Yucca Mountain Program (YMP) has approached the vadose zone drilling and testing with two basic technical elements: (1) dry drilling and (2) continuous coring. The drilling technology developed to accomplish dry continuous coring and instrumentation of the boreholes is custom in design. Review of the rates of progress, drilling objectives, and instrumentation approaches of the YMP characterization issue resolution strategies related to the adopted drilling technology suggest that an overall alternative strategy, that of using off-the-shelf drilling technology dual-wall reverse circulation (DWRC) air rotary and Westbay multiport instrumentation, may prove comparable from the database development prospective, and more efficient in terms of time requirements for installation and overall costs.

The primary objective of the Nye County (NC) drilling program is to evaluate dual-wall reverse circulation air rotary drilling technology and Westbay instrumentation in the Yucca Mountain area. Associated databases can be compared with YMP drilling strategy databases, as well as efficiency in time and costs between the two approaches. Dry drilling with the DWRC method should allow recovery of representative geologic cuttings and subsurface fluids that are unaffected by the addition of liquids, but not continuous coring.

Up to four DWRC boreholes have been approved on DOE/YMPO land. The first borehole to be drilled (UE-25 ONC#1) is located near the Yucca Mountain borehole RF-5. This hole is in the Bow Ridge Fault Zone midway between UZ-16 and the C-well Complex. Three remaining DWRC boreholes shall be located in areas where there are control data needs, as yet to be determined. These holes will not be drilled in FY 95. The Second hole (NRG-4) will be instrumented along with UE-25 ONC#1, with the Westbay downhole instrumentation package to obtain pneumatic response data

over the winter months, and also to monitor effects of TBM operations. NC borehole installations may be used by the YMP to establish additional monitoring well water-level records and performing well pumping tests. UE-25 ONC#1 near UZ-16 can be used to compare these two different drilling technologies versus useful scientific information obtained. Cross-borehole gas tracer tests and long-term vadose zone and saturated zone monitoring programs are planned in Nye County hole #2, located on the UZ-14 and UZ-1 drill pad.

The NC primary testing targets are the vadose zone and the uppermost saturated zone. During drilling, water sample field chemistry and discharge measurements will be collected from the saturated zone, as well as from intersected perched-water zones. Continuous cuttings shall be collected and stored such that a stratigraphic record is preserved from the surface to total depth for each borehole. After the total depth is reached for each borehole, geophysical logs will be run, followed by installation of Westbay/MOSDAX multi-level monitoring systems. The Westbay/MOSDAX systems will be used to monitor water-level changes induced by the nearby pump testing of the C-well complex in cooperation with the USGS, as well as other cooperative testing studies, such as tracer injection tests to establish both vadose zone and saturated zone pneumatic and hydrologic properties. Cross-borehole tracer tests performed at a later date in NC Well #2 would use the multiport Westbay/MOSDAX systems for sampling in the water-table and vadose zones during tracer injection. Long-term vadose zone monitoring (gas pressure, gas temperature, gas composition), fluid potential, and water chemistry shall be accomplished using the Westbay/MOSDAX systems.

1.0 PRE-DRILLING ACTIVITIES

1.1 Personnel and Subcontractor Qualifications

- 1.1.1 Nye County Personnel and contractors associated with this project shall meet qualifications and be assigned titles as described in Section 2.5 of Nye County Quality Assurance Manual.

- 1.2 Permits.
 - 1.2.1 Prior to commencement of drilling activities all applicable permits shall be obtained and copies furnished to DOE/YMP.

- 1.3. Environmental Operating Procedures.
 - 1.3.1 Obtain archeological and environmental surveys and applicable documents, establish an operating procedure for DOE/YMPO lands as per DOE/NC Protocol. All Nye County personnel and contract personnel must have completed the appropriate training for DOE/YMP land operations, specifically the GET/GERT Environmental Training.

- 1.4 Training.
 - 1.4.1 Notify DOE safety and health department prior to starting work, and follow current radiological and environmental procedures for work on DOE/YMPO lands.

 - 1.4.2. All contract personnel will receive appropriate badging for access to NTS/DOE Yucca Mountain area along with required security briefings.

1.5 Approval.

1.5.1 Obtain approval for DOE/YMPO prior to mobilizing drilling equipment for work on NTS/DOE property.

1.5.2 Obtain approved DIE and work package prepared for Nye County Work Program.

1.6 Locations.

1.6.1 The existing disturbed area within one hundred (100) feet of DOE hole RF-5 for the first Nye County Hole (UE-25 ONC#1) has been surveyed and approved for drilling. All other Nye County boreholes shall be within one hundred (100) feet of existing boreholes and in either the down-gradient or up-gradient groundwater direction.

1.7 Borehole Designations.

1.7.1 Identification names for the established boreholes in the NC drilling program will be as follows: The boreholes will be sequentially numbered in the temporal order of construction, with the type of borehole also indicated, and the site indicated if appropriate:

O = Oversight borehole.

NC = A Nye County borehole.

2 = The temporal position of the borehole in the ONC#1 drilling program, beginning with "1" and continuing in sequence, regardless of the fate of each borehole.

UE-25 = The DOE site area designator, UE indicates on the main block.

Example: UE-25 ONC#1

This designator would indicate the first Nye County monitoring and testing oversight borehole constructed in the Nye County drilling program and its location off the Yucca Mountain block. If another Nye County borehole were to be constructed at the same location at a later date, it would become **UE-25 ONC#5**, if it were to be the fifth monitoring and testing borehole of the program.

2.0 SITE PREPARATION

2.1 Borehole Location/Site Plan.

2.1.1 NC boreholes shall be prelocated by designation stake in cooperation with YMP representatives and shall be within one-hundred (100) feet of DOE/YMPO existing boreholes. Drill pads established for DOE/YMPO boreholes shall be used for NC boreholes.

2.1.2 A plan will be made for location and positioning of drilling support equipment in cooperation with YMP representatives. Appropriate plans for environmental control of fluids, etc., shall be developed.

3.0 DRILLING PROGRAM SPECIFICATIONS

3.1 Drilling.

- 3.1.1 Boreholes shall be drilled using dual-wall reverse circulation air rotary (DWRC) methodology.
- 3.1.2 A Center Sample Recovery Drilling System or equivalent DWRC drill rig will be used for drilling. In addition, at least 1,200 cubic feet per minute (cfm) - 350 pounds per square inch (psi) auxiliary compressor or as necessary will be used to facilitate drilling beyond 1,000 feet.
- 3.1.3 The estimated total depth for borehole UE-25 ONC#1 is 1,500-2,000 feet or as directed by the Project Manager (PM) and Principal Investigator (PI). The intended total depth is into the water table from 50 to 300 feet depending upon drilling conditions encountered during operations. When the water table is encountered drilling will temporarily stop while DOE logs the upper section of the hole and water samples will be taken. After logging and water sampling, drilling will restart.
- 3.1.4 Eight (8) inch ID conductor casing shall be set in a twelve (12) inch nominal diameter borehole from one (1) foot above ground surface through the unconsolidated material into the uppermost consolidated formation. Centralizers will be used to ensure the centering of the conductor casing in the borehole. A tremie line shall be used to inject a seal of portland cement in the annulus space.
- 3.1.5 Natural background air shall be used as drilling fluid. No water or other

liquid or other tracer gas shall be allowed into the borehole during drilling, to maintain as in-situ conditions as possible for data acquisition during post drilling long-term vadose zone monitoring.

- 3.1.6 Downhole center sample air hammer button bits shall be used on the drilling face. Nominal bit size shall vary between six (6) and six and three-fourths inch (6-3/4") from the bottom of the conductor casing/sanitary seal and may be progressively stepped-down in size to five and one-fourth inch (5-1/4") toward the bottom of the borehole to total depth. Borehole conditions will dictate the nominal bit diameter at various depths during the course of drilling or as directed by the PM and PI.
- 3.1.7 Dual-wall drill pipe shall be four and one-half inch (4-1/2") diameter and equipped with flush joints. This allows the borehole to be cut with a minimum of clearance to retard borehole contamination by caving and erosion of the borehole wall, and will help to stabilize the drilling pipe during drilling. Furthermore, twenty (20) to forty (40) feet of drill collar, with the diameter one-fourth (1/4) to one-half (1/2) inch less than the drilling face, may be positioned above the drill bit assembly. This to further minimize up-hole cuttings and formation fluid blowby, and provide directional control for a straighter borehole.
- 3.1.8 During drilling the following items will be recorded using a drill rig mounted geograph: (1) drilling penetration rate, (2) down hole air pressure in psi, (3) temperature, (4) bit and string weight indication, (5) depth, and (6) date and time.

3.1.9 A drilling log book shall be used to record all drilling activities, i.e. drilling progress, stand-by time, number and types of bits used, air-lift time, personnel and visitors on-site, etc.

3.1.10 If total depth is not reached due to borehole or drilling conditions, the drill string shall be removed from the borehole. The PM and PI shall determine whether to complete the borehole for monitoring or abandon the borehole per Nevada State and YMP requirements..

3.2 Geologic Cuttings Sampling.

3.2.1 Continuous geologic cuttings samples shall be split using a tiered sample splitter. Split design shall accommodate fifty (50) percent cuttings return to the DOE/YMP and fifty (50) percent cutting return to NC. The Nye County 50% split will be split again: one selected 25% sample split may be sealed for moisture testing and the other 25% sample split shall be collected to be available for lithologic analysis or other uses as directed by NC, the PM and PI.

3.2.2 Cuttings sample containers for lithologic splits will be clear plastic geologic sample bags sealed and marked for long-term storage. Selected splits for moisture analysis will be stored in impervious containers, such as Protecure, and then shipped to the laboratory for analysis. If moisture samples need to be stored for a short period of time, such as overnight, they will be put into the YMP SMF cold storage unit. All other lithologic samples will be stored in the YMP SMF general lockup storage areas. 50% sample splits for the

YMP will be bagged in plastic bags and either handled by the YMP Staff or by the NC on-site geologic staff.

3.3 Water Sampling and Testing

3.3.1 Fluid Potential Measurements.

3.3.1.1 Fluid potential measurements may be made and results recorded at the beginning of each eight (8) hour shift or at the direction of the PM and PI.

3.3.1.2 If free water is evident in the drill cuttings/discharge air, drilling progress shall cease, the drill string will be broken at the first drill joint near ground level, and water level shall be measured and recorded in Daily Drilling Log Book.

3.3.2 Discharge Sampling, Perched Water.

3.3.2.1 After attempting a static water-level measurement the drill bit will be raised one-half (1/2) to one (1) foot and discharge of sediment and water will continue (typically 1/2 to 1-1/2 minutes) until cuttings load has decreased sufficiently to acquire a water discharge sample. All discharged water will be collected in collector tank and transferred periodically to on-site storage. Flow rates will be determined by timed volume acquisitions. Perched water shall be sampled at each perching interval or as directed by the PM and PI.

3.3.2.2 Water-sample collection may also be accomplished at the surface by way of a dedicated in-line sample valve connected to the multi-compartment

discharge tank.

3.3.2.3 Water-sample containers will be stored on-site in refrigerated shipping containers used for storage of moisture sealed containers. Moisture samples will be shipped ASAP for analysis or stored temporarily in the cold storage at the SMF.

3.3.3. Discharge Sampling: Saturated Zone.

3.3.3.1 After reaching saturation downhole, drill progress shall periodically cease at zones which indicate increased water flows during drilling. The drill bit will then be raised one-half (1/2) to one (1) foot. Discharge of sediment and water will continue (typically 1/2 to 1-1/2 minutes) until sediment load has decreased sufficiently to acquire a representative water sample and flow rate. Water samples shall be collected from the water table-capillary zone interface and at a minimum sample interval of twenty (20) feet or as directed by the PM and PI. All water samples, at a minimum, will have field conductivity, pH, and temperature measured. All water samples and depths will be recorded in Daily Drilling Log Book.

3.3.3.2 Water sample collection will be accomplished at the surface by way of a dedicated in-line sample valve connected to the multi-compartment discharge tank.

3.3.3.3 Water-sample containers will be stored on-site in refrigerated shipping containers.

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3.3.4 Discharge Flow Tests, Saturated and Perched Zones.

3.3.4.1 Air-lifted water discharge shall be measured at the surface for depth/flow-rate information. Once reaching perched groundwater in the unsaturated zone, flow tests shall be performed. In the saturated formation, flow tests may be performed at twenty (20) foot intervals or as directed by the PM and PI. Flow rates may also be determined while drilling progress is being made by the timed/volume method in the discharge water collection tanks. At the surface, water shall be directed to a multi-compartment measurement tank. Different capacity tanks will be available to measure air-lifted water flows ranging from 0 to 100 gpm.

3.3.4.2 A trailer mounted water tank shall store (for off-site disposal) all developed water.

3.3.5 On-site field water sample analyses will consist of the following: (1) electrical conductivity, (2) pH, and (3) temperature and recorded in Daily Drilling Log Book.

3.3.6 Water samples collected will be analyzed as specified by NC PI.

3.4 Geophysical Logging and Surveying.

3.4.1 Upon recognizing that regional saturation has been intersected, drilling will be stopped and neutron probe logging may commence.

- 3.4.2 After drilling and sampling is complete, the drill string will be removed. Geophysical logging is dependent on availability of appropriate logging equipment probes and cooperative interactions with the YMP. The geophysical logs which may be run include: caliper, spontaneous potential, dual induction, laterolog, focus resistivity log, compensated acoustic or sonic log, thermal decay time log, natural gamma, temperature, fluid resistivity, resistivity, and video, or any other log or combination of logs as established by the PM and PI in cooperation with the YMP.
- 3.4.3 In cooperation with the YMP, surveys shall be established for borehole locations and elevations.
- 3.4.4 Meteorological Measurements.
- 3.4.5 Air temperature and air moisture hourly values shall be obtained from the closest DOE meteorologic station during drilling or as directed by the PM and PI.

4.0 IN SITU VADOSE AND SATURATED ZONE SAMPLING AND TESTING

- 4.1 Downhole Instrumentation.
- 4.1.1 Install MP-55 Westbay/MOSDAX sampling system using the on-site drill rig or pump rig. Appendix A is a compilation of information on Westbay multi-level saturated zone and vadose zone monitoring system installation, sampling, and testing methodology. Westbay/MOSDAX System quality

assurance (QA) and Quality Control (QC) procedures shall be implemented.

4.1.2 Casing shall be 1, 1.5, and 3 meter length sections appropriate for sampling zones and depths required. Plastic and steel casing and couplings shall be used as appropriate or as directed by the PM and PI.

4.1.3 Pressure tests will be performed at the surface on each section of casing and respective couplings to insure their integrity. This will be accomplished as the casing is lowered into the borehole.

4.1.4 After Westbay/MOSDAX system installation the drill or pump rig shall be demobilized.

4.2 Testing and Sampling Intervals.

4.2.1 Six (6) or more borehole intervals will be isolated for port sampling with the Westbay/MOSDAX system. These intervals may include, from the top to the bottom of the borehole: (1) The uppermost fractured rocks as determined during drilling or ten (10) meters below the first volcanic tuff unit that is intersected; (2) the lowest part of the fractured rock zone in the Tiva Canyon member of the Paintbrush Tuff, directly above the nonwelded bedded tuff zone; (3) The uppermost part of the fractured rock zone in the Topopah Springs member of the Paintbrush Tuff, directly below the nonwelded bedded tuff zone; (4) Immediately above saturation; (5) The first permeable zone below saturation, as determined during drilling; and (6) two-hundred (200) feet to three-hundred (300) feet below saturation or at total depth.

Subsurface conditions may warrant additional Westbay/MOSDAX system sample monitoring intervals. Potential hydrologic test zones include the following: Perched zones, the nonwelded bedded tuff units between the Tiva Canyon member and Topopah Springs member of the Paintbrush Tuff, or any other zone that meets the needs of testing will be isolated for sampling at the direction of the PM and PI and as dictated by borehole conditions.

