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Y/ER-283

ENVIRONMENTAL RESTORATION PROGRAM

Hydraulic Head Data from the DNAPL Monitoring Wells GW-726, GW-727, GW-729, GW-730, and GW-790 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

Third Quarter FY 1992 through Second Quarter FY 1996

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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

UCN-17560 (6 8-95)

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Energy Systems Environmental Restoration Program

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Third Quarter FY 1992 through Second Quarter FY 1996

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Date Issued—February 1997

Prepared by the
Environmental Sciences Division
Oak Ridge National Laboratory

Prepared for the
U.S. Department of Energy
Office of Environmental Management
under budget and reporting code EW 20

Environmental Management Activities at the
OAK RIDGE Y-12 PLANT
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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PREFACE

The work described in this document, *Hydraulic Head Data from the DNAPL Monitoring Wells GW-726, GW-727, GW-729, GW-730, and GW-790 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee: Third Quarter FY 1992 through Second Quarter FY 1996,* was performed under Work Breakdown Structure 4.1.05.10.01.06.04, "Y-12 Bear Creek Valley DNAPL Well Sampling, Groundwater Baseline Data." This document provides the Environmental Restoration Program with hydraulic head values in the vicinity of the Y-12 Burial Grounds. This data can be used to support estimates of contaminant transport behavior for intermediate and deep groundwater systems.

ACKNOWLEDGMENTS

This report could not have been completed without the help and cooperation of several people. Elizabeth Owens, assisted by Kirk Hyder, Jeff Williams, and Anthony Garland, ensured that all the field work was accomplished efficiently and properly. The Y-12 Environmental Restoration organization, through John Vanderlan, Helen King, Judy Hodgins, and Don Rosowitz, provided program direction and financial support.

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ABBREVIATIONS

cps	counts per second
DNAPL	dense nonaqueous-phase liquid
MP	multiport
OD	outer diameter
psi	pounds per square inch
TVD	true vertical depth

EXECUTIVE SUMMARY

In January 1990, dense nonaqueous-phase liquids (DNAPLs) were discovered at a depth of approximately 274 ft below ground surface along the southern border of the Y-12 Plant Burial Grounds. Immediately after the discovery, an investigation was conducted to assess the occurrence of DNAPL at the site and to make recommendations for further action. Detailed results of the preliminary DNAPL investigation are presented in Haase and King (1990a), and a work plan for assessment and characterization of the DNAPL is presented in Haase and King (1990b). A major task in the work plan calls for the construction and installation of five multiport wells.

This report summarizes fluid pressure monitoring activities for the five multiport wells. The report includes a discussion of data collection and processing, and presents the data in the form of hydraulic head graphs. The report does not include interpretation of (1) flow paths (2) aquifer characteristics or (3) spatial synthesis of data. As funding and need arises, these topics will be addressed in future reports.

To date, a series of fluid pressure measurements have been collected from each of the five Westbay-instrumented multiport wells that were built to quantify groundwater characteristics in the vicinity of a DNAPL plume. These measurements have been converted to hydraulic head, and the results are presented graphically in this report. It is recommended that future tasks use this data to support technically sound environmental remediation decisions. For example, these data can be used to design a remediation strategy or can be used to evaluate and rate a variety of remediation strategies.

1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

In January 1990, dense nonaqueous-phase liquids (DNAPLs) were discovered at a depth of approximately 274 ft below ground surface along the southern border of the Y-12 Plant Burial Grounds. Immediately after the discovery, an investigation was conducted to assess the occurrence of DNAPL at the site and to make recommendations for further action. To date, free-phase DNAPL contamination has been encountered in GW-625 (the discovery well), and is suspected to occur in GW-628 and GW-629 (Fig. 1. Figures appear in Chapter 5.) (Haase and King, 1990a).

In addition, groundwater from GW-117 (Fig. 1) shows levels of volatile organic compounds suggestive of a dissolved contaminant plume. Detailed results of the preliminary DNAPL investigation are presented in Haase and King (1990a), and a work plan for assessment and characterization of the DNAPL is presented in Haase and King (1990b). A major task in the work plan calls for the construction and installation of five multiport wells. These wells (GW-726, GW-727, GW-729, GW-730, GW-730 and GW-790) were constructed and instrumented with multiport components from August, 1991 to April, 1993 (Dreier and Caldanaro, 1994). This report summarizes fluid pressure monitoring activities for the five multiport wells. The report includes a discussion of data collection and processing, and presents the data in the form of hydraulic head graphs. The report does not include interpretation of (1) flow paths, (2) aquifer characteristics, or (3) spatial synthesis of data. As funding and need arises, these topics will be addressed in future reports.

The purpose of the multiport wells is two-fold and addresses specific recommendations made by an independent consultant and previous work (Keuper 1990; Haase and King 1990b):

1. Define the deep and intermediate groundwater flow system within the Bear Creek Burial Ground and contiguous areas. Place special emphasis on defining and characterizing major conductive zones through which most of the groundwater flow may be occurring or through which DNAPL migration may have occurred.

2. Track the dissolved plume from outside inward. With an understanding of the groundwater flow system, determine a nondetect envelope within which all DNAPL and dissolved DNAPL contamination exists. As such, the wells are intended to serve as an early warning system for dissolved plume migration.

Fluid pressure data are vital ingredients for understanding the groundwater flow system. Thus results presented in this report address both of the above-listed goals. If future technological development provides a feasible method to remove DNAPLs, then data from the multiport wells will provide general knowledge of the DNAPL location. Additionally, the information developed will be necessary to evaluate the effectiveness of the remediation technology (Haase and King, 1990b).

1.2 BOREHOLE INFORMATION

The locations of the five multiport wells (GW-726, GW-727, GW-790, GW-729 and GW-730) are shown in Fig. 1. The rationale for well placement is given in Haase and King (1990b) and Dreier and Caldanaro (1994). Construction logs for the boreholes are presented in Science Applications International Corporation report, 1993a-3, and the reader is referred to these reports for detailed construction histories of the wells. Condensed well construction information is presented in Table 1 (Tables appear in Chapter 6).

1.3 MULTIPORT WELL DESCRIPTION

The DNAPL investigation multiport wells use components designed by Westbay Instruments Inc. This system isolates zones of interest from each other by a series of packers fitted about a 1.5-in. diameter PVC (MP) casing (Fig. 2) that acts as an inner standpipe. Within specified sampling zones, fluid pressure data and water samples are collected using specialized probes that are lowered down the inner standpipe to the zones of interest. The probes access the zone through a measurement port coupling in the MP casing. Each sampling zone also contains a pumping port, which is used for purging activities. The pumping port is not used to collect fluid pressure measurements, but can be used for some hydraulic conductivity tests.

The sampling zones are isolated from each other by one to two additional zones, called QA zones, which contain measurement ports, but no pumping ports (Fig. 2). The zones provide added assurance that the sampling zones are isolated from each other. Although, it is possible to obtain water samples from these zones, it is not possible to purge these intervals because the zones do not contain pumping ports. Nevertheless, fluid pressure data are collected from these zones, and data from both sampling and QA zones provide a detailed vertical profile of fluid pressure regimes. Measurement zone information for each well is presented in Table 1 and Chaps 5 and 6.

2. FLUID PRESSURE MONITORING ACTIVITIES

2.1 DATA COLLECTION

Fluid pressure data are collected at specified intervals for several purposes. Table 2 lists the dates of data measurement from each well. Initially, pressure data are collected immediately after installation of the multiport components. If there is an appropriate vertical hydraulic head gradient, this data can be used to confirm successful isolation of the monitoring zones. In addition, anomalously high fluid pressures may be caused by packer squeeze, which is an artifact of the installation process. Packer squeeze results from inflating packers in areas with low to very low permeability. If it is apparent that anomalous pressures are caused by installation, the pressures are monitored at approximate weekly intervals until the pressure stabilizes.

