Addendum D 300 Area Process Trenches Groundwater Monitoring Plan

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7. Abstract

This document outlines the groundwater monitoring plan, under RCRA regulations in 40 CFR 264 Subpart F and WAC 173-300-645, for the 300 Area Process Trenches. The 300 Area Process Trenches will go into final status in September 1995 and sampled under a compliance monitoring program. This plan provides current program conditions and requirements.

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	U.S. Department of Energy
DQO	data quality objectives
DWS	Drinking Water Standards
ECOLOGY	State of Washington Department of Ecology
Eh	redox potential
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
GeoDAT	Geosciences Data Analysis ToolKit
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
OU	operable unit
PCE	perchloroethylene
POC	point of compliance
PNL	Pacific Northwest Laboratory
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act of 1976
TCE	trichloroethylene
TSD	treatment, storage, and disposal
VOA	Volatile Organic Analysis
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

This document describes the groundwater monitoring program for the Hanford Site 300 Area Process Trenches (300 APT). The 300 APT are a *Resource Conservation and Recovery Act of 1976* (RCRA) regulated unit. The 300 APT are included in the *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*, Permit No. WA890008967, (referred to herein as the Permit) (Ecology 1994) and are subject to final-status requirements for groundwater monitoring (Ecology 1994).

This document describes a compliance monitoring program for groundwater in the uppermost aquifer system at the 300 APT. This plan describes the 300 APT monitoring network, constituent list, sampling schedule, statistical methods, and sampling and analysis protocols that will be employed for the 300 APT. This plan will be used to meet groundwater monitoring requirements from the time the 300 APT becomes part of the Permit and through the postclosure care period until certification of final closure.

1.1 HISTORY OF GROUNDWATER MONITORING AT THE 300 APT

An extensive groundwater monitoring program was carried out during the operational life of the 300 APT (1975 to 1994). Prior to, and continuing beyond the time the 300 APT went into service, many of the wells in the 300 Area were monitored for both radioactive and nonradioactive constituents, as well as water levels. In 1994, Ecology issued a RCRA Permit for the Hanford Site (Ecology 1994). The effective date of the Permit was September 28, 1994. RCRA treatment, storage, and disposal (TSD) units included in the Permit are required to conduct a final status groundwater monitoring program (see Section 1.2). Only five TSD units were included in this Permit originally. The 300 APT is scheduled to be included in the Permit as a TSD unit undergoing closure through the permit modification process in September 1995. Currently, the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) Record of Decision is not completed. Consequently, final closure specifications (e.g., cleanup levels, remediation methodology) are not yet known to the closure process. In 1977, Pacific Northwest Laboratory (PNL) initiated a site-specific program of groundwater monitoring. During the first year of the program, groundwater samples were collected monthly from approximately 30 wells, and water levels were measured weekly. A reduced level of effort was continued on this program until 1985.

From 1985 to the present the 300 ATP site has been regulated under RCRA. The first groundwater monitoring compliance plan was initiated in 1986 (Schalla et al. 1986). In the *Consent Agreement and Compliance Order* (Ecology and EPA 1986) the 300 ATP site was placed in an interim-status groundwater quality assessment monitoring program. The assessment-* level status was based on the decision that (1) the groundwater monitoring wells around the 300 APT were inadequate for alternate groundwater monitoring as described in 40 CFR 265.90(d) (EPA 1984) and Washington Administrative Code (WAC) 173-303-400 (Ecology 1986) and (2) the groundwater quality in the 300 Area had been adversely impacted by the operations of the 300 APT. In response to the *Consent Agreement and Compliance Order* over 20 additional

wells were installed and monitored. The 300 ATP site was extensively characterized (Schalla et al. 1988b), and a revised groundwater monitoring compliance plan (Schalla et al. 1988a) was implemented in 1988. The plan has been modified as groundwater data were collected and analyzed. The data are reported to the State of Washington Department of Ecology (Ecology) quarterly, along with data from other RCRA-regulated units at the Hanford Site. Interpretive reports are submitted to Ecology annually.