4.3 Initial In-Situ Tests.

- 4.3.1 Hydrologic testing feasible in the saturated zone includes: slug, falling and constant head and pump tests. . However, these tests may not be compatible with the objectives of the present program.

If additional testing is warranted, based on results of drilling UE-25 ONC#1, Nye County and its technical contractor will consult with DOE to establish type and extent of tests to be performed.

4.4 Long-Term Saturated and Vadose Zone Monitoring

- 4.4.1 Temperature and barometric pressure in the vadose zone shall be monitored on a continuous long-term using the downhole MOSDAX automated recording system.
- 4.4.2 Temperature, water chemistry, and fluid pressures in the saturated zone shall be monitored on a long-term basis. Temperature may be measured continuously; groundwater chemistry samples will be taken periodically and

fluid pressure measurements may be continuous.

5.0 Notes

- 5.1 No water will be used for construction and dust control during drilling NC holes. The quantity of water produced on-site during drilling and disposed of off-site shall be included in a permanent record.
- 5.2 Borehole location, design, and construction of the surface conductor casing shall ensure that natural runoff water does not enter the borehole.
- 5.3 A water-tight locking cap on the conductor casing shall be installed, with lock, after instrumentation. Instrumentation shall be housed in a locked shelter.
- 5.4 All water uses at the sites shall be pre-approved by the PM and PI, and monitored after consulting YMP environmental staff personnel.
- 5.5 The time required to complete drilling for one (1) borehole is estimated at approximately fifteen (15) working days based on one eight (8) hour shift per day.
- 5.6 The time required to install two (2) Westbay Systems in two (2) boreholes is estimated at six (6) working days based on one eight (8) hour shift per day.

5.7 Geophysical logging of the NC hole will be from three (3) to four (4) days per DOE representative.

5.8 List of Appendices

5.8.1 Appendix A - Westbay/Mosdax System

5.8.2 Appendix B - Test Planning Package (TPP) 95-03 Rev. 0
(Incorporates by reference, DIE for UE-25 ONC#1 and USW NRG-4, BAAAE0000-01717-2200-00002)

DUAL-WALL REVERSE CIRCULATION DRILLING

BACKGROUND

Dual-wall reverse circulation drilling was developed in 1959 in Canada to penetrate permafrost, glacial till, and other terrain where conventional drilling methods are costly and usually ineffective. The need for a method to penetrate unconsolidated gravels and cobble without the use of drilling fluids for seismic shot holes and foundation studies promoted the development of the dual-wall and "triple wall" percussion hammer systems. The dual-wall rotary system became widely used for mineral exploration in consolidated sedimentary and crystalline formations because of exceptionally well controlled cuttings recovery for assay purposes.

Dual-wall systems were applied to hydrogeologic exploration and groundwater studies in Nevada during the late 1970's. With the recent emphasis on groundwater quality and contaminant migration studies in the United States, the dual-wall techniques have been used extensively since 1985 as exploration tools and for the installation of monitoring devices in environmental studies.

METHODOLOGY

Dual-wall reverse circulation rotary drilling uses double wall drill pipe with high pressure air, normally with a small addition of water in dry formations, as the circulating medium. Air is forced down the annular space between the inner and outer pipe and the cuttings are lifted up the inner pipe in a reverse circulation configuration. Continuous formation and water samples which have not been contaminated with drilling additives (if no water is added to the air) or mixed with other borehole materials are returned.

The dual-wall technique drills a borehole with a minimal annular space between the drill pipe and the formation. This small clearance within the borehole wall promotes the circulation medium (air) to remove the drill cuttings and formation waters produced at the drilling bit to travel up the inner drill pipe, the path of least resistance. Delineation and testing of different zones in the subsurface is possible because the drill pipe or drill collars essentially fill the borehole and minimize upper borehole derived water and formation material from reaching the bit. Typically, lithologic changes and water bearing zones within a few inches of vertical position can be recognized and located during the drilling process.

An air compressor capable of providing an uphole velocity of at least 70 ft/sec permits reliable logging of water, mineral, or contaminant-bearing strata. A filter is required on the compressor to prevent oil and foreign debris from entering the drilling air.

Cuttings are discharged through a cyclone separator assembly mounted on the drill unit which slows the velocity at which the cuttings travel. The majority of return air is vented and monitored from the top of the cyclone separator while cuttings and produced water fall by gravity from the bottom of the cyclone separator. Cuttings and produced water may be collected in drums, bins, or other containment vessels. The discharge system is an open system below the cyclone for timely recognition and logging of water production zones in both vadose and unsaturated zone drilling.

Dual-wall reverse circulation rotary drilling uses top head drive to rotate dual-wall drill pipe into the ground. Torque from the rotary system is applied to the outer pipe. A small annulus space cut by the bit reduces torque created by friction of the borehole wall against the drill string. The outer pipe of dual-wall drill pipe is flush threaded. Inner pipe connections are made with an airtight double "O" ring seal. The inner pipe is held in place within each joint of drill pipe by a centering device. The

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borehole may be drilled vertically, at an angle, or horizontally through unconsolidated or consolidated sediments or crystalline bedrock. Penetration rates of 100 ft/hr are common. The system is often limited to depths of approximately 1,200 to 1,400 ft in unconsolidated deposits and may be useful up to 2,000 ft in consolidated formations. It is a specialized drilling technology and requires experienced drilling crews for deep drilling conditions.

Drill Pipe and Bits

Dual-wall rotary pipe is available in three sizes: 3-1/2" OD x 1.732" ID, 4-1/2" OD x 2.469" ID, and 5-1/2" OD x 3.250" ID in 10 ft and 20 ft lengths. The 4-1/2" OD pipe is the most commonly used. Two types of bits are commonly used: tricone roller and down-the-hole (DTH) hammer.

Tricone roller bits utilize a sleeve threaded to the bit sub that shrouds the rollers and promotes the flow of the circulating medium into the inner pipe (Figure 2). Tricone bits are used to drill through coarse grained unconsolidated formations as well as consolidated formations. At greater depths in permeable formations tricone bits may be necessary (see below).

A DTH hammer bit uses an interchange sub attached to the bottom of the drill pipe which allows the air flow to fire the hammer mechanism and continuously remove the drill cuttings along the reverse circulation path (Figure 3). DTH hammer bits are generally used to penetrate consolidated formations, but may become ineffective when large quantities of water enter the borehole at heads greater than 400 feet due to the large air demand required to continuously lift water and operate the bit.

Applications for Groundwater Exploration/Scientific Investigations

The dual-wall rotary method is very useful and cost effective for test hole drilling in the exploration of groundwater conditions. The DWRC method has been successful and cost effective in the search for municipal and industrial water supply, particularly in arid terrain where the water table is deep or water quality varies vertically or laterally. It is rapid; it allows detailed vertical profiling of water quality during drilling; it allow recognition of water bearing zones and relative production during drilling. It avoids the necessity of geophysical logging and of casing boreholes before the testing of water quality and production can be accomplished.

Individual water-bearing zones may be recognized and tested as drilling proceeds, because the drill bit size is commonly one nominal size larger than the drill pipe, and up-hole formations are essentially cased off. Water samples circulated to the surface or bailed/pumped from a standing column in the drilling pipe are usually representative of the particular zone where the bit is located.

The quantity of formation waters circulated to the surface provide an indication of the potential yield of an individual zone. In addition, falling head permeability studies of individual zones at or below the bit may be performed with the drill pipe in place to ease off other formations. This latter testing method is not planned for the Nye County drilling as no introduction of water (even locally derived) is planned for the boreholes.

The dual-wall reverse circulation system has a number of advantages, particularly for database objectives associated with Yucca Mountain characterization studies:

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1. With the dual-wall system compressed air is used as the drilling medium and circulation is contained internally within the drill pipe. This assures total sample recovery and eliminates the need for casing and drilling muds when penetrating most geologic media. It does not work well in thick sequences of fat clay at depth, however, due to borehole wall friction when extensive clay zones squeeze into the borehole.
2. Indurated formations which have voids and/or fractures can also be easily drilled without the aid of lost circulation materials, installation of casing, or having to "cement off" the lost circulation zones.
3. Continuous and highly representative cutting samples are recovered as part of the drilling process. Vertical profiles of water quality (through frequent sampling) can also be recovered.
4. As the center of the drill pipe is always open to the bottom of the hole, water-level measurements or water samples may be taken at any interval through the center of the drill pipe. This eliminates pulling the drill pipe to take water samples or to measure water levels.
5. Relative rates of water yield from localized producing zones can be determined as the borehole is deepened.
6. Changes in geological strata are accurately determined while drilling is in progress. This is attributed to the internally contained system with a high up-hole velocity of

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cuttings ranging between 4,000 and 14,000 feet per minutes.

7. The reverse circulation method minimizes the smearing of the borehole with drill cuttings and prevents the build-up of mud cake on the borehole wall.
8. The location of perched water is normally recognized by a fine spray of liquid in the discharge with good depth control. As with permeable water yielding zones in the saturated zone, relative yields and samples can often be obtained when drilling into perched water if yields are significant.
9. Directional stability of the borehole is normally better than other methods due to borehole wall stabilizing the drill pipe/drill collars.
10. Blowby of cuttings and water is often minimal.

Summary of Dual-Wall Reverse Circulation Drilling Methodology

Abstracted Descriptions From:

Becker, W.R., 1991. Environmental drilling and sampling using reverse circulation dual-tube system: 21st Annual Maryland-Delaware Water Well Association, Inc. Convention

Driscoll, F.G., 1986. Groundwater and Wells, Second Edition: Johnson Filtration Systems, Inc.. St. Paul. Minnesota

Story, S.L., Melhorn, N.E., and Strauss, M.F. 1992, Applications of dual-wall reverse circulation drilling in groundwater exploration and monitoring: Layne-Western Company, Inc., Chandler, Arizona

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APPENDIX A

Westbay/Mosdax System

Multi-Level Groundwater Monitoring with the MP System®

Abstract

Defining the extent of a groundwater contaminant plume in geologic materials requires a three-dimensional array of sampling points. Such an array is commonly installed by placing a single access tube and inlet screen in each of a series of boreholes. With this method, the number of sampling points at a given site is generally limited by the high cost of drilling. An alternative is to install monitoring points at many levels in each drillhole. Multi-level monitoring can provide increased data density and therefore an improved understanding of site conditions. This paper describes how the MP System®, one type of multi-level monitoring well, is installed and operated. Field quality control procedures, 1) to verify the integrity of the access tube, inlet valves, and drillhole seals, and 2) to confirm the operation of measuring and sampling equipment, are also discussed.

Introduction

When groundwater contaminant plumes are suspected of having significant depth as well as lateral distribution, a three-dimensional array of monitoring points is needed to identify and characterize such plumes. Thus, groundwater data must be obtained from a number of different locations and from a number of different depths at each location. As a result, either a large number of drillholes are required, each with a separate instrument installed, or instruments must be combined and installed at multiple levels in each of a smaller number of drillholes.

Multi-level groundwater monitoring devices have been described by many writers, some discussing the technical benefits and others the advantages to schedules and costs which can result when multi-level monitoring devices are used to reduce the number of drillholes required. Most important, however, are the advantages that accrue from the increased data density and from the field verification procedures that are available. The very fact that one is capable of accessing several different discrete zones in one monitoring well provides a testing and verification capability that is simply not possible in a single-level device such as a standpipe monitor well.

The basic requirements of any groundwater monitoring system are that it provide the user with the

ability to measure fluid pressure, purge the monitoring zone, collect fluid samples, and undertake standard hydrogeologic tests, such as permeability tests and tracer tests. In addition, quality assurance plans for groundwater monitoring programs have led to a requirement for periodic testing and calibration of all aspects of groundwater monitoring devices.

Quality assurance plans normally require field verification tests immediately following installation and again at periodic intervals during the operating lifetime of the installation. In fact, few groundwater monitoring devices are designed to allow extensive field verification tests to be carried out. However, some types of multi-level monitoring instruments, such as the MP System® developed by Westbay Instruments Inc., were designed with field verification tests in mind (Patton and Smith, 1986). With such systems, questions of data quality can be readily addressed.

General Description of the MP System

The MP System is a modular multi-level groundwater monitoring device employing a single, closed access tube with valved ports. The valved ports are used to provide access to several different levels of a drillhole through a single well casing. The modular design permits as many

Monitoring zones as desired to be established in a drillhole. Furthermore, at the time of installation, zones may be added or modified without affecting other zones or significantly complicating the installation. As a result, the number and location of monitoring zones can be decided based on the information obtained during drilling. Only a broad scope of requirements need be defined in advance of drilling.

The MP System consists of casing components, which are permanently installed in the drillhole, portable pressure measurement and sampling probes, and specialized tools. The casing components include casing sections of various lengths, regular couplings, two types of valved port couplings with different capabilities, and packers, which seal the annulus between the monitoring zones. The MP System has been used in many different geologic and climatic environments in drillholes ranging from a few feet to over 4,000 ft (1,200 m) in length. The 1.5-inch (38 mm) I.D. MP38 System has been used in the field since 1978, while the 2.25-inch (55 mm) I.D. MP55 System was developed in 1990-91.

Casing Components

The casing components of the MP System are made in either plastic or stainless steel. While the illustrations are of plastic components, the descriptions of operating principles that follow apply to both types of materials. Most of the components referred to are shown in Figures 1 and 2.

Casing

MP casing is supplied in a number of different lengths to provide flexibility in establishing the position of monitoring zones and associated seals in the drillhole. Common nominal casing lengths are 2 ft (0.5 m), 5 ft (1.5 m) and 10 ft (3.0 m). Actual casing lengths are less than the nominal lengths to account for the lengths of the couplings. The casing ends are machined to mate with MP System couplings.

Telescoping casing sections are used to protect the casing string from damage when ground movements are anticipated or where measurements of vertical displacements are desired.

Regular Couplings and End Caps

MP regular couplings are used to connect casing lengths where valved couplings are not required. The couplings incorporate O-rings for a positive hydraulic seal. A flexible shear rod provides a tensile connection. No adhesives are used when joining casings and couplings. MP38 regular couplings incorporate an internal, helical shoulder for the accurate location of

probes and tools in the well. MP55 regular couplings do not incorporate a helical shoulder.

End caps are placed on the bottom of a casing string. They also incorporate an O-ring seal so that the entire casing string is hydraulically sealed during installation. End caps are frequently used to seal the top of the casing between monitoring periods.

Valved Couplings

There are two types of valved couplings, measurement port couplings and pumping port couplings. Measurement port couplings (or measurement ports) are used where pressure measurements and fluid samples are required. In addition to the features of a regular coupling (including the helical shoulder in the case of MP55), measurement ports incorporate a valve in the wall of the coupling, a leaf spring which normally holds the valve closed, and a cover plate or screen which holds the spring in place. When the valve is opened, an access port is provided for the groundwater to enter the coupling.

Pumping port couplings (or pumping ports) are used where the injection or withdrawal of larger volumes of fluid is desired than would be reasonable through the relatively small measurement port valve (such as for purging or hydraulic conductivity testing). Pumping ports incorporate a sleeve valve, sealed by O-rings, which can be moved to expose or cover slots that allow groundwater to pass through the wall of the coupling. A screen is normally fastened around the coupling outside the slots.

Annulus Seals

When there are many monitoring zones in a single drillhole, multiple seals are required to prevent fluid migration from one zone to another along the annular opening between the drillhole wall and the casing. Placement of these seals can be difficult with any groundwater monitoring device. However, considerable success has been achieved with three types of well completion used with the MP System, provided each is combined with appropriate drilling and placement methods.