After all the wells stabilize, a concerted effort is made to collect monthly fluid pressure measurements from each well. Because of construction activities at the Y-12 Burial Grounds, which prevented access to some of the wells, this activity was delayed until February, 1994. These data show background response to seasonal effects, including precipitation, which shows the greatest affect during winter storms, and evapotranspiration effects, which are most apparent from mid-spring to early fall.

Currently, fluid pressure measurements are taken quarterly to show longer term responses and as a comparison with the background monthly data. As necessary, this monitoring is given a lower priority than other multiport-related activities, such as sampling. Therefore, there are time periods up to or greater than one year, where no pressure data has been collected from a well.

2.2 DATA PROCESSING

Fluid pressure data are converted to values of hydraulic head in order to facilitate interpretation of hydraulic gradients and to compare pressure values between different zones of interest. A complete discussion of hydraulic head is not appropriate for this report and the reader is referred to Freeze and Cherry (1979) for a further explanation of this topic. In addition, this report should not be used as an operations manual for field data collection. The reader is referred to draft procedure Y50-66-EM-351 (Pressure Profiling of Wells Equipped with Westbay Monitoring System Instrumentation) for this purpose.

Two methods are used to translate fluid pressure data to hydraulic head. In general, both methods are used to calculate head as a quality assurance check. The first method uses a reference hydraulic head value with an associated fluid pressure that is collected from a known depth inside the MP casing. The formation fluid pressure is obtained at that same depth, and the formation hydraulic head is calculated from the difference between the reference and formation pressure.

In this case

(1) $\text{Head}_{formation} = \text{Head}_{MP} - [(P_{out}-P_{in})/0.4335]$

- or expanding -

$\text{Head}_{formation} = \text{Elevation} - \text{DTW} - [(P_{out}-P_{in})/0.4335]$

where:

¥ $\text{Head}_{formation}$	=	Hydraulic head of the formation at a specified location
¥ Head_{MP}	=	Hydraulic head of the reference column of water in the MP casing
¥ Elevation	=	Elevation at the top of the MP casing
¥ DTW	=	Depth to water measured in the MP casing from the top of the MP casing
¥ P_{in}	=	Fluid pressure in the MP casing at specified port depth
¥ P_{out}	=	Fluid pressure outside the MP casing in the zone of interest
¥ 0.4335^{-1}	=	the conversion factor from pressure in psi units to ft of water (density of 1 gm/c^3 and temperature of 4° C)

The second method directly translates fluid pressure measured in the formation of interest to hydraulic head:

(2) $\text{Head}_{formation} = \text{Elevation} - \text{Depth}_{port} + [(P_{out}-P_{atm})/0.4335]$

where symbols are as above and:

¥ Depth_{port}	=	True vertical depth of port measured from the top of the MP casing.
¥ P_{atm}	=	Atmospheric pressure

2.2.1 Potential Errors

Depth_{port}. Initially, the true vertical depth (TVD) to a particular measurement port can be approximated from a borehole deviation log or from a map of the well components that were installed into the borehole. At best this is an approximation, and the TVD can vary from this estimate by many feet, depending on borehole conditions. The worse case is for a deviated borehole for which there is no deviation log. In this case (e.g. GW-730) an estimate of the depth to a particular measurement port is an approximation. We approach this problem by using a variation of equation (2) to solve for Depth_{port}, and substitute the column of water inside the MP casing for the formation fluid:

(3) $\text{Depth}_{port} = [(P_{in}-P_{atm})/0.4335] + \text{DTW}$

We commonly average results from several different measurements over a period of time to determine the best Depth_{port}. This method for determining Depth_{port} is only appropriate if P_{atm} does not fluctuate greatly during the measurement process (see below) and if the fluid inside the MP casing has a density of 1 gm/c^3. Thus, Depth_{port} should be determined, if possible, before any purging activities are started, because purging zones with brackish to briney fluids will introduce fluids into the MP casing that have a density greater than 1 gm/c^3.

P_{atm} Atmospheric pressure is measured by the same probe that is used to measure formation fluid pressures and is measured at the beginning and end of the data collection process. Because the process of collecting pressure data from an individual well can take several hours or longer, it is possible that P_{atm} can change significantly during this time. At present, we approach this problem in several ways. If the beginning and ending P_{atm} are close to each other (within a few hundreths of a psi), we assume that P_{atm} didn't fluctuate. If there is a change from initial to final psi, an average P_{atm} is used to determine hydraulic head. Finally, if $Depth_{port}$ has been determined, then the primary measurement difference between equations (1) and (2) is P_{atm}. Thus, if fluid conditions in the MP casing remain the same, any change in the difference between the two methods of determining hydraulic head can be attributed to P_{atm}.

Because of these potential measurement errors, method one is the method of choice for the situation where there are no density effects. Any potential problems associated with incorrect depth and P_{atm} values are canceled out by using the hydraulic head in the MP casing as a reference frame. This is because P_{in} and P_{out} are measured at the same depth, and there will be a minimal change in P_{atm} during the period that P_{in} and P_{out} are measured. However, if there are density effects, method one should not be used to calculate final hydraulic head values. This is because the reference frame used in method one is only valid if it has the same fluid density structure as the formation fluids. In addition, method one cannot be used if the DTW is greater than $Depth_{port}$, or if DTW was not recorded by the field technician.

P_{out} As part of the procedure for collecting formation fluid pressure data, several (three or greater) P_{out} measurements are taken. Examination of the pressure response in the field by technicians, as well as subsequent examination of the data during processing shows that P_{out} can take from a few seconds to greater than 15 minutes to stabilize. This characteristic is related to both the permeability of the zone (personal communication; K. S. Novakowski, January 20, 1995) and to the pressure differential between P_{in} and P_{out}. The field technicians take care to collect data after P_{out} has stabilized. Nevertheless, if the P_{out} data show a consistent decreasing or increasing trend, the latest data measurement (i.e. the most stable) is used to determine hydraulic head.

2.2.2 Conversion Factor

Conversion Factor for psi to ft of Water Lusczynski (1961)describes a method of incorporating stratified fluid densities into hydraulic head measurements. A cursory examination and trial use of his techniques shows that the use of a constant conversion factor from pressure to ft of water creates a minimal error in calculation of hydraulic gradients. Because of this and the fact that the density structure cannot be accurately or easily determined, no attempt was made to correct the psi--ft H_2O conversion factor for changes in fluid density. If future remedial decisions require this type of information, more effort will be directed toward determining the local change in hydraulic head as a function of fluid density.

3. RESULTS

Representative hydraulic head profiles from each of the five wells are presented in Figs. 3 - 7. In addition, data from all five wells from April 1995 are shown in Fig. 8 in order to show lateral changes in hydraulic head in the vicinity of the Y-12 Burial Grounds. Similar elevation and hydraulic head scales are maintained in all of these figures to facilitate comparisons.

As stated previously, further data interpretation is not included in this report and may be addressed as funding and need arises. Nevertheless, it should be noted that some hydraulic head values are lowered significantly by purging activities. Because of the high priority given to collecting groundwater samples for analysis, it was necessary to purge sampling zones during the year that monthly pressure measurements were obtained. Hence, some zones show artificially low hydraulic heads that are not indicative of natural conditions. Care should be taken in future data analysis to separate these artificial anomalies from naturally occurring low pressure anomalies.

As necessary, the data are available electronically from the authors of this report and data transfer will be administered by the Environmental Restoration Organization.