The 300 APT are located in the 300-FF-1 source operable unit (OU) and 300-FF-5 groundwater OU, under the authority of RCRA TSD and CERCLA past practice. In an expedited response action (ERA) in 1991, sediment from the sides and bottom of the trenches was removed and stored at the northern ends of the trenches. The action lowered the concentrations of uranium and various nonradioactive constituents, but uranium, trichloroethylene (TCE), and cis-1,2-dichloroethylene (cis-DCE) are still detected in downgradient wells. Any additional corrective action deemed necessary will be deferred until decisions are made regarding the 300-FF-1 and 300-FF-5 OUs.

1.2 CHANGES FROM INTERIM-STATUS GROUNDWATER MONITORING

Interim- and final-status groundwater regulations differ in several respects. The "assessment" program under interim status is equivalent to a "compliance" program in final status. In compliance monitoring, specific constituents are chosen and compared to concentration limits. If these limits are exceeded, the site enters a corrective action phase. Statistical methods proposed in this document are different than those used under interim status. Final-status regulations require independent samples, which involves waiting periods between samples, rather than filling multiple bottles at once (replicates). In final status, samples are required at least semiannually rather than quarterly as in interim status.

The proposed program has a smaller monitoring well network and a shorter constituent list than the previous program. A complete description of the proposed groundwater monitoring program is presented in Section 4.0.

2.0 FACILITY DESCRIPTION AND OPERATION HISTORY

The 300 APT are located in the 300 Area of the Hanford Site (Figure 2-1). The 300 Area is a research and former nuclear fuels operations area encompassing approximately 2.9 km^2 (720 acres) in the southeastern portion of the Hanford Site. Figure 2-2 shows the 300 Area main facilities.

The 300 APT began operating in 1975 and was the main facility for disposal of most liquid process wastes generated in the 300 Area until the trenches were removed from service. The liquid waste discharged to the 300 APT consisted mostly of wastewater with relatively low concentrations of chemical contaminants. More concentrated wastes were generally not discharged to the 300 APT. The discharge rate has varied over the years, but it reached a maximum average of about 8,641 L/min (2,283 gal/min) during 1979. Total discharge for 1979 was 4.5E9 L (1.2E9 gal). Since 1987, when fuels fabrication ceased in the 300 Area, the wastewater has consisted of cooling water with small quantities of nonhazardous maintenance and process waste. When the 300 APT were in use, the east and west trenches were used alternately for periods of up to approximately 8 months. The west trench was removed from service in November 1992; the east trench remained in service with an average discharge of 814 L/min (215 gal/min). The 300 APT was administratively isolated from receiving further discharges in December 1994 and was physically isolated in January 1995.

The 300 APT consist of two separate 457-m- (1,500-ft-) long trenches excavated 3.7 m (12 ft) into the subsurface and separated by an earthen berm. The unlined trenches are excavated into the sandy gravels of the Hanford formation, and the bottoms of the trenches are about 6.1 m (20 ft) above the water table. Figure 2-3 contains a schematic cross section showing the dimensions and relationship of the eastern trench to the water table and the nearby Columbia River. Figure 2-3 also shows the area in plan view with the location of the schematic cross section, some example well locations, and nearby facilities. If the cross section were continued to the west to include the western trench, it would look very similar to the eastern trench except for the enlarged northern end which is caused by a natural depression (Figure 2-4). In 1990, the depression was separated from the west trench by a berm needed to support a birdscreen placed over the trench. The north 91 m (300 ft) of the original trenches, including the depression, are now an impoundment area for covered, low-level radioactive and low-level, mixed waste soils.

A concrete weir box is located at the south end of the trenches. Process sewer effluent reached the trenches through 24-inch-diameter 300 Area Process Sewer System piping that is connected to the weir box. The weir box measures 21.3 m (70 ft) long (east-west dimension), 3 m (10 ft) high, and 3 m (10 ft) wide. It has two sluice gates that, in the past, allowed the trenches to be operated alternately.

Administrative controls to prevent disposal of dangerous wastes to the 300 APT were instituted on February 1, 1985. Prior to that time, a variety of chemical wastes was included with the wastewater. However, no large quantity of any one waste was included in the process wastes. Estimated amounts of chemicals discharged to the 300 APT are summarized in Table 2-1. From the

Figure 2-1. Location of the 300 Area and the Hanford Site.