With the MP System, seals can be obtained by: a) backfilling with alternating layers of sand and bentonite or grout, b) using hydraulic (water) inflated packers or c) using packers inside a cased well with multiple screens. Figure 1 illustrates a drillhole containing the MP System with packers. Figure 2 illustrates a single measurement zone where the MP System is completed by each of the three common methods. Each sealing method is possible in most environments, but in many situations one method will stand out as the most advantageous.

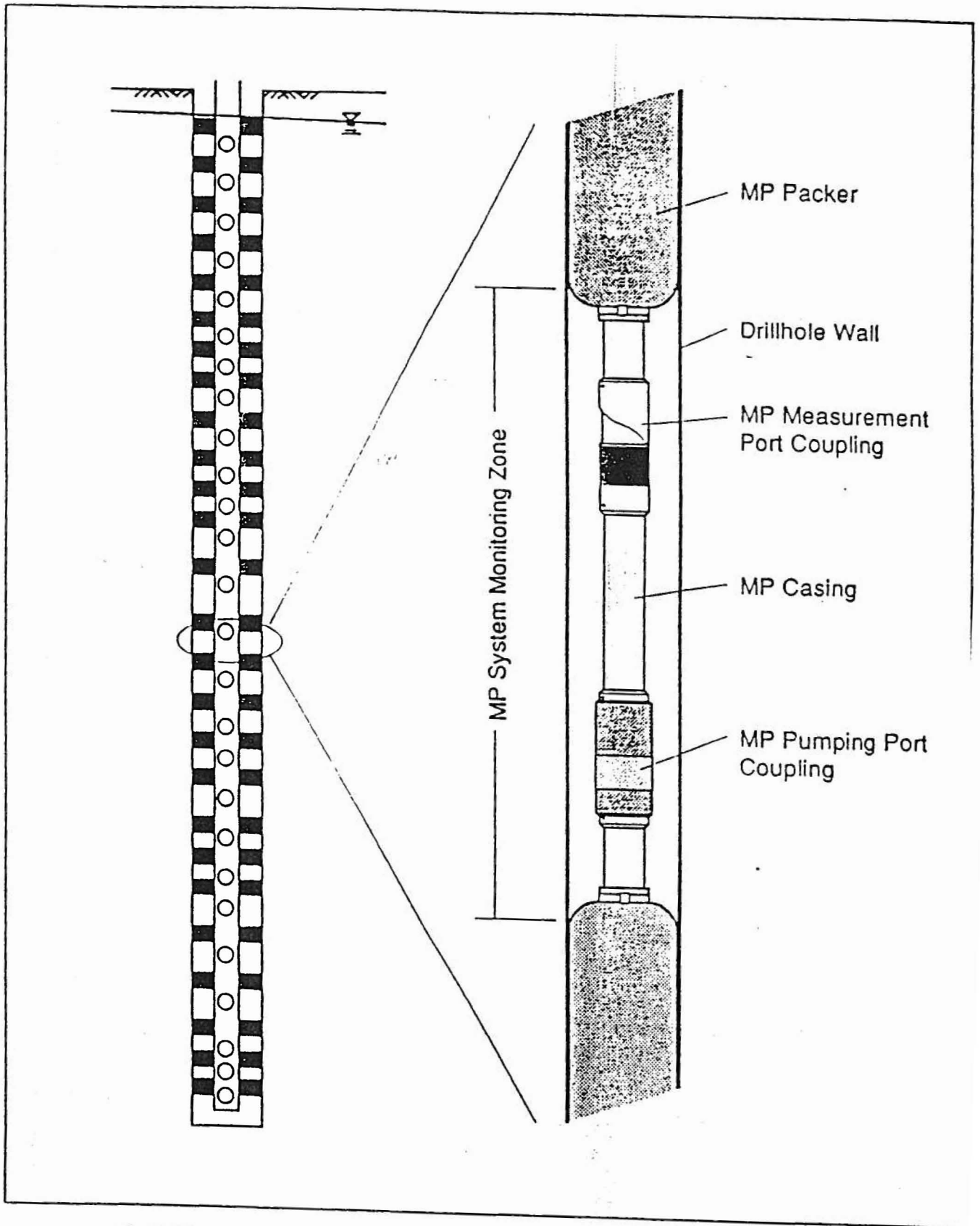


Figure 1. MP System Installation with monitoring zones isolated by packers.

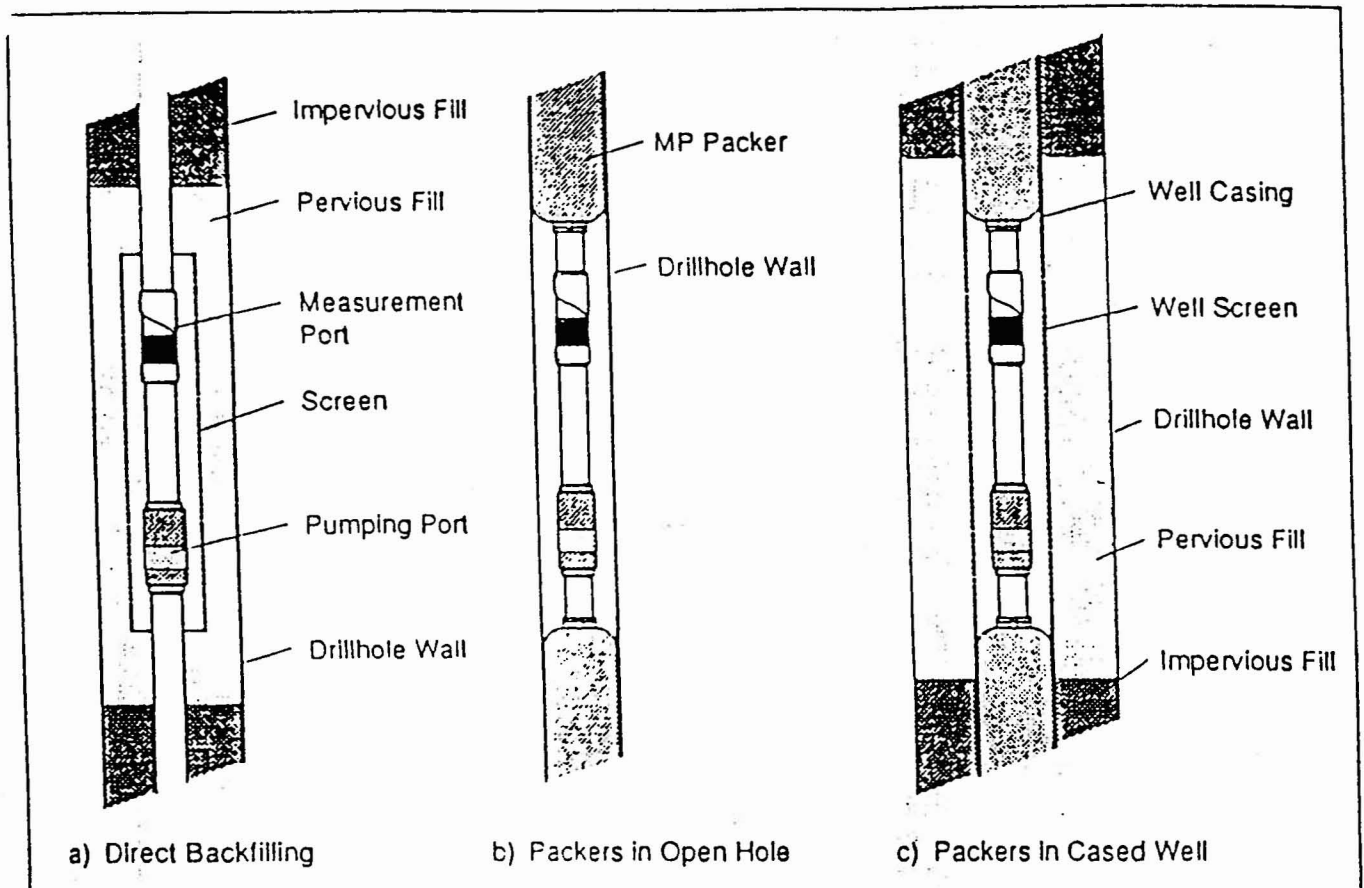


Figure 2. Common completion methods for the MP System.

Direct backfilling (Figure 2a) is recommended for: 1) large diameter drillholes, 2) shallow drillholes, 3) drillholes where little or no fluid circulation is anticipated in the hole during installation (i.e., when near-hydrostatic fluid pressures or low hydraulic conductivity is present over the length of the drillhole), and d) where packer gland materials are incompatible with the chemistry of the fluids present.

When direct backfilling is considered and fluid sampling is required, a very clean drilling method must be employed. While the MP System does permit purging of monitoring zones, the small size of the casing (particularly MP38) prevents sufficient energy being generated to develop the monitoring zone.

Backfill seals may include bentonite and/or grout slurries, bentonite chips or pellets or other materials with a relatively low hydraulic conductivity in comparison to that of the natural formations present.

MP casing packers incorporate an expandable gland mounted over a standard length of MP casing. The casing incorporates a one-way valve that allows fluid to travel through the wall of the casing into the packer and

prevents this fluid from flowing back out of the packer. Gland lengths are typically 3 ft (-1 m).

Packers in an open borehole (Figure 2b) are typically recommended for: 1) small diameter drillholes (those too small for good quality backfilling to be achieved), 2) deep drillholes, and 3) sealing against significant flows (e.g., flowing artesian conditions) in the drillhole. When packers are used, field labour is reduced since packer inflation is generally much faster than backfilling. When using packers, additional measurement ports are installed between monitoring zones. Such additional ports provide additional fluid pressure data for quality assurance (QA) purposes.

Packers in a cased well (Figure 2c) is a completion method that has proven very successful, particularly for environments where available hole sizes are too large for packers and/or where drilling additives, such as mud, must be used. This completion method involves drilling a large diameter hole, typically 12-inch (300 mm) and installing a 4-inch (100 mm) (for MP38) nominal diameter well casing with multiple screens. The well screens are located at all of the desired monitoring levels, based on information gathered during and following

drilling. Layers of backfill are placed to provide filters around the well screens and annular seals between. Each monitoring zone is then developed through the well casing. Following development, MP casing, ports and packers are installed inside the well casing. The MP packers are inflated against the inside of the well casing, providing interior annular seals between the monitoring zones. This completion method provides the ability to properly develop mud from deep mud-rotary drillholes, as well as to service the MP System during the operating life of the monitoring well.

Whenever casing packers are used, whether in open drillholes or cased wells, additional measurement ports are installed between monitoring zones for QA purposes. Measurements and tests carried out through these additional "QA ports" enable an evaluation of the effectiveness of each annulus seal. In open hole installations, such additional ports also provide added information on piezometric pressures in the portions of the drillhole between primary monitoring zones.

Screens and Filters

Where both pumping ports and measurement ports are being used and the ports are likely to be surrounded by sand fill or collapsed geologic material, a single well screen is generally placed over both the measurement port coupling and pumping port coupling in each monitoring zone as shown in Figure 2a. The screen helps ensure that the zone influenced by pumping through a pumping port coupling will extend to and include the region surrounding the adjacent measurement port coupling. Screen slot size and length should be chosen with a knowledge of local site conditions. If only fluid pressure measurements are required, a simpler fabric filter tube can be placed over the measurement port coupling and clamped at either end. This filter will help maintain the length of the monitoring zone and protect the measurement port valve from fine particles. The filter material should be compatible with the chemistry of fluids present.

Installation Procedures

Selection of Casing Components

The valved couplings (measurement port couplings and pumping port couplings) allow many monitoring zones to be established in a single drillhole. Horizons of hydrogeological interest are targeted on the basis of the best drillhole geologic and geophysical logs available. An installation log is prepared showing the locations of the casing components. If only fluid pressures are needed, only a measurement port coupling is required in each monitoring zone. If sampling, fluid withdrawal or fluid injection is anticipated, both a pumping port coupling and

a measurement port coupling are recommended in each monitoring zone. This is the case illustrated in Figures 1 and 2.

The casing lengths are chosen based on the desired locations of the monitoring zones and sealing elements. This requires an interpretation of the hydrogeologic conditions anticipated in each drillhole. Caliper logs and borehole video can be useful in selecting packer locations.

If consolidation or heave is expected along the borehole axis, telescoping casing sections may be used to minimize the opportunity for compressional or tensile forces to damage the casing.

MP Casing Installation

The downhole MP System components - casing, couplings and packers - are laid out at the site of the proposed monitoring well in accordance with the casing installation log. At that time, any last minute adjustments required to make the positions of the monitoring zones and seals match hydrogeologic details of the drillhole are completed and the appropriate revisions made to the installation log.

Next, the required coupling is attached to the top of each length of casing. The casing layout is checked again for compliance with the installation log. Serial numbers of measurement ports, pumping ports and packers are recorded, indicating their position on the installation log. The length of all casing sections is measured and recorded on the log.

The casing string is then assembled by lowering the casing segments into the drillhole and attaching each successive segment to the adjacent coupling one at a time. As each successive MP casing section is attached to the string in the well, the section number is checked and recorded on the installation log. The coupling joint is then subjected to an internal hydraulic pressure to verify its hydraulic integrity and the test result is recorded on the log. At intervals during placement of the MP System casing clean water is added to the inside of the MP casing to reduce its buoyancy.

In collapsing soil and poor quality rock, MP casing with packers and screens may be installed through flush-jointed guide tube such as drill rods or casing. Table 1 provides ranges of drillhole, casing and guide tube sizes for the MP38 and MP55 Systems. Figure 3 illustrates the major stages of installing through a guide tube: A) Following completion of drilling, the guide tube is positioned in the hole. All parts of the guide tube, including any shoe attached to the bottom, must be flush on the interior and of sufficient inside diameter to permit the MP components to pass through; B) The MP components are assembled and lowered into the guide

| System | I.D. | | Max. Depth | | Drillhole/Casing Size | | Min. Guide Tube Size | |
|--------------|------|----|------------|-------|-----------------------|---------|----------------------|-----|
| | In. | mm | ft | m | In. | mm | In. | mm |
| Plastic MP38 | 1.5 | 38 | 1,500 | 450 | 3-4.5 | 75-115 | 3 | 75 |
| Steel MP38 | 1.5 | 38 | 5,000 | 1,500 | 4-4.5 | 100-115 | 4 | 100 |
| Plastic MP55 | 2.25 | 55 | 2,500 | 750 | 4.5-7 | 115-175 | 4.5 | 115 |
| Steel MP55 | 2.25 | 55 | 6,600 | 2,000 | 4.5-7 | 115-175 | 4.5 | 115 |

Table 1. Important dimensions for the MP System.

tube in such a fashion that the packers and ports will be correctly positioned in the hole when the bottom of the MP is resting on the bottom of the drillhole; C) The guide tube is pulled back to expose a packer and that packer is inflated. The pulling/inflating sequence is repeated until all of the packers have been inflated. More than one packer may be exposed during each pull of the guide tube, depending upon the stability of the drillhole walls.

Casing without packers can be placed in various sizes of drillholes, with or without protective casing, as long as the drillhole diameter (and casing) is compatible with the backfilling method. Good backfilling techniques involve the use of one or more tremie pipes.

Once the MP casing has been placed in the drillhole, the packers are inflated (see Figure 3) or backfill is placed. If the MP casing was lowered inside a guide tube, the guide tube may be withdrawn all at once or in steps as the packer inflation or backfilling operation proceeds. An incremental casing withdrawal can reduce the opportunity for the drillhole wall to loosen and cave prior to the placement of seals.

Packer Inflation

Figure 4a shows the appearance of a casing packer when it has been placed in a drillhole before inflation. Figure 4b shows how the MP System casing packers are individually inflated using a packer inflation tool. This tool is lowered down the inside of the MP casing and is located in the correct position by the location arm seating in a coupling adjacent to the packer.