4. SUMMARY/FUTURE WORK

To date, a series of fluid pressure measurements have been collected from each of the five Westbay-instrumented multiport wells that were built to quantify groundwater characteristics in the vicinity of a DNAPL plume. These measurements have been converted to hydraulic head, and the results are presented graphically in this report. It is recommended that future tasks use this data to support technically sound environmental remediation decisions. For example, these data can be used to design a remediation strategy or can be used to evaluate and rate a variety of remediation strategies.

5. CONSTRUCTION AND WELL DESIGN FIGURES

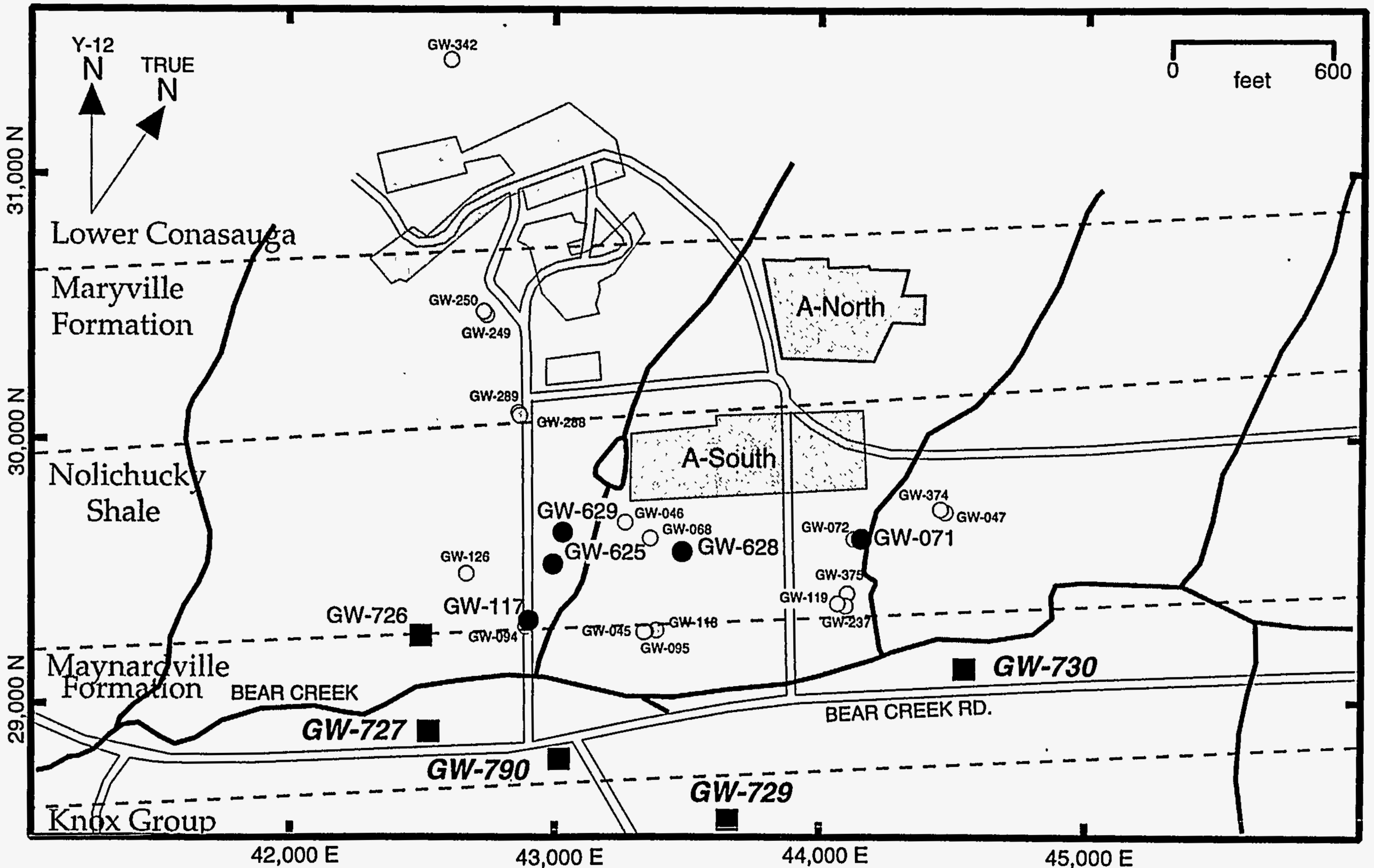

Fig. 1. Y-12 Burial Grounds location map. Dark circles are wells with known DNAPL accumulation or are wells that intercept secondary groundwater contaminant plumes. Black squares are the five multiport DNAPL investigation wells. Estimated locations of geologic contacts are shown.

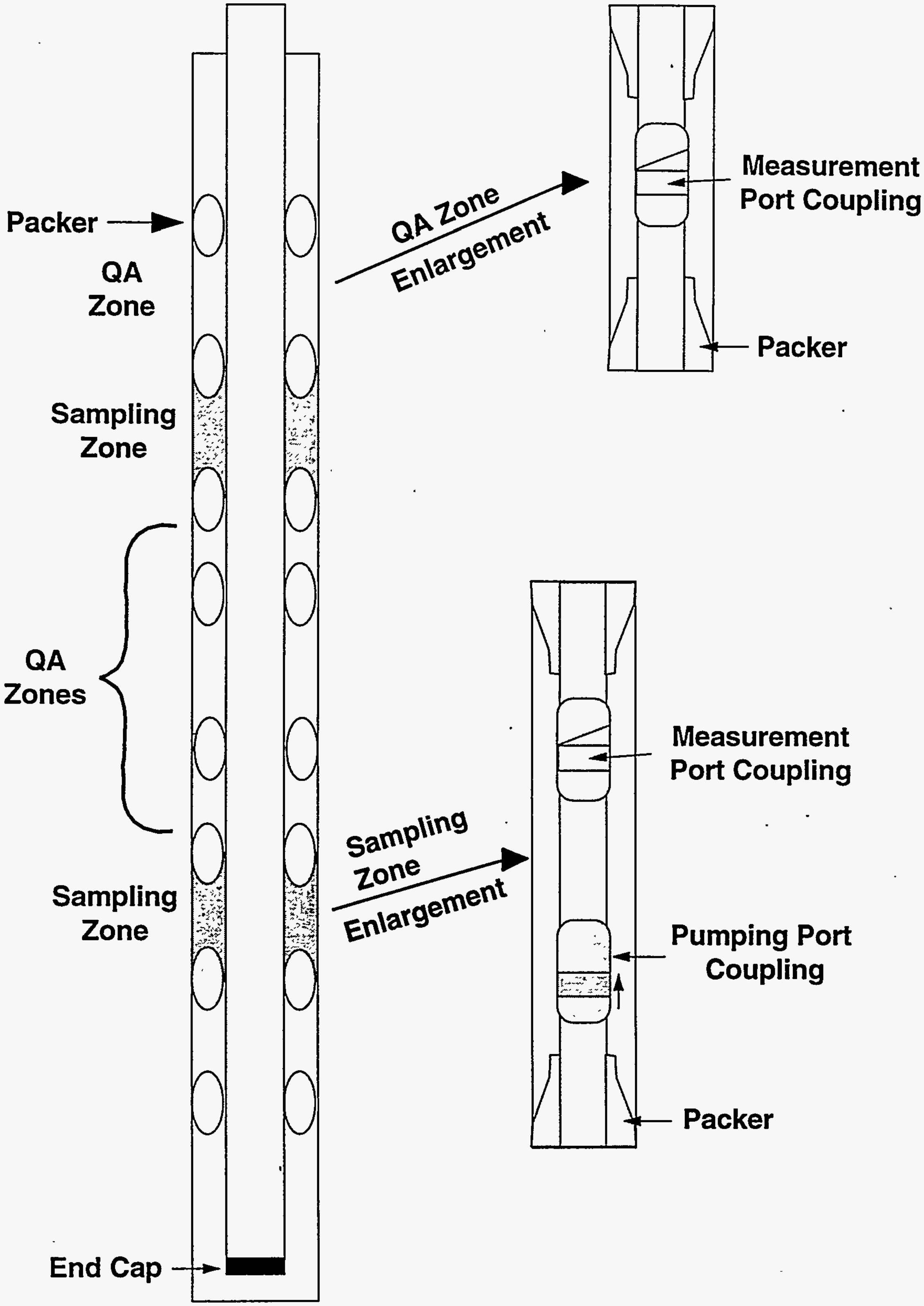

Figure 2. Generalized multiport well design.

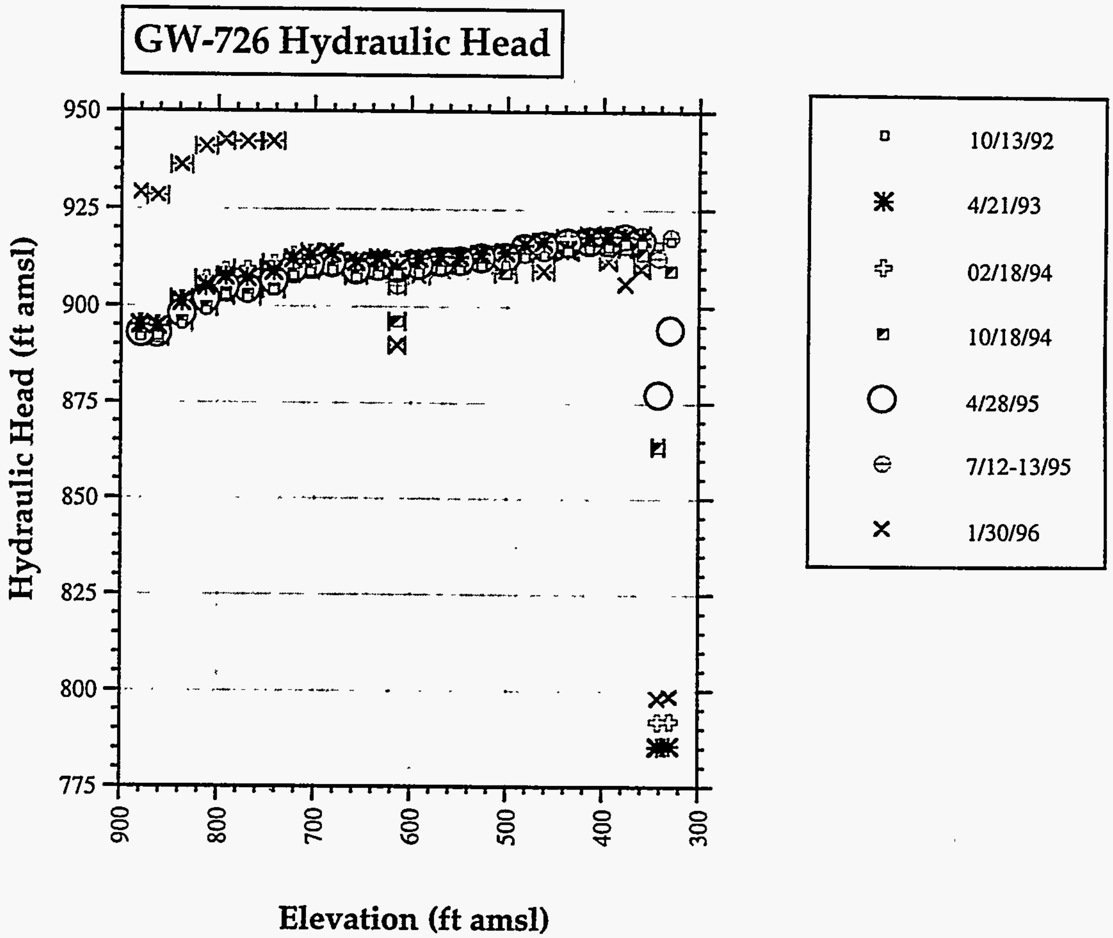

Figure 3. Representative hydraulic head profiles from GW-726.

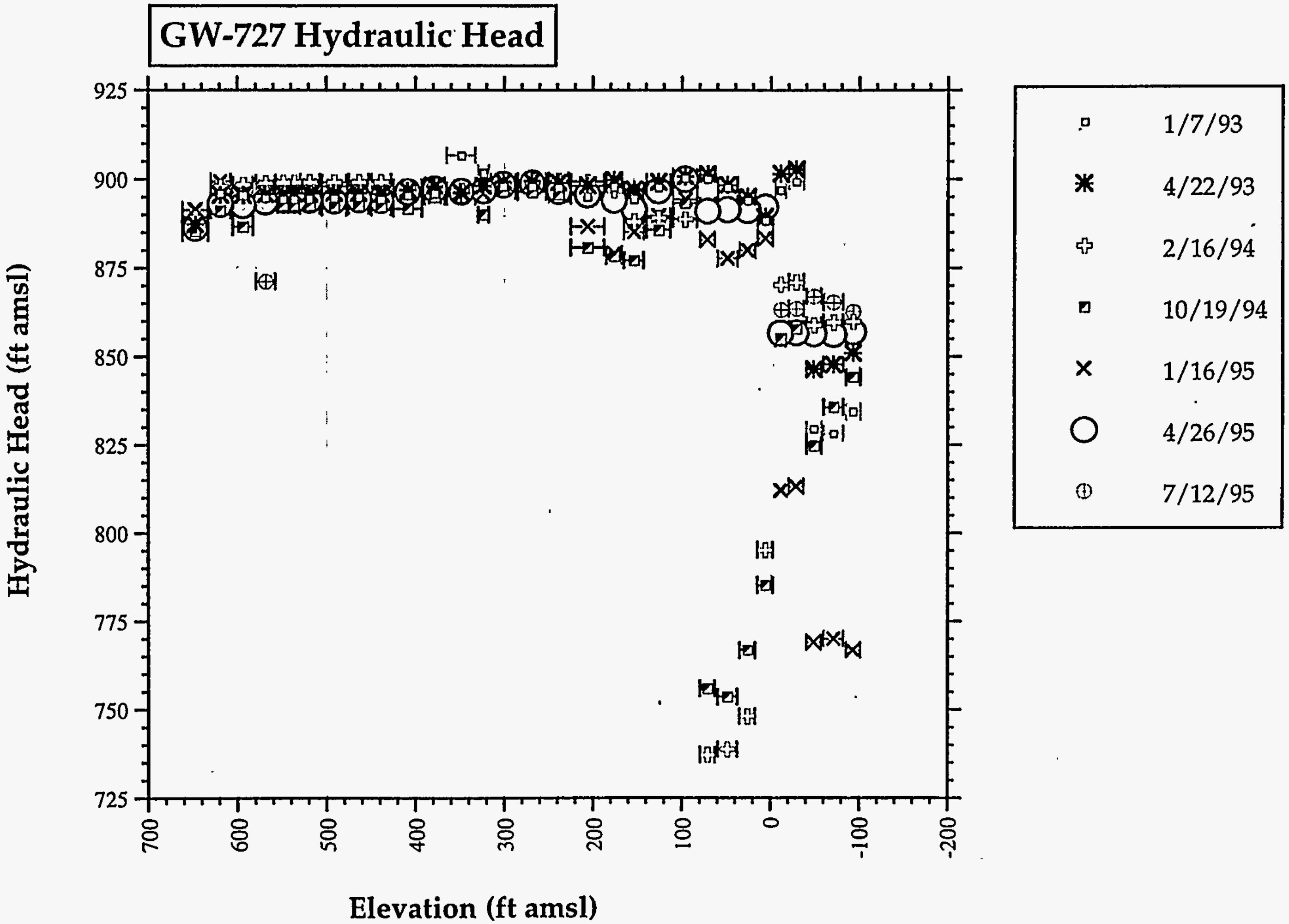

Figure 4. Representative hydraulic head profiles from GW-727.