Two small packers (tool packers) are inflated, isolating the short segment of the casing containing the valve for the casing packer. At a pre-set pressure, the tool

injection valve opens and water is injected into the casing packer. During inflation the vent-head mechanism on the tool holds open the measurement port beneath the packer. This vents the pressure in the zone below the packer, allowing the packer to square-off without generating unnatural squeeze pressures. Figure 4c shows the inflated MP packer after the inflation tool has been removed. At increments of volume during the inflation process, pumping is stopped and the fluid pressure of the inflation system is measured and recorded. The pressure/volume data is plotted and kept for quality assurance purposes.

Packer inflation proceeds from the bottom of the hole to the top. There are no permanent inflation lines leading to each packer. As a result, there is no limit to the number of packers that can be placed in a drillhole apart from the finite limitations of packer length and drillhole length.

Purging Monitoring Zones

The strategy for purging the monitoring zones may vary depending on site conditions. Figure 5 shows a typical sequence of events in drilling and completing a monitoring well. Figure 5a shows a typical drillhole environment where the invasion of drilling fluids and/or the unnatural circulation of formation fluids has caused groundwater adjacent to the drillhole to be nonrepresentative of the formation fluid. Once the casing and annular seals (packer seals are shown in Figure 5b) have been installed, it is usually desirable to remove the nonrepresentative fluid. This removal, or purging, can be done in one of two basic ways: 1) Purging by natural groundwater flow, or 2) Pumping to purge monitoring zones.

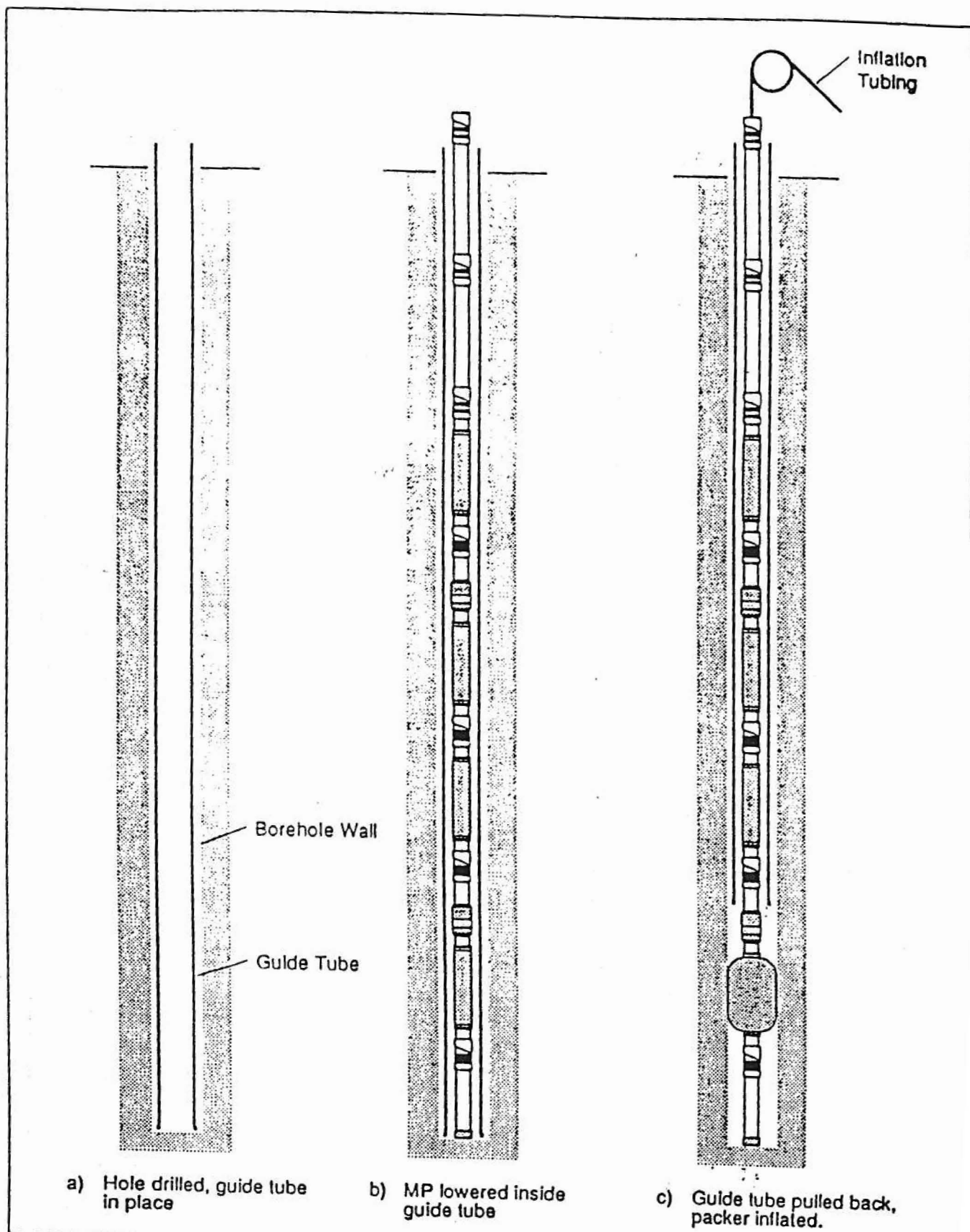


Figure 3. Installation of MP casing through a guide tube.

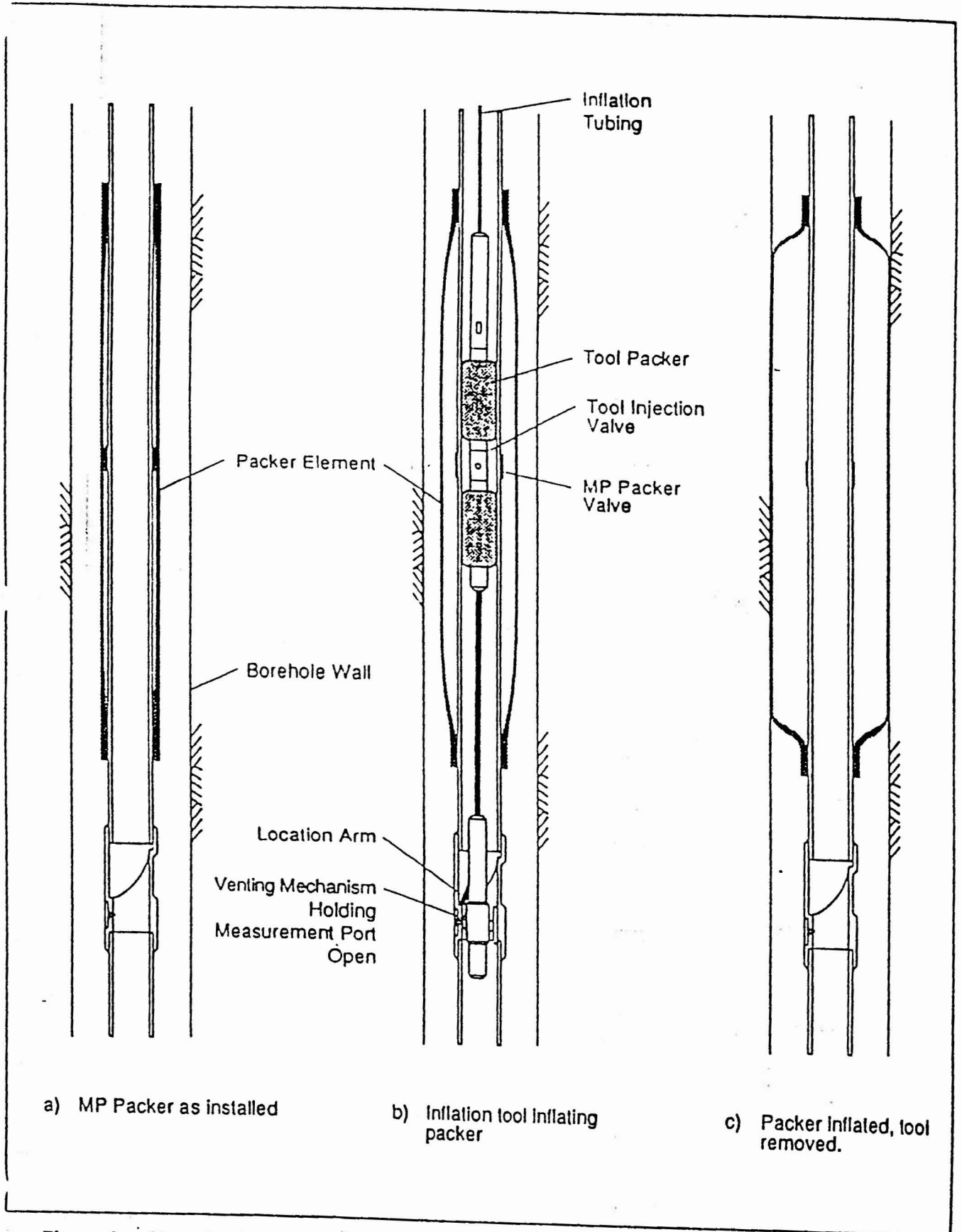


Figure 4. Steps In the Inflation of an MP System packer.

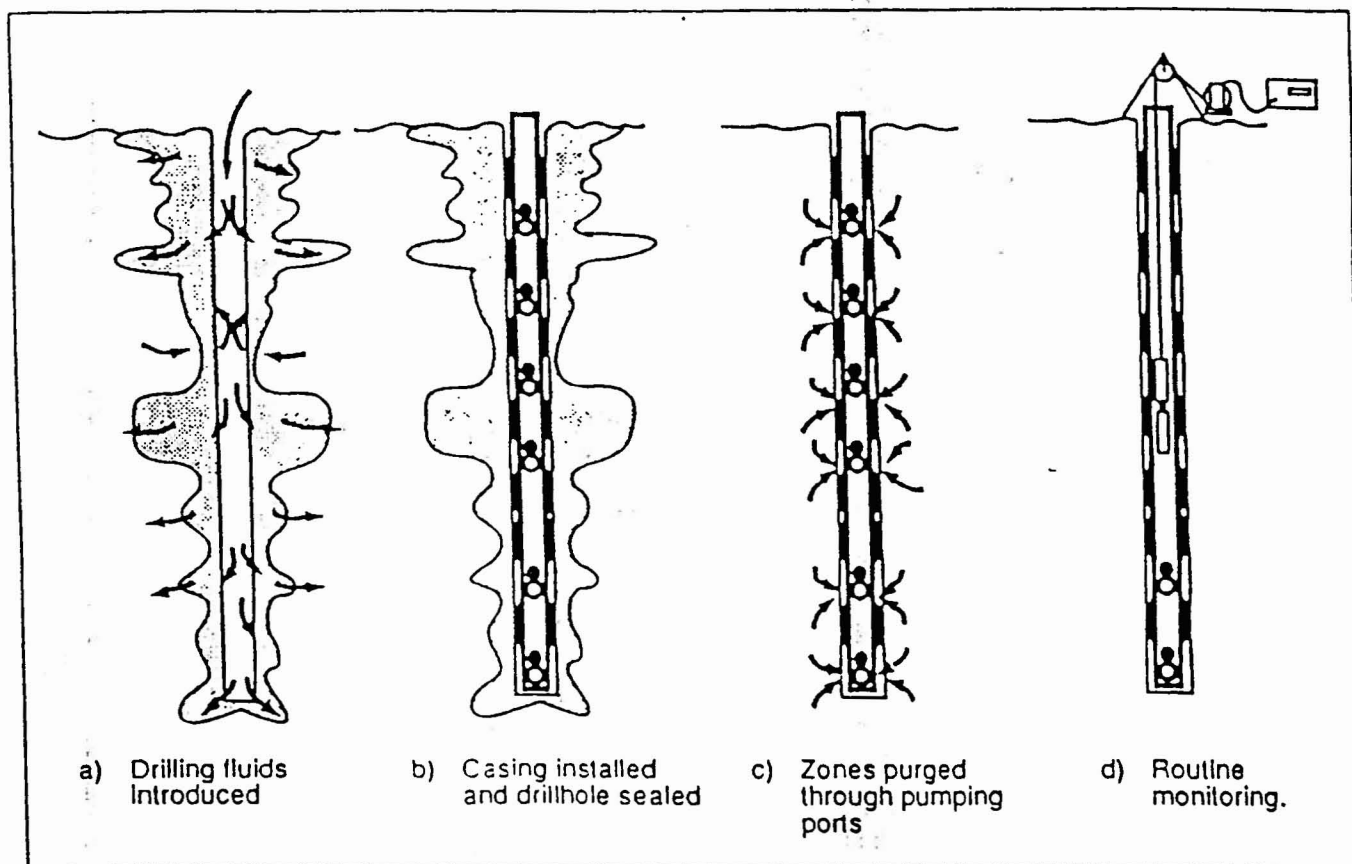


Figure 5. Typical sequence of events in purging monitoring zones.

Purging by natural groundwater flow is attractive, particularly in environments where groundwater flow is understood to be relatively rapid. In such an environment, unnatural fluids introduced during drilling may no longer be adjacent to the drillhole by the time the monitoring system has been installed. In such a case, there may be little to be gained from the investment of time and resources to pumping an arbitrary volume of water from each monitoring zone. Rather, fluid samples might be collected over a period of time and analytical results compared in order to evaluate the stabilization of conditions in the monitoring zone.

When purging by natural flow is not acceptable, monitoring zones can be purged by pumping. Zones may be pumped individually or several at a time (as shown in Figure 5c). Individual hydrogeologists and hydrochemists may prefer different purging techniques depending upon local conditions. However, the purging procedures are essentially the same as would be used for a single standpipe piezometer. One procedure which has been successfully used is described below.

- 1) An acceptable and convenient tracer is added to the drill fluid during drilling.