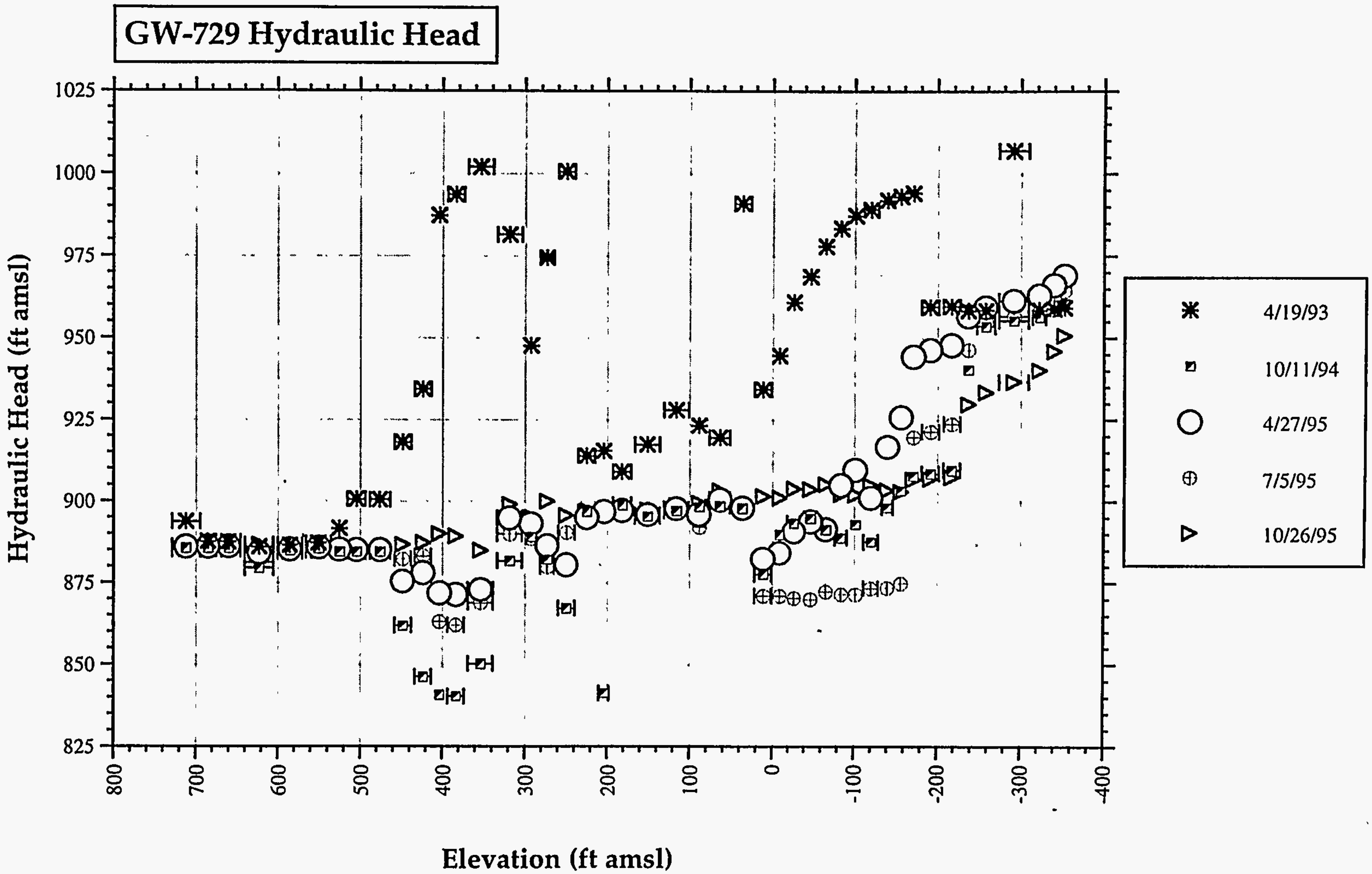

Figure 5. Representative hydraulic head profiles from GW-729.

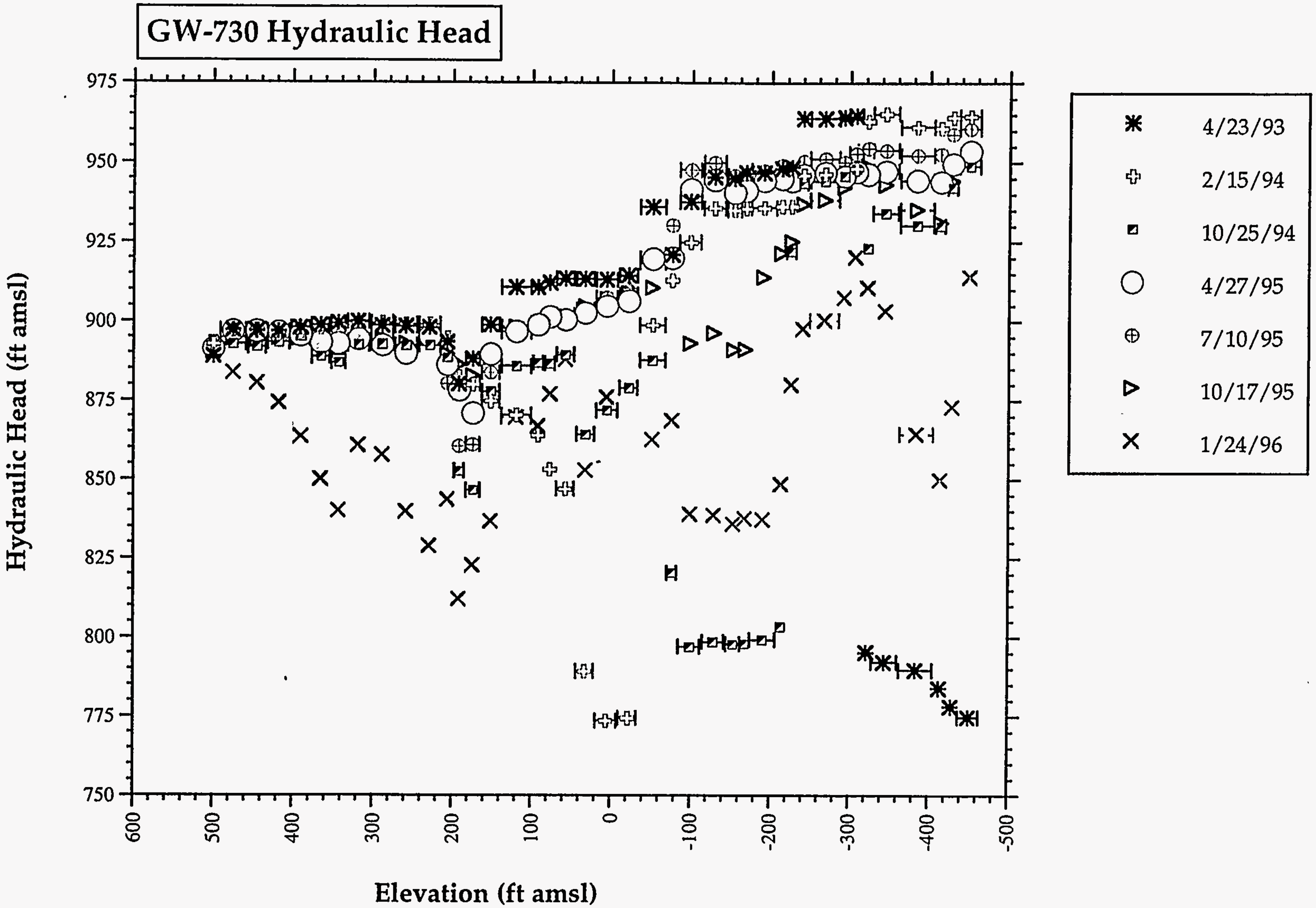

Figure 6. Representative hydraulic head profiles from GW-730.

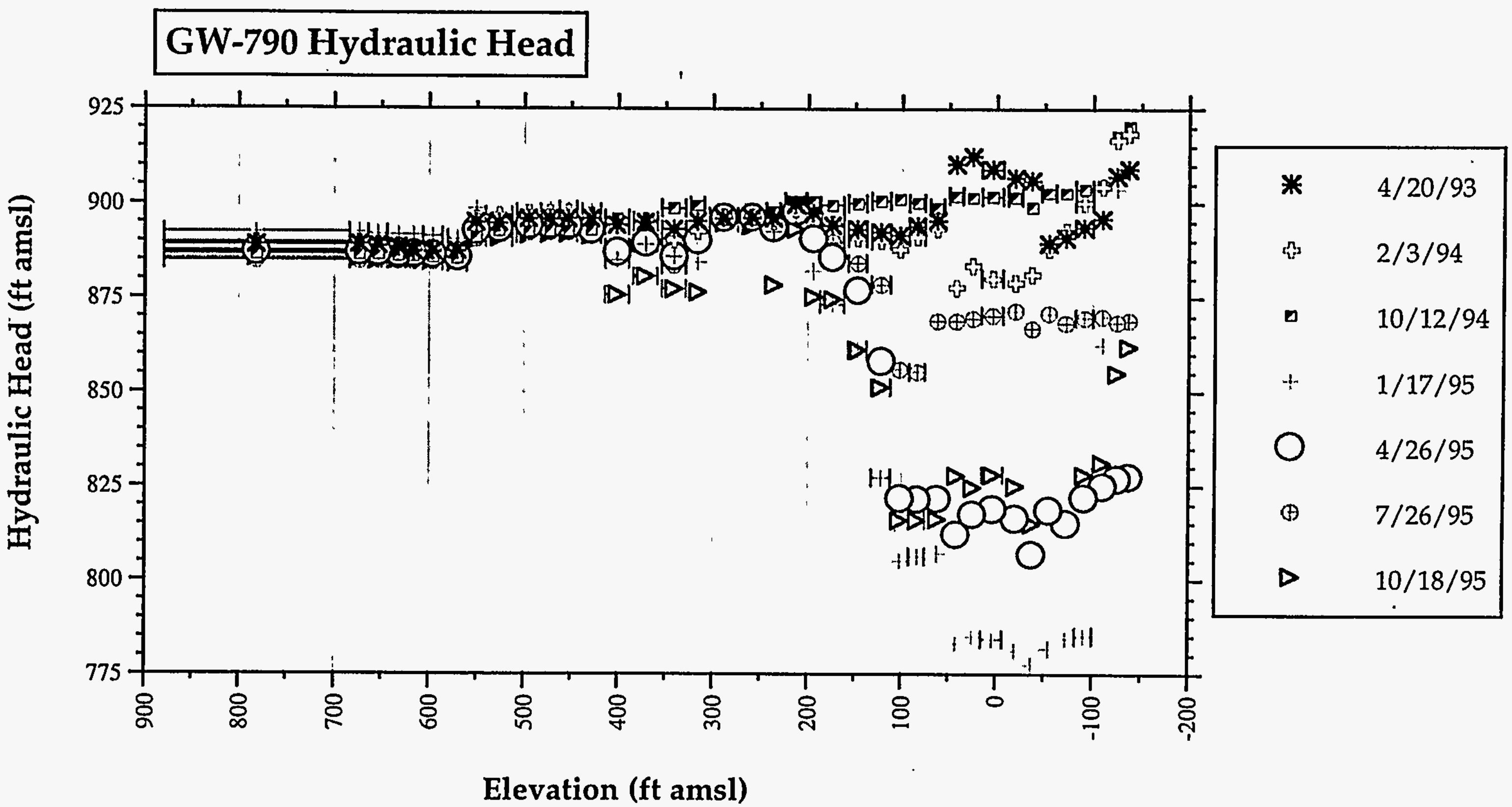

Figure 7. Representative hydraulic head profiles from GW-790.

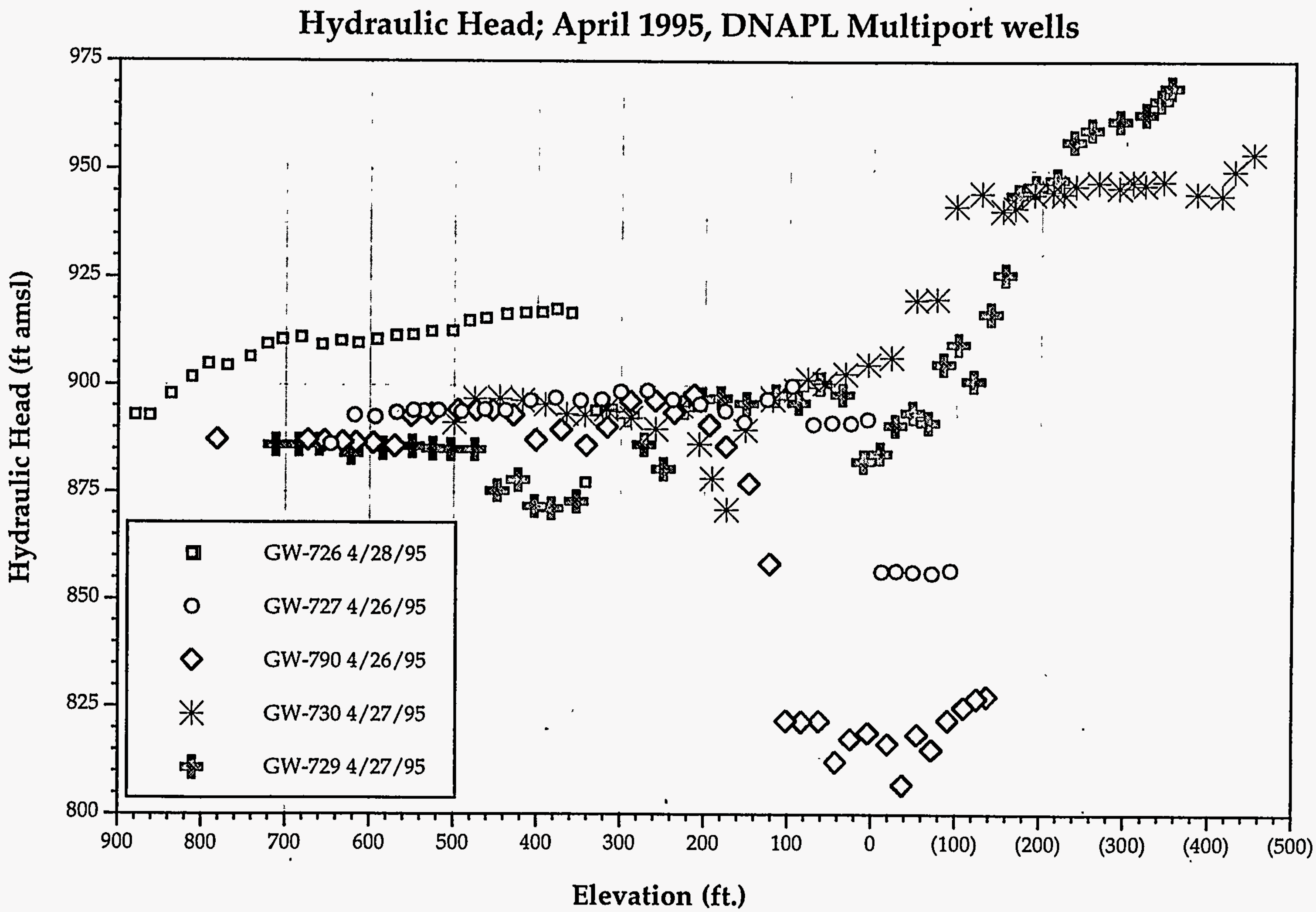

Figure 8. Hydraulic head profiles from GW-726, GW-727, GW-729, GW-730 and GW-790 for April 1995.