- 2) After the casing has been installed and the packers have been inflated, the pumping ports in all or a portion of the monitoring zones are opened with the use of an open/close tool.
- 3) Fluid from the inside of the MP casing is pumped out of the well. The volume of fluid removed and the pumping time will depend on many factors including: the drilling method, the length of time the hole was left open prior to completion, the hydrogeological conditions in the drillhole, and the accuracy required. The use of a tracer can be helpful in determining when the pumping is completed.
- 4) Once pumping has been completed, all the pumping ports except one are closed with the use of the open/close tool. With one pumping port open, the MP casing is hydraulically identical to a standpipe piezometer. A quantity of fluid may be pumped from inside the MP casing to complete the development of this monitoring zone. Hydrogeologic testing of this zone and its adjacent casing seals can be done at this time. For example, slug tests can be undertaken to obtain transmissivity and storativity values. Thi

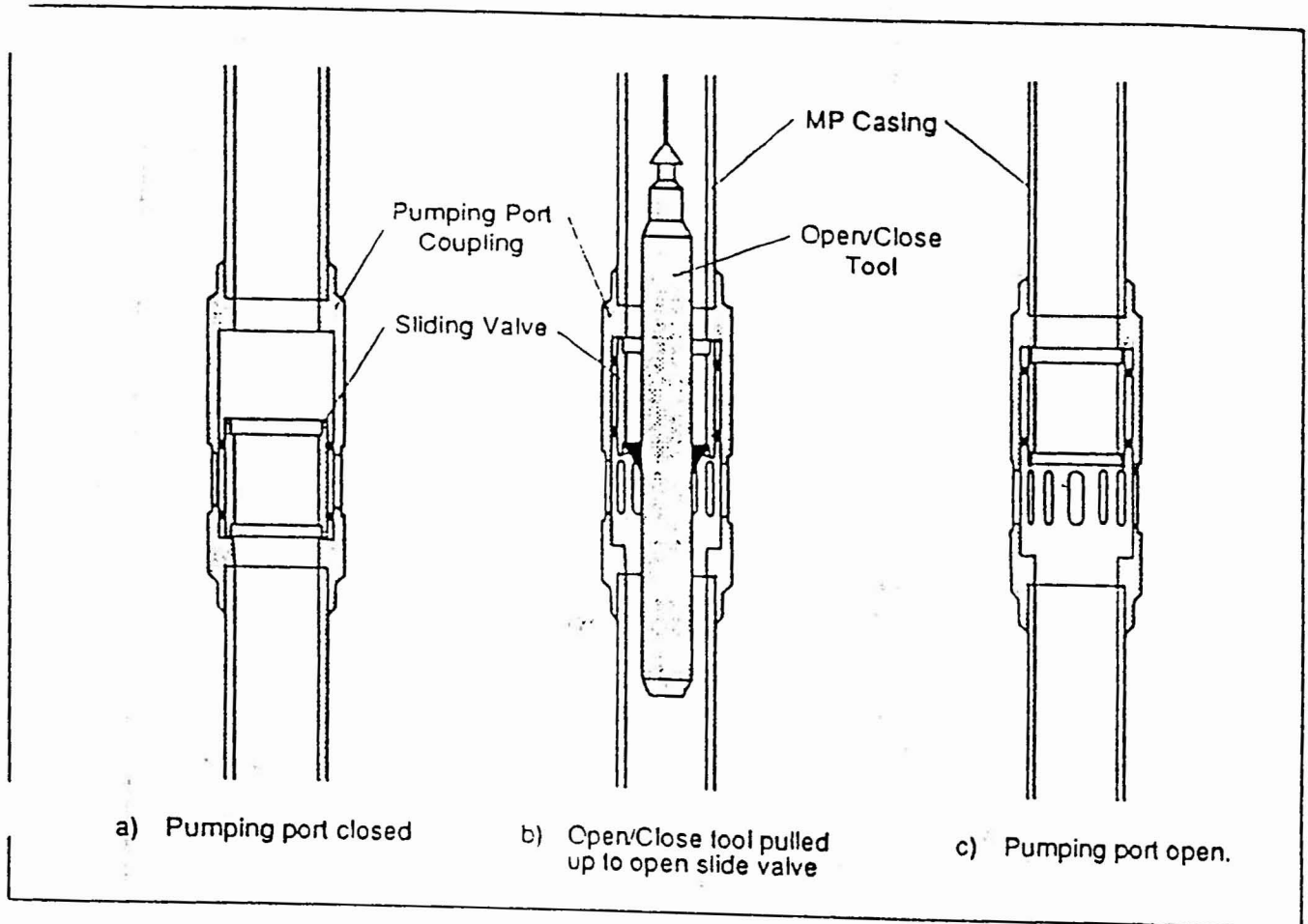


Figure 6. Operation of an MP pumping port.

pumping port can then be closed, the next one opened and the process repeated.

Following purging, the MP System is ready for sampling and for pressure measurements as indicated in Figure 5d.

Operation of the Pumping Ports

To operate the pumping port valve, an open/close tool is used as illustrated in Figure 6. This tool has spring-loaded "jaws" which can be mechanically activated from the surface. The pumping port is shown closed in Figure 6a. To open the valve, the tool is lowered on a wireline with the jaws extended and pointing upward (i.e., so that they will catch on shoulders when the tool is raised). In this condition, the jaws will spring through the couplings as the tool is lowered to just below the desired pumping port coupling. The tool is then pulled up so that the jaws engage the bottom shoulder of the sliding valve. By continuing to pull up on the wireline, the valve can be opened, as in Figure 6b. Once the valve is opened, the jaws can be collapsed into the housing and the tool recovered. With this one valve opened, fluids can be added to or removed from the monitoring interval by

injecting or pumping from the MP casing. Other zones may still be monitored in the normal manner using a pressure probe or sampling probe as they will not be hydraulically connected to the interior of the casing.

To close the pumping port coupling, the open/close tool is brought to the surface and the housing is reversed so that the jaws point downward (i.e., the tool will stop on exposed shoulders when the tool is lowered). The tool is lowered to the open pumping port with the jaws collapsed into the housing. Once the tool is located near the pumping port, the jaws are released and the valve is closed by tapping on the top shoulder of the sliding valve with the tool.

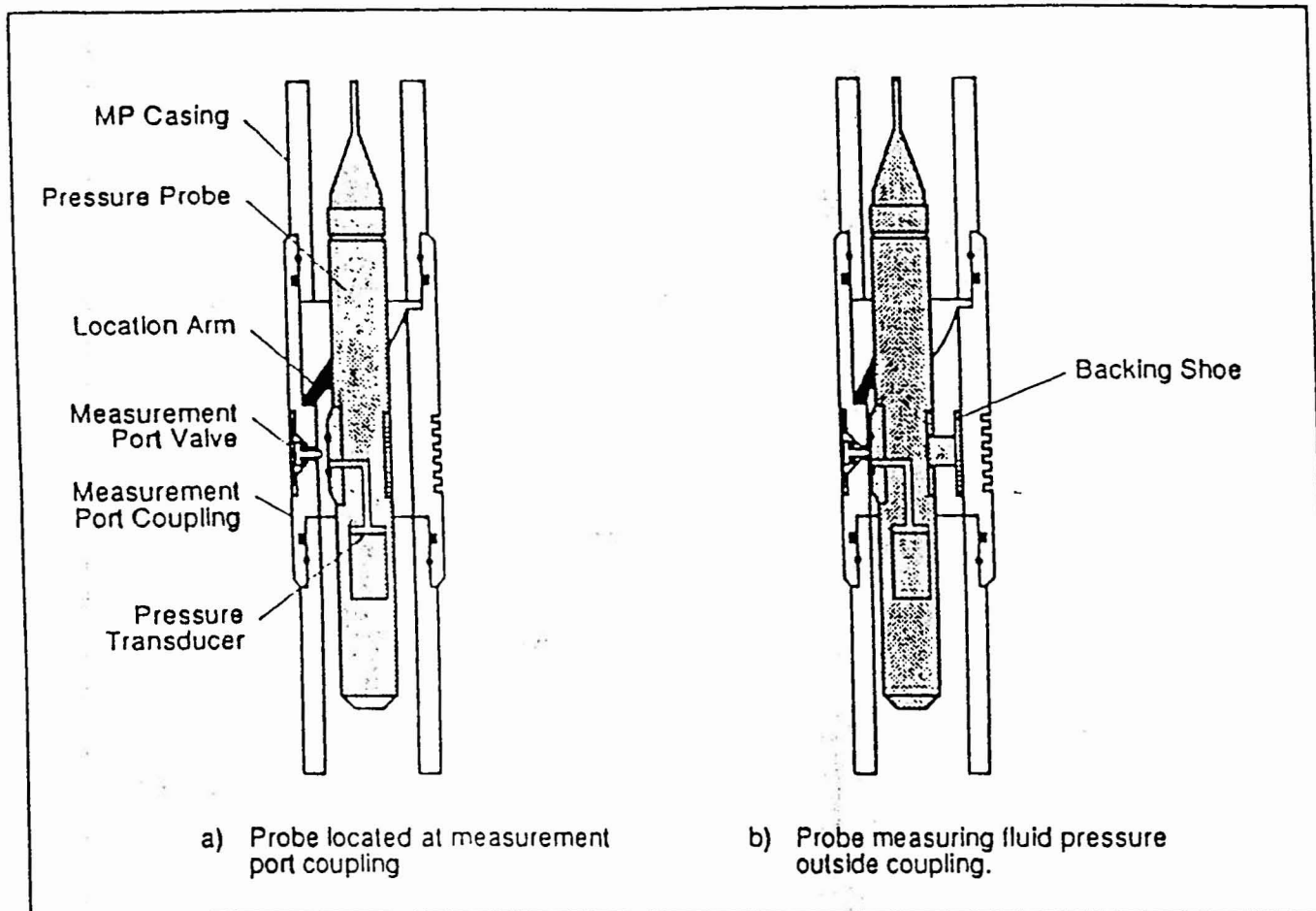


Figure 7. Operation of a pressure probe.

Testing and Monitoring

Fluid Pressure Measurements

Fluid pressure measurements can be made at each location in a drillhole where an MP measurement port coupling has been installed. The measurement coupling includes a helical landing ring and a leaf spring valve which is normally closed. The fluid pressure is measured using a MOSDAX® pressure probe which incorporates a location arm, a backing shoe, a face seal, and a fluid pressure transducer. These features are shown on Figure 7. The probe is operated on a cable connected to an interface and portable computer at the top of the monitoring well. Using MProfile™ software, the computer displays the pressure both graphically and digitally, along with transducer temperature, well information and probe status (see Figure 8).

The following procedure is used to make fluid pressure measurements. The probe is lowered to a point below the first measurement port to be accessed (usually the deepest). The location arm is released from within the probe body. The probe is raised to just above the

measurement port coupling and then lowered until the location arm rests on the helical landing ring in the coupling. The weight of the probe causes it to rotate into position at the correct depth and orientation to operate the valve (Fig. 7a). At this point the pressure transducer is measuring the fluid pressure inside the MP casing at that depth. This reading will be displayed on the surface computer and is recorded. If convenient, the depth to water inside the MP casing is also measured and recorded at this time as a check on the pressure transducer.

The backing shoe is then activated. It pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The transducer is now hydraulically connected to the fluid outside the coupling and isolated from the fluid inside the casing (Fig. 7b). The reading displayed on the surface computer will be the fluid pressure in the formation outside the measurement port. The pressure outside the port can be observed as long as desired and recorded as often as desired. After the reading has been recorded, the probe backing shoe is deactivated (retracted) and the valve in the coupling reseals. The probe will again be

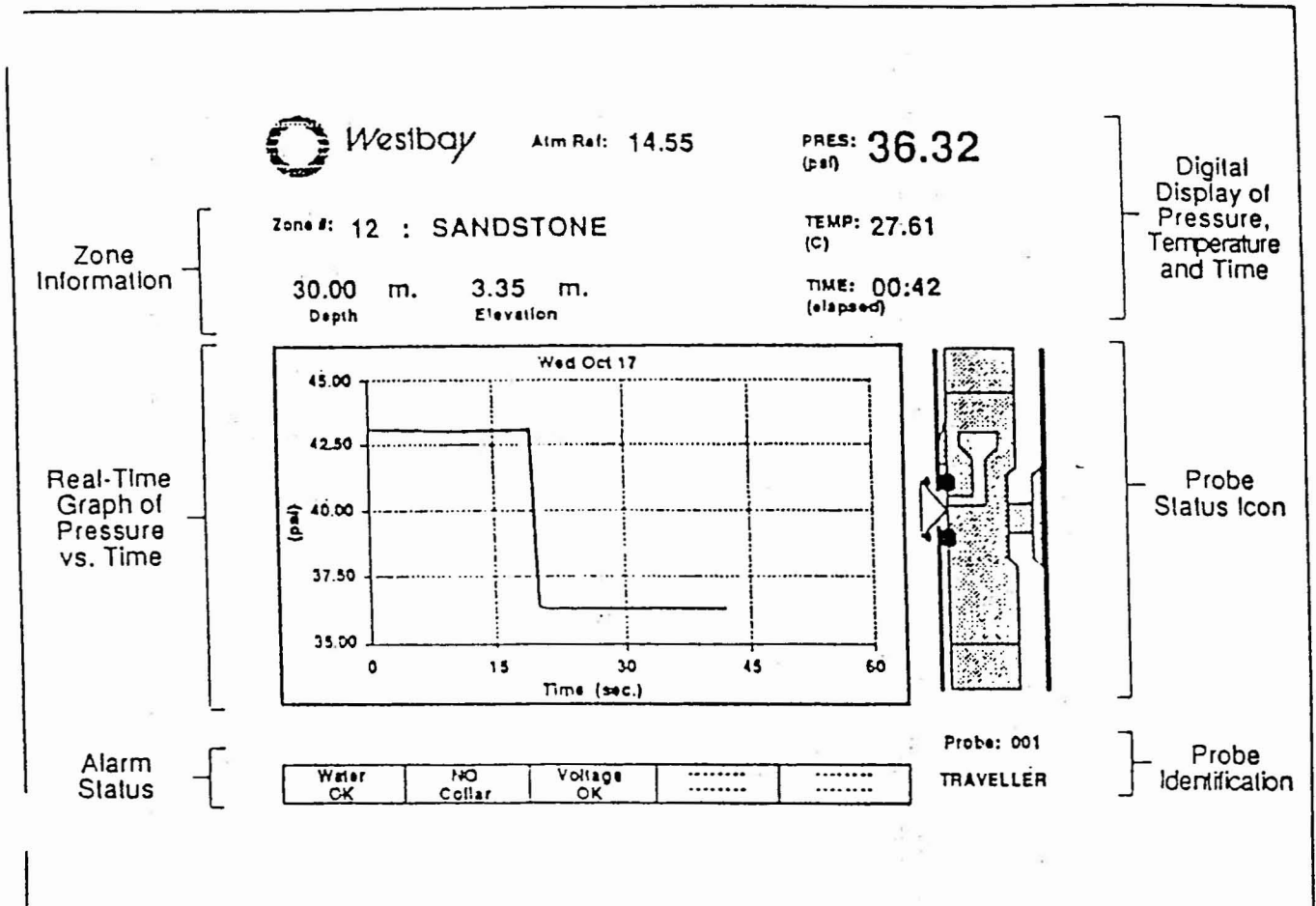


Figure 8. Data display on surface computer when using MProfile software to operate a MOSDAX pressure probe.

measuring the fluid pressure inside the MP casing (Fig. 7a). The pressure in the casing is again recorded, for quality assurance purposes.

Measuring Pressure In Low Permeability Environments

Very low permeability environments present a special challenge for measuring fluid pressures. When the routine profiling procedures described above are followed, a stable pressure may be observed through the measurement port. However, the act of opening the port may have been sufficient to change the pressure in the monitoring zone, and if the zone is very tight, that pressure change may not dissipate quickly enough to be observed. In such an environment it is always difficult to determine the validity of a static measurement unless some form of dynamic test is carried out as well. In the case of the MP System, this is done through the use of a MOSDAX sampler probe. As illustrated in Figure 9a), the MOSDAX sampler incorporates all of the features of a pressure probe, plus a valved passage which is controlled via the surface computer. With the sampling valve closed the probe acts

identically to a pressure probe and thus may be used for single-probe profiling. The difference is that once the probe is located and activated (Fig. 9b), the fluid level inside the MP casing may be adjusted to a level slightly higher or lower than the piezometric level in the monitoring zone. The sampling valve is then opened (Fig. 9c), exposing the monitoring zone to the fluid pressure in the MP casing. In very low permeability environments, no water will flow during this time. The sampling valve may be kept open for a specified period of time (such as one minute). The sampling valve is then closed (Fig. 9d) and the pressure recovery in the monitoring zone is recorded vs. time (Fig. 10). Standard analytical methods can be applied to the pressure recovery data in order to determine the apparent pressure in the monitoring zone. The same procedure can be used for testing hydraulic conductivity in low-k zones.