6. CONSTRUCTION AND WELL DESIGN TABLES

Table 1. Construction information

Well Name:	GW-726	GW-727	GW-729	GW-730	GW-790
Surface Casing (ft)*:	39.9	241.8	281.5	420.3	40
casing, not grouted (ft)*	-	-	-	-	212.5
Total depth (ft)*:	600.4	1000.1	1361	1424.8	1040.3
Grid system:	Y-12	Y-12	Y-12	Y-12	Y-12
Northing:	29200.66	28734.12	28500.35	28920.84	28676
Easting:	42467.12	42540.07	43656.67	44607.57	43041.1
Ground surface elevation:	922.77	897.96	1002.5	922.64	909.7
Top of concrete pad:	923.37	898.57	NA	923.25	NA
Top of steel casing:	925.69	900.77	1004.61	926.19	911.67
Top of MP casing:	925.39	900.63	1004.48	926.09	911.51
Number of fluid pressure monitoring zones:	27	31	45	41	39
Number of sampling zones:	8	11	11	11	11
Start date:	12/17/91	9/4/91	3/18/92	8/7/91	9/10/92
Finish date:	4/27/92	2/17/92	7/9/92	11/13/91	2/9/93

* all depths measured from ground surface

Table 2. Dates of fluid pressure measurements

GW-726	GW-730	GW-727	GW-790	GW-729
7/27/92	8/6/92	8/17/92		
8/20/92	8/24/92	8/31/92		
9/9/92	9/8/92	9/9/92		
10/13/92				
	11/2/92	10/29/92		
	12/1/92	11/30/92		
1/7/93	1/8/93	1/7/93		
			4/8/93	
4/21/93	4/23/93	4/22/93	4/20/93	4/19/93
			4/28/93	4/28/93
			5/11/93	5/6/93
			5/18/93	5/17/93
			6/3/93	6/10/93
			6/29/93	7/2/93
			7/22/93	7/22/93
			8/18/93	
ONE YEAR OF MONTHLY MEASUREMENTS				
2/18/94	2/15/94	2/16/94	2/3/94	2/4/94
3/14/94	3/18/94	3/17/94	3/18/94	3/11/94
4/15/94	4/14/94	4/15/94	4/13/94	4/12/94
5/9/94	5/11/94	5/11/94	5/10/94	5/10/94
6/13/94	6/13/94	6/8/94	6/8/94	6/7/94
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11/15/94	11/8/94	11/15/94	11/14/94	11/9/94
12/8/94	12/7/94	12/8/94	12/7/94	12/6/94
1/24/95	1/10/95	1/16/95	1/17/95	1/18/95
4/28/95	4/27/95	4/26/95	4/26/95	4/27/95
7/12-13/95	7/10/95	7/12/95	7/26/95	7/5/95
10/1/95	10/17-18/95	10/16/95	10/1/95	10/1/95
1/30/96	1/23-25/96			

Table 3. GW-726 well design information

SURVEY COORDINATES					
MULTIPORT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
1	591-596	591	591.52	333.87	
2	**576-586**	**581**	**581.68**	**343.71**	**586**
3	556-571	561	561.74	363.65	
4	**541-551**	**546**	**546.82**	**378.57**	**551**
5	521-536	526	526.92	398.47	
6	**501-516**	**511**	**511.98**	**413.41**	**516**
7	476-496	486	487.12	438.27	
8	451-471	461	462.25	463.14	
9	**436-446**	**441**	**442.29**	**483.10**	**446**
10	411-431	421	422.30	503.09	
11	386-406	396	397.42	527.97	
12	**366-381**	**376**	**377.51**	**547.88**	**381**
13	346-361	356	357.59	567.80	
14	321-341	331	332.65	592.74	
15	301-316	306	307.76	617.63	
16	**281-296**	**291**	**292.69**	**632.70**	**296**
17	256-276	266	267.73	657.66	
18	231-251	241	242.71	682.68	
19	210-226	215	217.80	707.59	
20	**195-205**	**200**	**202.89**	**722.50**	**205**
21	170-190	180	182.82	742.57	
22	140-165	155	157.77	767.62	
23	**125-135**	**130**	**132.79**	**792.60**	**135**
24	100-120	110	112.86	812.53	
25	75-95	85	87.91	837.48	
26	50-70	60	62.88	862.51	
27	0-45	40	42.94	882.45	

NOTE: all depths except for "true depth" are measured along the borehole with no correction for borehole deviation.
* MP = Westbay Multiport Casing, ags = above ground surface.
* bgs = below ground surface, amsl = above mean sea level.
* TOMP = Top of MP casing

Table 4. GW-727 construction and well design information

MULTIPORT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
1	987-997	987	985.9	-85.3	
2	**962-982**	**972**	**971.0**	**-70.4**	**982**
3	942-957	942	941.1	-40.4	
4	922-937	922	921.2	-20.6	
5	**907-917**	**912**	**911.2**	**-10.6**	**917**
6	887-902	887	886.3	14.3	
7	867-882	867	866.4	34.3	
8	**842-862**	**852**	**851.4**	**49.3**	**862**
9	**822-837**	**832**	**831.4**	69.2	**837**
10	792-817	792	791.5	109.1	
11	762-787	762	761.6	139.0	
12	737-757	737	736.7	164.0	
13	**717-732**	**727**	**726.7**	**174.0**	**732**
14	676-711	676	676.7	223.9	
15	**651-671**	**661**	**661.8**	**238.9**	**671**
16	616-646	616	616.9	283.7	
17	586-611	586	586.9	313.7	
18	**571-581**	**576**	**576.9**	**323.7**	**581**
19	536-566	536	537.0	363.6	
20	511-531	511	512.0	388.7	
21	476-506	476	477.0	423.7	
22	**451-471**	**461**	**462.0**	**438.6**	**471**
23	426-446	426	427.1	473.6	
24	396-421	396	397.1	503.6	
25	**371-391**	**381**	**382.1**	**518.6**	**391**
26	361-366	361	362.1	538.5	
27	**346-356**	**351**	**352.1**	**548.6**	**356**
28	321-341	321	322.2	578.4	
29	296-316	296	297.1	603.5	
30	**271-291**	**281**	**282.1**	**618.5**	**291**
31	0-266	261	262.1	638.5	

NOTE: all depths except for "true depth" are measured along the borehole with no correction for borehole deviation.
* MP = Westbay Multiport Casing, ags = above ground surface.
* bgs = below ground surface, amsl = above mean sea level.
* TOMP = Top of MP.casing

Table 5. GW-729 well design information

MULTIPORT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (msl) (ft)	Port depth bgs (ft)
1	1359-1364	1359	1354.8	-350.1	
2	**1344-1354**	**1349**	**1344.9**	**-340.2**	**1354**
3	1323-1339	1323	1318.9	-314.2	
4	1283-1318	1283	1279.1	-274.5	
5	1256-1278	1256	1252.3	-247.6	
6	**1241-1251**	**1246**	**1242.4**	**-237.7**	**1251**
7	1216-1236	1216	1212.2	-207.5	
8	1190-1211	1190	1186.4	-181.7	
9	**1175-1185**	**1180**	**1176.5**	**-171.8**	**1185**
10	1160-1170	1160	1156.6	-151.9	
11	1142-1155	1142	1138.6	-133.9	
12	**1120-1137**	**1130**	**1126.7**	**-122.0**	**1137**
13	1104-1115	1104	1101.6	-96.9	
14	1084-1099	1084	1081.8	-77.2	
15	**1067-1079**	**1074**	**1071.7**	**-67.0**	**1079**
16	1047-1062	1047	1044.8	-40.1	
17	1026-1042	1026	1023.8	-19.1	
18	**1011-1021**	**1016**	**1013.8**	**-9.2**	**1021**
19	986-1006	986	983.9	20.8	
20	961-981	961	958.9	45.7	
21	931-956	931	929.0	75.7	
22	**911-926**	**921**	**919.0**	**85.6**	**926**
23	876-906	876	874.2	130.5	
24	841-871	841	839.2	165.4	
25	814-836	814	812.3	192.4	
26	**797-809**	**802**	**800.3**	**204.3**	**809**
27	772-792	772	770.4	234.3	
28	747-767	747	745.4	259.2	
29	725-742	725	723.5	281.2	
30	**708-720**	**710**	**708.5**	**296.2**	**720**
31	673-703	673	671.6	333.1	
32	638-668	638	636.6	368.1	
33	613-633	613	611.7	392.9	
34	**598-608**	**603**	**601.7**	**403.0**	**608**
35	573-593	573	571.7	433.0	
36	548-568	548	546.6	458.0	
37	518-543	518	516.7	488.0	
38	491-513	491	489.8	514.9	
39	**476-486**	**481**	**479.8**	**524.9**	**486**
40	440-471	440	439.9	564.8	
41	405-435	405	404.9	599.7	
42	365-400	365	365.0	639.7	
43	330-360	330	330.0	674.7	
44	**315-325**	**320**	**320.1**	**684.6**	**325**
45	0-310	300	300.1	704.6	

NOTE: all depths except for "true depth" are measured along the borehole with no correction for borehole deviation.
* MP = Westbay Multiport Casing, ags = above ground surface.
* bgs = below ground surface, msl = mean sea level.
* TOMP = Top of MP casing

Table 6. GW-730 construction and well design information

MULTIPORT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
1	1374-1384	1374	1364.6	-438.5	
2	**1359-1369**	**1364**	**1354.6**	**-428.5**	**1369**
3	1344-1354	1344	1334.8	-408.7	
4	1298-1339	1298	1290.2	-364.1	
5	1263-1293	1263	1255.5	-329.4	
6	1253-1258	1253	1245.6	-319.5	
7	**1233-1248**	**1243**	**1235.7**	**-309.6**	**1248**
8	1223-1228	1223	1215.9	-289.8	
9	1183-1218	1182	1176.1	-250.0	
10	1168-1178	1168	1161.3	-235.2	
11	**1153-1163**	**1158**	**1151.3**	**-225.2**	**1163**
12	1143-1148	1143	1136.5	-210.4	
13	1108-1138	1108	1101.6	-175.5	
14	1098-1103	1098	1091.8	-165.7	
15	**1078-1093**	**1088**	**1081.8**	**-155.7**	**1093**
16	1048-1073	1048	1042.2	-116.1	
17	1018-1043	1018	1012.5	-86.4	
18	**1003-1013**	**1008**	**1002.6**	**-76.5**	**1013**
19	968-998	968	962.9	-36.8	
20	942-963	942	938.1	-12.0	
21	**912-937**	**922**	**918.2**	**7.9**	**932**
22	887-907	887	883.6	42.5	
23	862-882	862	858.7	67.3	
24	847-587	847	843.9	82.2	
25	**832-842**	**837**	**833.9**	**92.2**	**842**
26	792-827	792	789.2	136.9	
27	767-787	767	764.5	161.6	
28	**747-762**	**757**	**754.5**	**171.6**	**762**
29	732-742	732	729.6	196.4	
30	**717-727**	**722**	**719.7**	**206.4**	**727**
31	687-712	687	684.9	241.1	
32	657-682	657	655.2	270.9	
33	627-652	627	625.4	300.7	
34	597-622	597	595.5	330.6	
35	**576-592**	**586**	**585.5**	**340.6**	**592**
36	551-571	551	550.6	375.5	
37	526-546	526	525.8	400.2	
38	496-521	496	496.0	430.1	
39	**471-491**	**481**	**480.9**	**445.2**	**491**
40	436-466	436	436.1	489.9	
41	0-431	421	421.2	504.9	

NOTE: all depths except for "true depth" are measured along the borehole with no correction for borehole deviation.
* MP = Westbay Multiport Casing, ags = above ground surface.
* bgs = below ground surface, amsl = above mean sea level.
* TOMP = Top of MP casing

Table 7. GW-790 construction and well design information

MULTIPORT DESIGN					
COMPLETION ZONE		MEASUREMENT PORT			PUMPING PORT
Zone Number	Interval depth bgs (ft)	Port depth bgs (ft)	True Port depth from TOMP (ft)	Elevation (amsl) (ft)	Port depth bgs (ft)
1	1036-1041	1036	1035.51	-124.00	
2	**1021-1031**	**1026**	**1025.55**	**-114.04**	**1031**
3	1006-1016	1006	1005.63	-94.12	
4	982-1001	982	982.67	-71.16	
5	**967-977**	**972**	**972.68**	**-61.17**	**977**
6	947-962	947	947.77	-36.26	
7	**932-942**	**937**	**937.79**	**-26.28**	**942**
8	912-927	912	912.86	-1.35	
9	885-907	885	885.86	25.65	
10	**870-880**	**875**	**875.87**	**35.64**	**880**
11	850-865	850	850.89	60.62	
12	830-845	830	830.89	80.62	
13	808-825	808	808.87	102.64	
14	**793-803**	**798**	**798.86**	**112.65**	**803**
15	768-788	768	768.90	142.61	
16	743-763	743	743.93	167.58	
17	713-738	723	723.91	187.60	
18	703-708	703	703.87	207.64	
19	**676-698**	**686**	**686.95**	**224.56**	**698**
20	656-671	656	656.97	254.54	
21	631-651	631	632.02	279.49	
22	596-626	596	597.05	314.46	
23	**576-591**	**586**	**587.06**	**324.45**	**591**
24	546-571	546	547.06	364.45	
25	516-541	516	517.12	394.39	
26	486-511	486	487.11	424.40	
27	461-481	461	462.11	449.40	
28	437-456	437	438.10	473.41	
29	**422-432**	**427**	**428.13**	**483.38**	**432**
30	392-417	392	393.15	518.36	
31	358-387	358	360.16	551.35	
32	**343-353**	**348**	**350.14**	**561.37**	**353**
33	318-338	318	320.09	591.42	
34	292-313	292	294.07	617.44	
35	**277-287**	**282**	**284.08**	**627.43**	**287**
36	260-272	260	262.04	649.47	
37	235-255	235	237.05	674.46	
38	220-230	220	222.03	689.48	
39	**198-215**	**203**	**204.98**	**706.53**	**215**

NOTE: all depths except for "true depth bgs" are measured along the borehole with no correction for borehole deviation.
* MP = Westbay Multiport Casing, ags = above ground surface.
* bgs = below ground surface, amsl = above mean sea level.
*TOMP = Top of MP casing
** casing is grouted to 40.0' rather than 212.5 ft.

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