Pressure Monitoring Methods

The two principle methods of monitoring fluid pressure with the MP System are illustrated in Figure 11. Single probe profiling (Fig. 11a) involves an operator

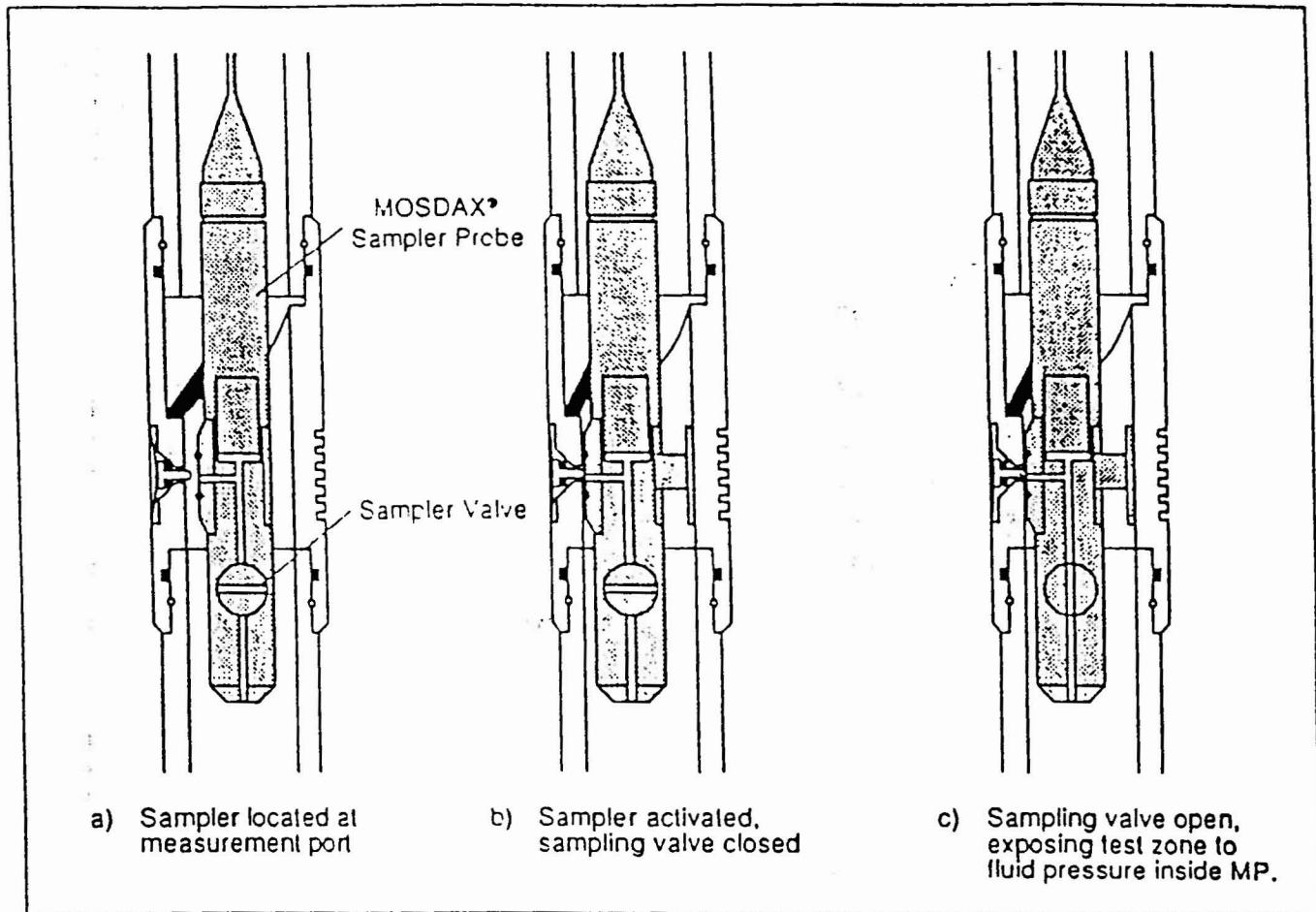


Figure 9. Using a sampler probe for testing hydraulic conductivity and verifying fluid pressure measurements in low permeability environments.

travelling to each well with a set of portable equipment including a pressure probe, cable and reel, interface and computer. The operator manually locates the probe at each measurement port and carries out fluid pressure measurements one at a time. MProfile stores the data on disk with each record tagged as to the location of the probe in the well, date, time, and probe status. Single probe profiling is generally adequate for monitoring fluid pressure up to a frequency of once per month.

When pressure measurements are desired more frequently than is reasonable for single-probe profiling, or when continual observation and recording of unanticipated events is required, the monitoring well can be configured for automated datalogging (Fig. 11b). Any or all of the measurement ports in a well may be selected for automated monitoring. Lengths of cable are made up to span the distance between each probe and the next. The string of probes and cable is assembled and lowered into the well. The datalogger and a computer are attached at the surface and the lowermost probe is located and activated in the appropriate measurement port. The

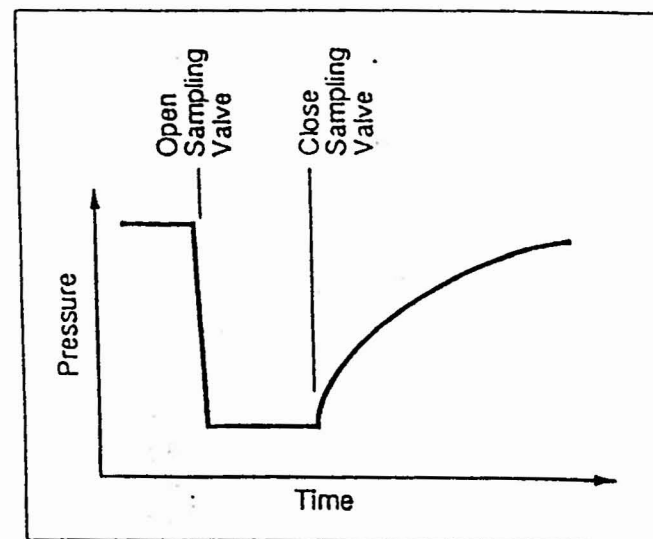


Figure 10. Typical data record from a test in a low permeability zone using sampler

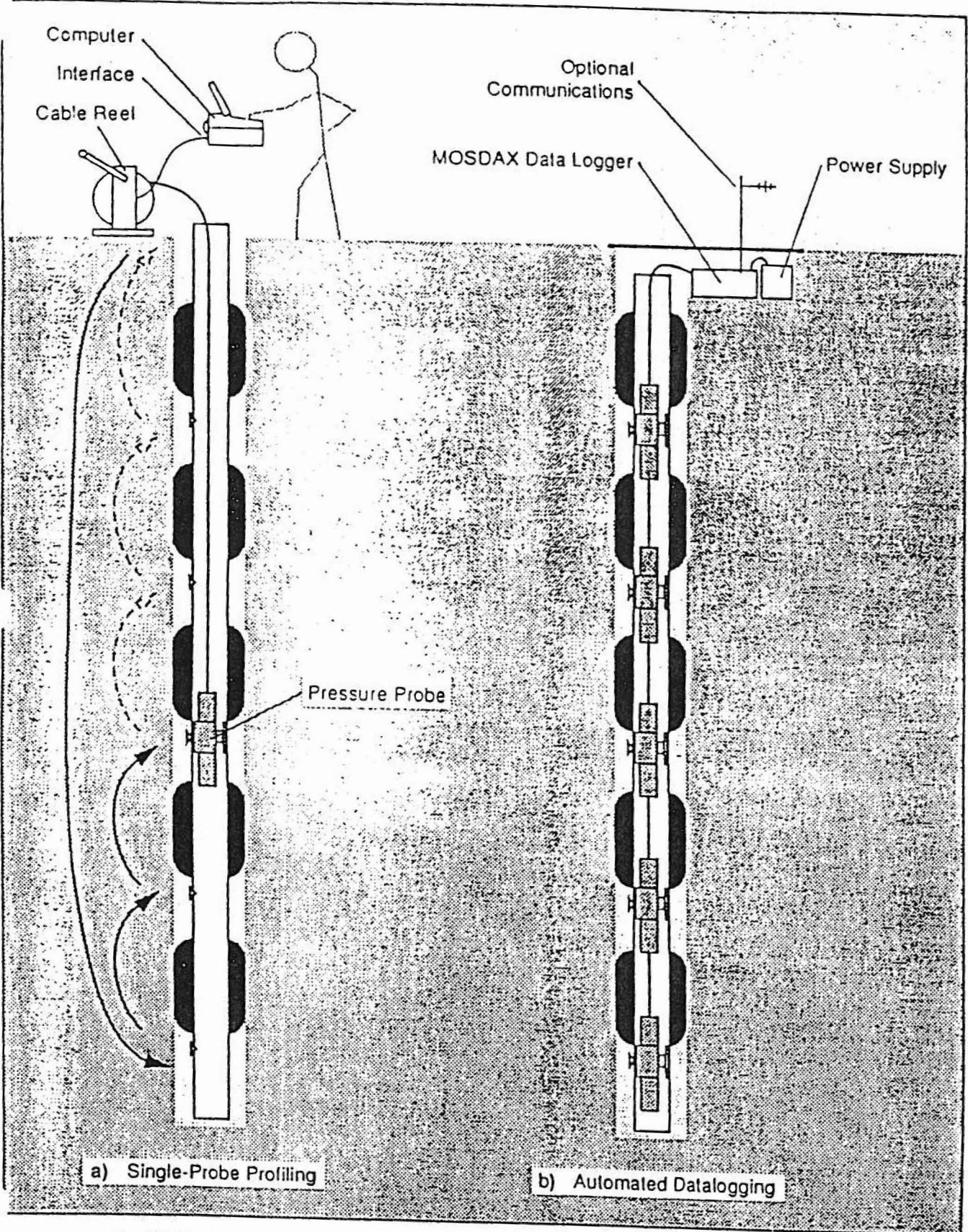


Figure 11. Methods of monitoring fluid pressure with the MP System.

remaining probes are located and activated sequentially from the bottom of the well to the top. Once all of the probes are activated, the computer is used to program the datalogger.

Recording of pressure measurements may be carried out on a simple time basis (e.g., one reading per hour or one per day), or the logger may be programmed to continually scan each probe and record pressures if a specific threshold value is exceeded. Each probe may be assigned an independent threshold (i.e., record data if probe 1's reading changes by 1 ft of water, probe 2 by 3 ft, etc.).

The datalogger may stand unattended, in which case an operator would periodically visit the site to download the stored data, or the datalogger may be connected to a telemetry system such as an RF modem, cell phone system, or landline. When connected to a communication device, a second threshold can be designated for each probe which will cause the logger to transmit an alarm signal to the host computer.

A unique aspect of monitoring in the MP System is that unusual pressure readings can often be verified by means of an in-situ calibration check. When an alarm condition is received, a natural first reaction is to question the validity of the measurement ("is it real, or is it the instrument?"). When datalogging with the MP System, if an alarm were received, the operator can log onto the well via remote communications, deactivate two or more probes including the one causing the alarm and compare their measurements of the fluid pressure within the MP casing. The column of fluid inside the MP casing is independent of all of the monitoring zones and thus serves as a reference pressure source. If the deactivated probes agree on the internal pressure, the alarm condition can be taken to be valid and the probes can be reactivated to resume monitoring. If the probe causing the alarm did not agree with the others, instrument error might be suspected. In such a case, an operator could visit the well, remove the string of probes, replace the offending probe and reinstall the string to resume monitoring. The offending probe could then be calibrated and serviced in a laboratory.

Fluid Sampling

Fluid samples are obtained by lowering a sampling probe and sample container to the desired measurement port coupling. As shown on Figure 12, the sampling probe operates in similar fashion to the pressure probe except that a groundwater sample is drawn through the measurement port coupling. Whenever the sampling probe is operated with the sampling valve closed, it is identical to a pressure probe, supplying the same data.

The procedure for taking a groundwater sample is as follows. A clean, empty sample container is attached to the sampling probe. The probe and container are prepared (e.g., evacuated) in a manner suited to the specific project and the sampling valve is closed to prevent the fluid inside the MP casing from entering the sample container. The probe and container are lowered to below the selected measurement port coupling. The location arm is released and the probe is positioned in the measurement port coupling (Fig. 12a). The fluid pressure inside the MP casing is recorded.

The backing shoe is activated and pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The interior passage of the probe is now hydraulically connected to water outside the coupling (Fig. 12b), but no fluid movement takes place. During this operation the change in fluid pressure is observed at the surface and may be recorded.

The sampling valve in the probe is opened, allowing fluid from outside the measurement port to flow through the probe and enter the sample container (Fig. 12c). The fluid displayed at ground surface drops and then recovers as the fluid in the container builds to formation pressure. Once the container is full, the sampling valve is closed (Fig. 12b), the backing shoe is deactivated (retracted) (Fig. 12a) and the fluid pressure inside the MP casing is once again recorded. The sampling probe and sample container are then pulled to the surface. The sampling probe can then be cleaned, a clean container attached and the procedure repeated.

When using a non-vented sample container, the fluid sample is maintained at formation pressure while the probe and container are returned to the top of the well. Once recovered, there are a variety of methods of handling the sample:

- the sample may be depressurized and decanted into alternate containers for storage and transport,
- the sample container may be sealed and transported to a laboratory with the fluid maintained at formation pressure,
- the sample may be transferred under pressure into alternate pressure containers for storage and transport.

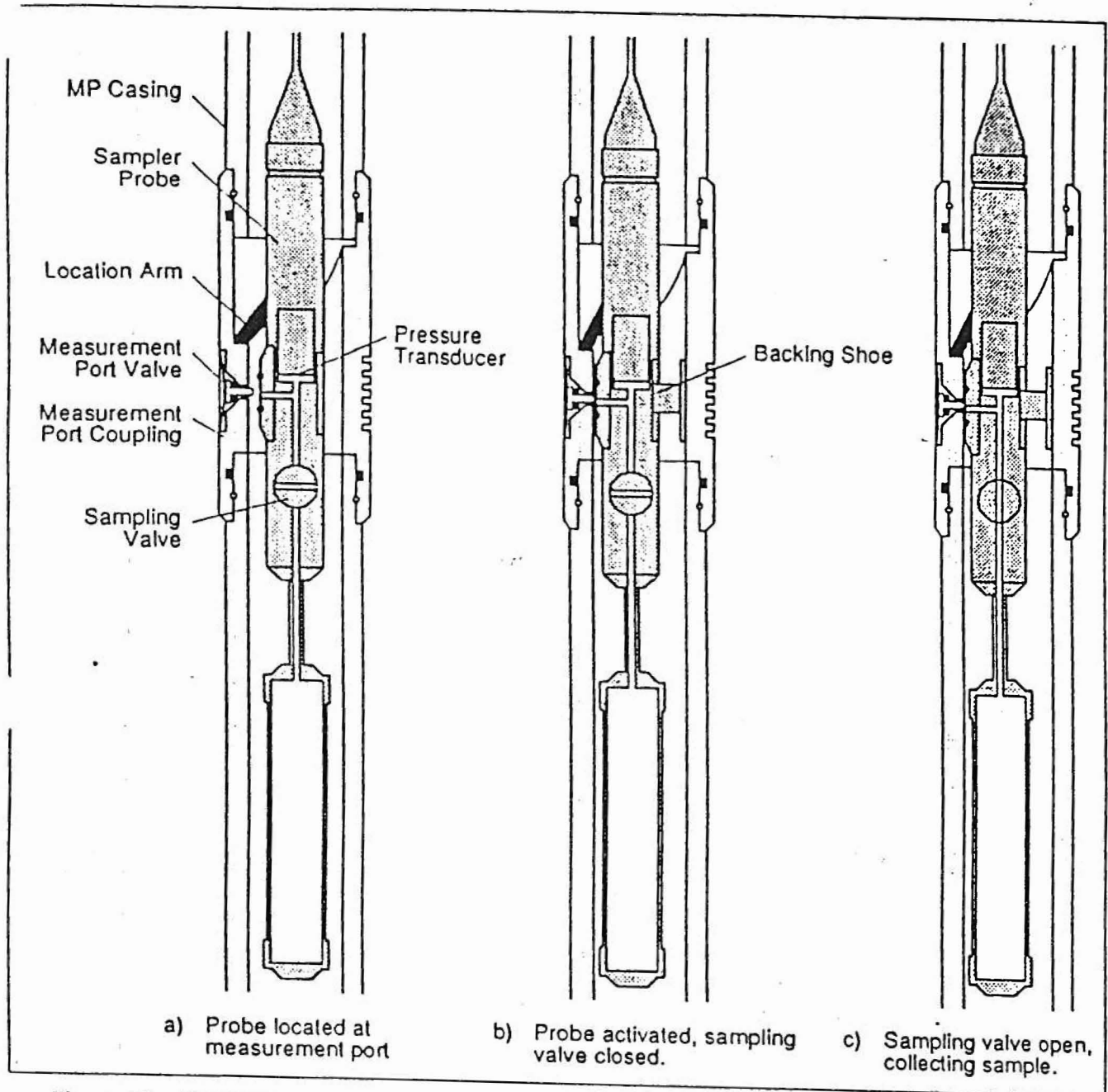


Figure 12. Operation of a sampler probe.

The advantages of this discrete sampling method can be summarized as follows:

- 1) The sample is drawn directly from formation fluids outside the measurement port. Therefore, there is no need for pumping a number of well volumes prior to each sampling event. Because there is no pumping prior to sampling, the sample is obtained with minimal distortion of the natural groundwater flow regime, the storage and disposal of large volumes of hazardous purge fluids is eliminated, and operator exposure to hazardous fluids is reduced.
- 2) The lack of pumping means samples can be obtained quickly, even in relatively low permeability environments.
- 3) The sample travels a short distance into the sample container, typically from 1 to 2 ft (0.3 to 0.6 m), regardless of depth.
- 4) The risk and cost of storing and disposing of hazardous purge fluids is virtually eliminated.

Hydraulic Conductivity Testing

A variety of different test methods can be employed to measure the hydraulic conductivity of formation materials with the MP System. These include variable head, constant head and pressure-pulse tests.

Variable head tests are the single well test method most commonly used with the MP System. Using these types of tests in the MP System, hydraulic conductivities between 10^{-7} and 10^{-4} cm/sec can be measured.

For variable head tests the valved pumping port couplings are used to provide the hydraulic connection between the interior of the MP riser tube and the test zone. In cases where monitoring zones are to be purged, it is convenient to carry out hydraulic conductivity testing just prior to or following purging. The head (fluid level) inside the MP casing can be adjusted while all port valves are closed, then the selected pumping port can be opened in a controlled manner (pumping port operation is described in the discussion of purging). This allows accurate measurement of both the initial head change and the time at which the head change is applied (t_0). The pumping port valve is opened rapidly (in less than one second), which satisfies the theoretical requirement that an instantaneous head change be applied to the tested zone.

For rising head tests the water level inside the MP casing is bailed or pumped down to a pre-determined level below the static water level in the test zone. For falling head tests the water level is raised to a level above the static water level in the zone to be tested. Measurement equipment is set in place and the pumping port valve is opened. Recovery of the water level in the MP casing is measured and recorded vs. time. A water level tape or pressure transducer is commonly used to

record the water level changes. Figure 13 shows a typical record of water levels during a rising head hydraulic conductivity test.

Slug tests are carried out by opening the pumping port coupling at the zone to be tested and allowing the water level in the MP casing to equilibrate to the static water level for that zone with measurement equipment in place. The initial head change is then applied by rapidly lowering a displacement slug (a length of solid rod or sealed pipe) into the water. The recovery of the water level is measured and recorded vs. time. The slug test can be repeated and recorded again when the slug is removed from the water. Figure 14 shows a typical record of water levels during a slug test of hydraulic conductivity.

Data from variable head hydraulic conductivity tests may be analysed using any preferred calculation method. The most commonly used methods are those of Hvorslev (1951), Cooper et al. (1967) and Bouwer and Rice (1976). Selection of these or any other analytical method should be based upon an assessment of how well the test conditions comply with the simplifying assumptions inherent in the analytical method.

In very low permeability environments (hydraulic conductivity less than 10^{-7} or 10^{-4} cm/sec) the formation fluid pressure can be changed with very little fluid movement. As a result, tests can be carried out through the measurement port valve rather than the pumping port valve. Using a sampler probe with a transducer the zone to be tested may be exposed to the fluid pressure inside the MP casing for a period of time (see Fig. 9 and discussion of measuring fluid pressure in low-k environments). The zone may then be shut-in and the recovery of fluid pressure over time measured and recorded. Figure 10 shows a data record from such a test.

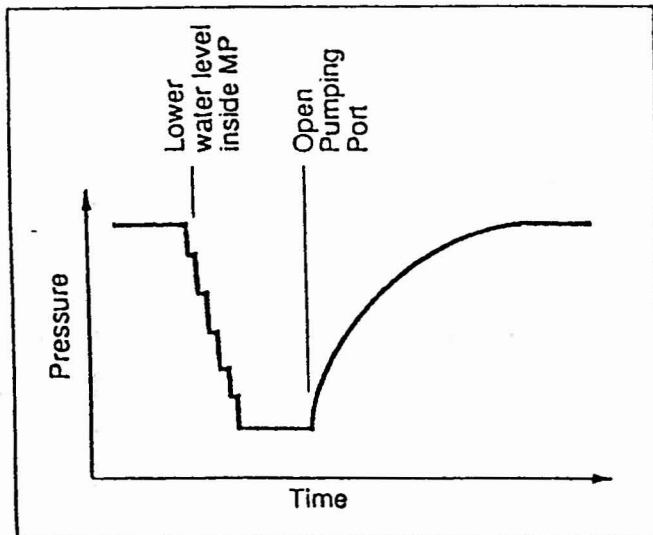


Figure 13. Typical data record from a rising head test.

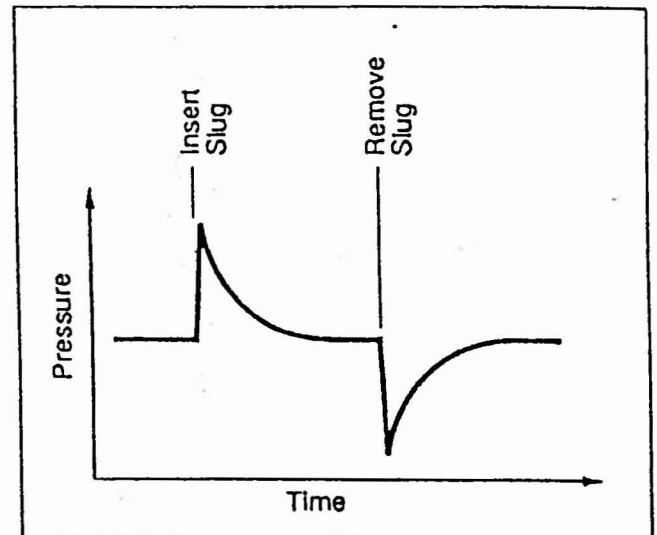


Figure 14. Typical data record from a slug test.

Field Quality Control

There are two distinctive parts to any quality assurance program. The first involves manufacturing and testing procedures which avoid the production or installation of equipment that may result in the collection of erroneous data. The second involves field operational procedures which will ensure that erroneous data are not generated as a result of the failure of any component to function as intended. Although the first part is necessary to allow the installation of useful monitoring wells, the second must also be rigorously applied to identify sources of erroneous and misleading results.

The MP System has many unique features for field quality control which clearly separate it from other types of groundwater monitoring instrumentation. These features are the result of designing components in response to the stringent requirements of users in the fields of nuclear and hazardous waste management.

Quality control tests are carried out at various points during the field use of the MP System and tend to be grouped into three periods: during installation, following installation, and during routine monitoring.

During Installation

During installation of the MP System the following operations form part of the quality control procedures:

Drill core or cuttings and geophysical logs are carefully checked to see that monitoring zones and annular seals are placed at the optimum positions. In cased wells, the well casing is inspected to verify that the interior surfaces are suitable for establishing good quality packer seals and backfill is placed under carefully controlled conditions with frequent measurements of material depths.

Westbay casing components are carefully inspected to see that critical surfaces are undamaged, sealing O-rings are clean and in place, and components are correctly oriented. Serial numbers are recorded along with component position in the installation. These operations link the field quality control to production test results.

As each section of MP casing is attached, the connection is pressurized with water and observed for any signs of leakage. Test results are recorded on the installation log.

During inflation of each MP packer, incremental volumes and pressures are recorded and plotted. These data allow an evaluation of drillhole conditions and provide the first indication of the quality of the annular seal obtained.

Following Installation

Immediately following installation further checks are carried out to verify the operation of the system. These include the initial pressure profile which serves to confirm the operation of the inlet valves of the measurement port couplings. Observed head differences across exterior casing seals directly indicate the seal effectiveness. Where such head differences are not observed, the annular seals can be artificially stressed by opening a pumping port in one monitoring zone and withdrawing or adding a slug of water from inside the casing while using the pressure probe to observe the pressure response in the monitoring zone on the other side of the seal. In cased wells and wells in low permeability environments, stresses can be applied through measurement ports in order to evaluate seal integrity.

Additional measurement ports are routinely installed between monitoring zones, further enhancing the ability to carry out thorough quality control tests.

Fluid can be added to packers at any time following installation and the pressure at which further fluid injection occurs can be compared with the injection pressures recorded during the initial inflation.

During Routine Monitoring

A number of quality control checks are built into the routine monitoring procedures.

When measuring fluid pressures, the pressures measured inside the MP casing at each measurement port are recorded immediately before and after the measurement made through the port. These inside casing values serve a number of purposes: 1) comparison of the two values confirms that the transducer was operating the same way after the reading as before, 2) comparison of the inside values from one set of measurements to the next confirms transducer stability over the intervening time period (assuming the water level inside the casing is the same), and 3) if the head of fluid inside the MP casing is known, an in-situ calibration check of head of water versus transducer output is obtained. Any unacceptable changes which show up during monitoring can be checked and corrected through laboratory calibration of the instrument.

Water sampling procedures with the MP System improve quality control because: 1) the short flow path between the formation and the container greatly reduces the surface area contacted by the sample, 2) the contacts between the water sample and the atmosphere are eliminated, 3) observing and recording the water level inside the MP casing during sampling confirms that the sample obtained is from outside the casing, and 4) sampling without purging reduces the disturbance of the

natural system, minimizing unnatural changes in chemistry. Sampling methods can be varied to compare the effects of atmospheric contact versus no atmospheric contact and maintaining the sample under pressure versus allowing depressurization of the sample.

During water sampling, sample blanks and spikes may be collected using identical procedures for sampling, preservation, handling and shipping. Travel blanks and spikes may also be collected using identical procedures for handling, preservation and shipping. The chemical analyses of samples obtained using the MP System may be compared with those of samples collected from the same zone by alternate means.

Finally, the pumping port may be reopened should further purging appear to be desirable.

For both fluid pressure and water quality data, the MP System can provide corroborative data. That is, a high density of data can be obtained in a single installation so that significant changes in piezometric pressure and/or water quality can appear as transitions along a depth profile. Thus, neighboring values will corroborate one another rather than indicating abrupt changes which would cause one to question anomalous values.

Serviceability

In the event that quality control testing should reveal a component which is not operating properly, various steps can be taken to remedy the problem including, in certain cases, removing the MP casing string, replacing faulty components and reinstalling the string.

Table 2. Summary of major quality control aspects of the MP System.

| Provides the Ability to Verify | |
|---------------------------------------|---|
| Well Integrity | ✓ |
| Individual Seals | ✓ |
| Sample Origin | ✓ |
| Fluid Pressures | ✓ |
| Well is Serviceable | ✓ |

Summary

The modular nature of the MP System permits a large number of monitoring zones to be accessed through valves placed inside a single closed tube or casing installed in a single drillhole. Such a monitoring system can provide a detailed view of the variation of piezometric pressure and water quality with depth. The valved couplings permit purging of the well following installation and allow all standard hydrogeologic tests to be carried out in each zone. Routine sampling is carried out without repeated purging, eliminating the need to store and dispose of large volumes of purge fluid and reducing operator exposure to hazardous fluids. The valves also permit an evaluation of the condition of exterior casing seals at any time after installation. Casing packers allow multiple seals to be established easily and quickly, providing the required hydraulic isolation of each monitoring zone. The modular design of the downhole components means the number and location of monitoring zones and seals can be modified on the basis of the best information available in the field at the time of installation. The exact depth of monitoring zones need not be known when equipment is purchased.

Field quality control procedures have been established which permit the quality of a well installation and the proper operation of testing and sampling procedures and equipment to be routinely verified. Thus, groundwater data and the additional data required to define the quality of the field data can be routinely collected. Furthermore, when a high density of groundwater monitoring zones are installed by using multi-level monitoring wells, the redundant monitoring points can provide important corroborative field data to an extent which is not available with single level monitoring wells. The result is a monitoring system which provides data with a degree of defensibility unattainable with any other monitoring method, single or multi-level.

References

- Patton, F.D. and H.R. Smith. 1986. Design considerations and the quality of data from multiple-level groundwater monitoring wells. Proc. ASTM Symp. on Field Methods for Groundwater Contamination Studies and Their Standardization. Cocoa Beach, FL.
- Bouwer, H. and R.C. Rice. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, Vol. 12, No. 3, June 1976.
- Cooper, H.H., Jr., J.D. Bredehoeft, and S.S. Papadopoulos. Response of a finite-diameter well to an instantaneous charge of water. Water Resources Research, Vol. 3, No. 1, First Quarter 1967.
- Hvorslev, J.M. Time lag and soil permeability in ground-water observations. Bull. 36, U.S. Corps of Eng., Waterways Exp. Sta., Vicksburg, MI, 1951.
- NOTICE The sliced-circle logo, Westbay logotype, MP System and MOSDAX are registered trademarks of Westbay Instruments Inc. MProfile and MLog are trademarks of Westbay Instruments Inc.

Nye County/YMP Drilling Program
Revision #4
December 2, 1994
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APPENDIX B

Test Planning Package (TPP) 95-03 Rev.0

J. Nick Stellavato
On-Site Geotechnical Representative
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SITE INTEGRITY CONCERNS FOR THE UE-25 ONC#1 BOREHOLE AND UE-25 NRG-4 INSTRUMENTATION (SCPB: N/A)

In accordance with Section IV.B.2 of "Appendix A: Access and Procedures for On-Site Independent Verification and Testing," we have reviewed the plans for drilling the UE-25 ONC#1 borehole and identified U.S. Department of Energy/Yucca Mountain Site Characterization Office (DOE/YMSCO) concerns related to test-to-test interference and safety or waste isolation. These concerns are stated as "Requirements" in Section B.1, "Determination of Importance Evaluation (DIE) Controls," of Test Planning Package (TPP) T-95-3, "Nye County Drilling: UE-25 ONC#1 and NRG-4 Instrumentation." A copy of the TPP is enclosed for your reference.

Please review these requirements. If the requirements are acceptable to the County, please provide a revised Nye County Drilling Program Work Plan that incorporates the applicable requirements given in the TPP and resubmit the revised work plan to Jeanne Nesbit. DOE/YMSCO Quality Assurance Division will review the work plan and DOE/YMSCO will authorize drilling on the borehole to begin when the work plan is accepted. DOE/YMSCO intends to observe/inspect the drilling operation in order to provide documentation for DOE/YMSCO records that constraints resulting from site integrity concerns were complied with. Any concerns relating to site integrity that arise from these observations will be resolved using the processes agreed upon in existing protocols between DOE/YMSCO and the County.

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J. Nick Stellavato

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If you have questions regarding DOE/YMSCO site integrity concerns, please contact Jeanne C. Nesbit at (702) 794-7930 or me at (702)794-7613.

AMSP:JCN-1078

Susan B. Jones
Assistant Manager for
Scientific Programs

Enclosure:
TPP T-95-03

cc w/o encl:

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Amelia Landeros, RBECO/PSDO, Las Vegas, NV
R. L. Patterson, YMSCO, NV
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R. E. Spence, YMQAD, NV

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
TEST PLANNING PACKAGE APPROVAL AND RELEASE

Test Planning Package Title: Nye County Drilling: UE-25 ONC#1 & USW NRG-4 Inst. Revision: 0

Test Planning Package Number: 95-3

Responsible Project Engineer: Terry A. Grant

Summary of Scope:

Site Integrity Controls for Borehole ONC-1.

Job Package Number: N/A

WBS Number (third level): 1.2.3

Affected Organization: N/A

Concurrence of requirements by affected Technical Project Officers and affected Assistant Managers:

TPO: N/A Date: _____

TPO: N/A Date: _____

TPO: N/A Date: _____

TPO: N/A Date: _____

TPO: N/A Date: _____

Affected Assistant Managers:

AM: *Juan Jose* AMSP Date: 12-1-94

AM: *W. Williams for Deb Spence* YMQAD Date: 12/1/94

AM: _____ Date: _____

Release to:

Assistant Manager for
Administration for job assembly
for nonfield work

YMSCO Approvals:

Responsible Assistant Manager: N/A Date: _____

U.S. DEPARTMENT OF ENERGY

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**YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT**

**TEST PLANNING PACKAGE (TPP) 95-03
Rev. 0**

**Nye County Drilling: UE-25 ONC#1 and
USW NRG-4 Instrumentation**



December 1994

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Nye County Drilling: UE-25 ONC#1 and USW NRG-4 Instrumentation

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Test Planning Package (TPP) 95-3, Rev. 0
Nye County Drilling: UE-25 ONC#1 and USW NRG-4 Instrumentation

A. TEST AND TEST RELATED INFORMATION

1. Workscope Overview

In accordance with the provisions of the "Protocol Addressing Procedures for Nye County On-Site Representation During Yucca Mountain Project Site Characterization Activities" (the Protocol) and "Appendix A: Access and Procedures for On-Site Independent Verification and Testing" (Appendix A), the responsibility of DOE during independent testing by Nye County (the County) is limited to maintaining the integrity of the site in accordance with 10 CFR 60.15(c). The Protocol and Appendix A, dated 10/19/92 and 7/1/94 respectively, represent the formal agreements between the County and DOE on the conduct of independent testing by the County at the Yucca Mountain site. This Test Planning Package (TPP) provides the determination of test-to-test interference and waste isolation concerns for the Nye County drilling program at the UE-25 ONC#1 borehole and instrumentation activities at the USW NRG-4 borehole to implement Section IV.B.2 of Appendix A.

As described in the Protocol and Appendix A, all other test planning activities, such as permitting, data management, sampling, Quality Assurance, and safety and health, are the responsibility of Nye County and are not addressed in this TPP.

DOE will conduct geophysical logging in the UE-25 ONC#1 borehole and receive splits of drill cuttings and other samples for use by the Yucca Mountain Site Characterization Project as described in Appendix A.

2. Identification of Primary and Secondary Users

a. Primary Users

The primary user of the UE-25 ONC#1 borehole is Nye County and its subcontractors. They will be responsible for drilling operations, testing, data collection, and sample collection, handling, and storage.

b. Secondary Users

The secondary user of the UE-25 ONC#1 borehole is DOE and its subcontractors/affected organizations. They will be responsible for documenting actions relating to site integrity concerns, geophysical logging in the borehole, receiving splits of samples at the borehole, and conducting some testing and/or measurements in the borehole at agreed upon times.

3. Pertinent Test Planning Information

All wireline borehole geophysical logging activities conducted at the UE-25 ONC#1 borehole by DOE and its support organizations shall be performed under YAP-SIII.4Q (current revision), "Yucca Mountain Site Characterization Project Field Verification of Geophysical Logging Operations." Sample handling of splits supplied by Nye County shall be conducted in accordance with DOE subcontractor Work Instruction WI-DS-001 (current revision), "Field Logging, Handling, & Documenting Borehole Samples." Depth information and other pertinent drilling information relating to samples will be supplied by Nye County.

4. List of Pertinent Study Plans

No study plans apply to this TPP. Nye County will be responsible for UE-25 ONC#1 and USW NRG-4 test planning.

5. Borehole Activities

Planning and conduct of borehole activities is the responsibility of Nye County under the Protocol and Appendix A.

6. Water-Related Instructions

There are no water-related instructions for these activities except for those described in Section B of this TPP.

7. Sealing

Sealing of the UE-25 ONC#1 borehole will not occur at this time. Separate

plans and/or requirements for sealing of the UE-25 ONC#1 borehole will be prepared at a later date.

B. QUALITY ASSURANCE CONTROLS

1. Determination of Importance Evaluation (DIE) Controls¹

DOE has evaluated the planned work and generated the following controls to be applied to UE-25 ONC#1 drilling and testing and NRG-4 instrumentation operations to maintain site integrity. This evaluation is contained in Document BAAAE0000-01717-2200-00002, "DIE For UE-25 ONC#1 and USW NRG-4," and the requirements listed below are transcribed directly from that document. Comments have been added to the requirements to provide clarification on the methods and responsibilities for meeting these requirements. Nye County will be responsible for implementing these requirements except where indicated in the comments.

Requirement 1: The ONC#1 and NRG-4 boreholes and drill pads shall be maintained to limit the potential for waste isolation and test interference impact by creation of ponding, alteration of natural drainage, or creation of drainage that would result in preferential surface water runoff into the borehole. Any significant ponding created by construction, drilling, or testing equipment must also be mitigated to the extent practical, applying the following controls [SBTFRD 3.2.3.4.2U, 3.2.3.3.1.B.3]:

(Comment: DOE will be responsible for drill pad maintenance.)

- (1a) Measures shall be taken (e.g., maintaining pad grade, installation of surface sealing apparatus) to limit preferential surface water flow into the borehole.
- (1b) Periodic inspections of the pad (not less than monthly) will be made during construction or operation or following maintenance. These inspections are intended to ensure that drainage characteristics (as discussed above) have not been altered in a way that would create preferential flow into the borehole or surface runoff impoundment areas that would result in ponding of water that would be pumpable with standard equipment. Any such areas shall be corrected/repared upon discovery, subject to requirement 1c.

(Comment: DOE will perform these inspection and repair services)

- (1c) Construction trenching or other excavations which create surface impoundment areas (as described in 1b) are required to be inspected weekly for accumulation of water. Pumpable water in these impoundment areas shall be removed upon discovery. Pounded water as a result of non-routine water use (i.e., spillage or fire mitigation) shall be removed as soon as practical.

(Comment: DOE will perform these inspections)

Requirement 2: The following limits apply to the total use of water for construction, borehole drilling and testing activities (including water for dust control), compaction of engineered fill and structure, and facility and improvement operations within the Conceptual Controlled Area Boundary [SBTFRD 3.2.2.1.12F, 3.2.2.11B]:

- (2a) Application of such water shall not exceed 2 gal/yd²/day averaged over a six-month period for 5 years. Water utilization shall be limited to the minimum necessary for the required application.
- (2b) All water utilized for construction, dust control, and other borehole and pad activities shall be measured.

(Comment: DOE will document the amounts of water it provides and/or disperses on the drill pad for dust control or other purposes. Nye County will provide measurements of water it transports and uses at the drill site.)

- (2c) Weekly records shall be made and provided of water use in accordance with the TFM Management Plan of borehole preparation (i.e., borehole pad, access road construction and operation, borehole drilling and testing activities, and any wetting of the borehole unsaturated zone), water use by water source (e.g., J-13), and by specific activity (e.g., dust suppression, compaction of engineered fill, drilling, etc.).

(Comment: DOE will document the amounts of water it provides and/or disperses on the drill pad for dust control or other purposes. Nye County will provide measurements of water it transports and uses at the drill site.)

- (2d) Tracers shall not be added to construction water for surface use without reevaluation by DOE.
- (2e) Disposal of water generated from drilling shall be per a DOE-approved disposal plan. This plan shall as a minimum satisfy the requirements

stated in 2a, 2b, and 2c if disposed within the YMP site.

Requirement 3: The amount of hydrocarbons (i.e., hydraulic fluid, fuels, oils, etc.), solvents, or cementitious or other materials spilled and lost on the ONC#1 and NRG-4 drill pads and ONC#1 and NRG-4 boreholes shall be minimized in accordance with 10CFR60.15(c)(1) [SBTFRD 3.2.2.12.A]:

- (3a) Purposeful emplacement of tracers, fluids, and materials (TFMs) shall be limited to the required application (e.g., grout and other materials for testing, oil for compressed air drilling, etc.).
- (3b) Periodic inspections (not less than monthly) will be conducted on fixed equipment and vehicles; hydrocarbon material, coolant, acids, or solvent leakage from any such construction or support equipment in excess of drips (as from ruptured hoses, spills from reservoirs or tanks, etc.) shall be contained, mitigated, or repaired upon discovery.

(Comment: DOE will perform the inspections. Vehicle or equipment owners shall be responsible for mitigation.)

- (3c) Tracer gas is not required for compressed air drilling. Tracer gas introduced for testing purposes shall be limited to SF₆. The amount of tracer gas left in the surrounding rock following completion of testing shall be minimized to the extent practical (removal of tracer gas introduced during testing by pulling a partial vacuum on the borehole is an acceptable method for implementing this portion of the requirement).

Requirement 4: A record shall be made and provided in accordance with the TFM Management Plan of all tracers, fluids, and materials consumed (i.e., purposely emplaced or spilled and not recovered) during construction and operation on the ONC#1 and NRG-4 drill pad, access road, and borehole including any unrecovered spill material and their location. [SBTFRD 3.2.2.11.B, 3.2.2.11.C, 3.2.2.12.A, 3.2.2.12.B]

Requirement 5: The Nye County On-Site Representative (OSR) shall notify the YMP Field Test Coordinator (FTC) and DOE Point of Contact upon encountering perched water. The FTC in conjunction with the OSR will decide on any additional actions to be taken prior to the resumption of drilling.

Requirement 6: The DOE Point of Contact and FTC (who shall notify the Principal Investigator (PI) in charge of C-hole complex pumping testing) shall be notified by the Nye County OSR of drilling at or below the water table level or of any pumping activities within ONC#1 prior to their occurrence.

Requirement 7: Chloride based materials (e.g., NaCl, MgCl) are prohibited on the pad or road (e.g., as an electrical grounding medium for pad equipment, or use of a salt encrusted tape for water level measurement). A graphite-based grounding medium, such as "GEM", is acceptable. [SBTFRD 3.2.2.12.A]

Requirement 8: Following the completion of drilling operations, a land survey will be made to determine the surface location (coordinates, elevation) for the land and casing of ONC#1 in Nevada Plane Coordinates or UTM Coordinates. The total depth of the borehole shall be determined by DOE Field Drilling Engineer. The borehole directional survey, bottom hole coordinates, and caliper log shall be determined by DOE in accordance with YAP-S.III.4Q. A borehole completion diagram will be prepared by DOE to summarize the information.

(Comment: DOE will conduct the survey of land surface and casing location and elevation and conduct the geophysical logging. Nye County will make the hole available for these activities and notify the FTC and DOE Point of Contact of the approximate time drilling will reach total depth so that a Drilling Engineer can be dispatched to observe/verify the total depth measurement.)

Requirement 9: The OSR shall obtain DOE approval for modifications to the drilling and testing activities specified in the Work Plan. DOE shall assess the need to revise the DIE accordingly, prior to the implementation of the revised Work Plan.

(Comment: The work plan referenced in this requirement is the Nye County Drilling Program Work Plan.)

Requirement 10: Site data or formation samples gathered from ONC#1 and NRG-4 through Nye County shall not be used for DOE site characterization until DOE concurrence is provided that the data or samples are acceptable under a DOE-approved QA program.

(Comment: As noted above, representatives of DOE will observe/inspect actions taken to maintain site integrity and comply with identified controls. Documentation of these observations will be prepared for DOE records. Any concerns noted regarding the preservation of site integrity will be communicated to the designated DOE point of contact (R. Patterson, 4-7691) who will work to resolve such concerns with Nye County under the provisions of the Protocol and Appendix A.)

2. **Tracers, Fluids, and Materials Controls**

Control of tracers, fluids, and materials (TFM) at the drill sites will be as described in Requirements 3, 4, and 7 listed in the section above. The County will record tracer, fluid, and materials use during the course of testing and will supply copies of these records to DOE for incorporation into the TFM database.

Nye County will be responsible for complying with applicable State and Federal regulations if hazardous materials are used on the drill site.

C. **PERMITS**

In accordance with the Protocol and Appendix A, Nye County will be responsible for the determination of the applicability permits to County activities and will be responsible for securing and maintaining all permits, including any necessary rights-of-way.

D. **OTHER INSTRUCTIONS**

1. **Hold Points**

A hold on drilling activities will occur if perched water is encountered during the drilling of UE-25 ONC#1. If perched water is encountered, the designated points of contact for the County and DOE will meet to agree on any sampling or testing requirements before drilling resumes.

2. **Interfaces**

Formal interfaces between Nye County and DOE relating to the UE-25 ONC#1 and USW NRG-4 instrumentation shall be conducted in accordance with the Protocol and Appendix A. Site integrity concerns relating to the UE-25 ONC#1 drilling and testing operations or USW NRG-4 instrumentation will be referred to the designated point of contact for DOE (R. Patterson, 4-7691) who will be responsible for working with the County for resolution of concerns.

3. **Data Submittals**

All data submittals generated during wireline geophysical logging operations conducted by DOE subcontractors/affected organizations in the UE-25 ONC#1 borehole shall be handled in accordance with YAP-SIII.4Q (current revision),

"Yucca Mountain Site Characterization Project Field Verification of Geophysical Logging Operations." Data submittals on water and TFM usage will be made by the responsible parties (the County or DOE subcontractors) identified in Section B.1 in accordance with applicable procedures.

4. Sample Collection

DOE subcontractors/affected organizations will receive splits of cuttings and other samples at the UE-25 ONC#1 borehole location from the County. DOE samples will be handled in accordance with DOE subcontractor Work Instruction WI-DS-001 (current revision), "Field Logging, Handling, & Documenting Borehole Samples." Drilling or sample related data necessary for sample identification and labeling will be supplied by the County. Samples will be transmitted to the Sample Management Facility for storage and will be released to Principal Investigators by the Sample Overview Committee in accordance with applicable procedures.

5. Site Characterization Plan (SCP) Comments

No SCP comments are relevant to this activity since it is outside the scope of SCP planning.

6. Reference to Design Requirements

Not applicable to this activity. Nye County is responsible for USW NRG-4 instrumentation and UE-25 ONC#1 planning and design.

7. Cost and Schedule Information

Relevant cost information for DOE geophysical logging is contained in TPP T-94-16 (current revision), "Yucca Mountain Site Characterization Geophysical Logging Program." Logging will occur when Nye County makes the borehole available for logging.

8. Quality Assurance (QA) Preparation

No relevant QA concerns (including unresolved Corrective Action Requests or Stop Work Orders) have been identified against the geophysical logging program or drilling support (sample handling) program. All other drilling and testing operations will be conducted by the County and not controlled by the DOE QA program.

Quality Assurance Grading Reports (QAGRs) previously applicable to the geophysical logging and sampling work described in this TPP have been

canceled. Affected participants shall comply with their approved Quality Assurance Grading Procedures for the determination of required QA controls.

Concerns arising relative to the implementation by the County of controls relating to site integrity will be addressed in accordance with the Protocol and Appendix A.

9. Readiness Review

The AMSP has determined that a Readiness Review is not necessary for the geophysical logging and sample receiving activities related to UE-25 ONC#1.

10. Other Controls

Although this is not a QA control, it is recommended that the OSR remain cognizant, through DOE, of DOE field activities in the vicinity of ONC#1 and NRG-4. This is recommended as a conservative measure to minimize the potential for interference with Nye County's test data.

11. Sequencing of Multiple Investigations and Computer Software

These topics are not applicable to this TPP.

REFERENCES

1. U.S. Department of Energy, Yucca Mountain Site Characterization Office, November 30, 1994. DIE for UE-25 ONC#1 and USW NRG-4. BAAAE0000-01717-2200-00002.