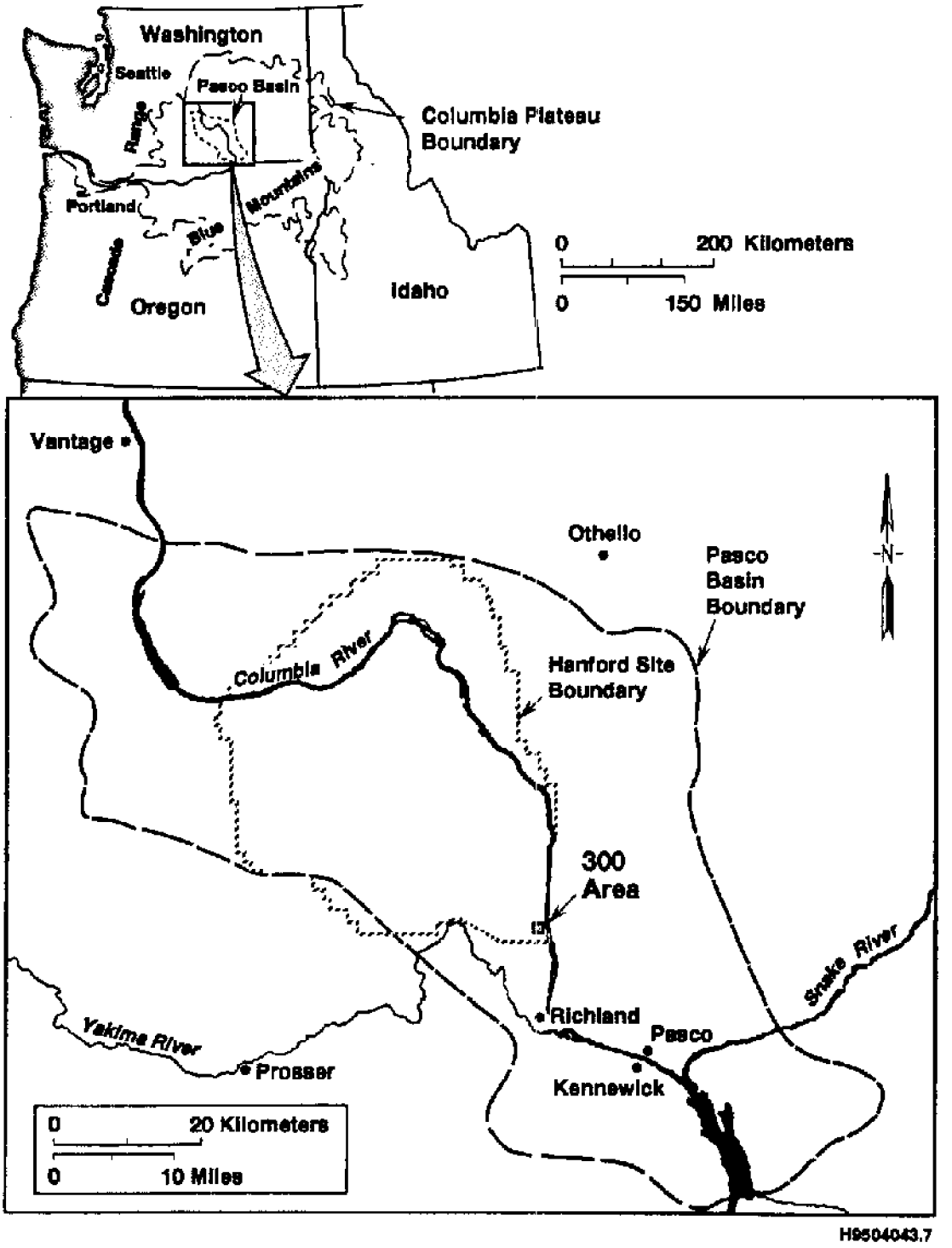


Figure 2-2. Locations of Main Facilities in the 300 Area.

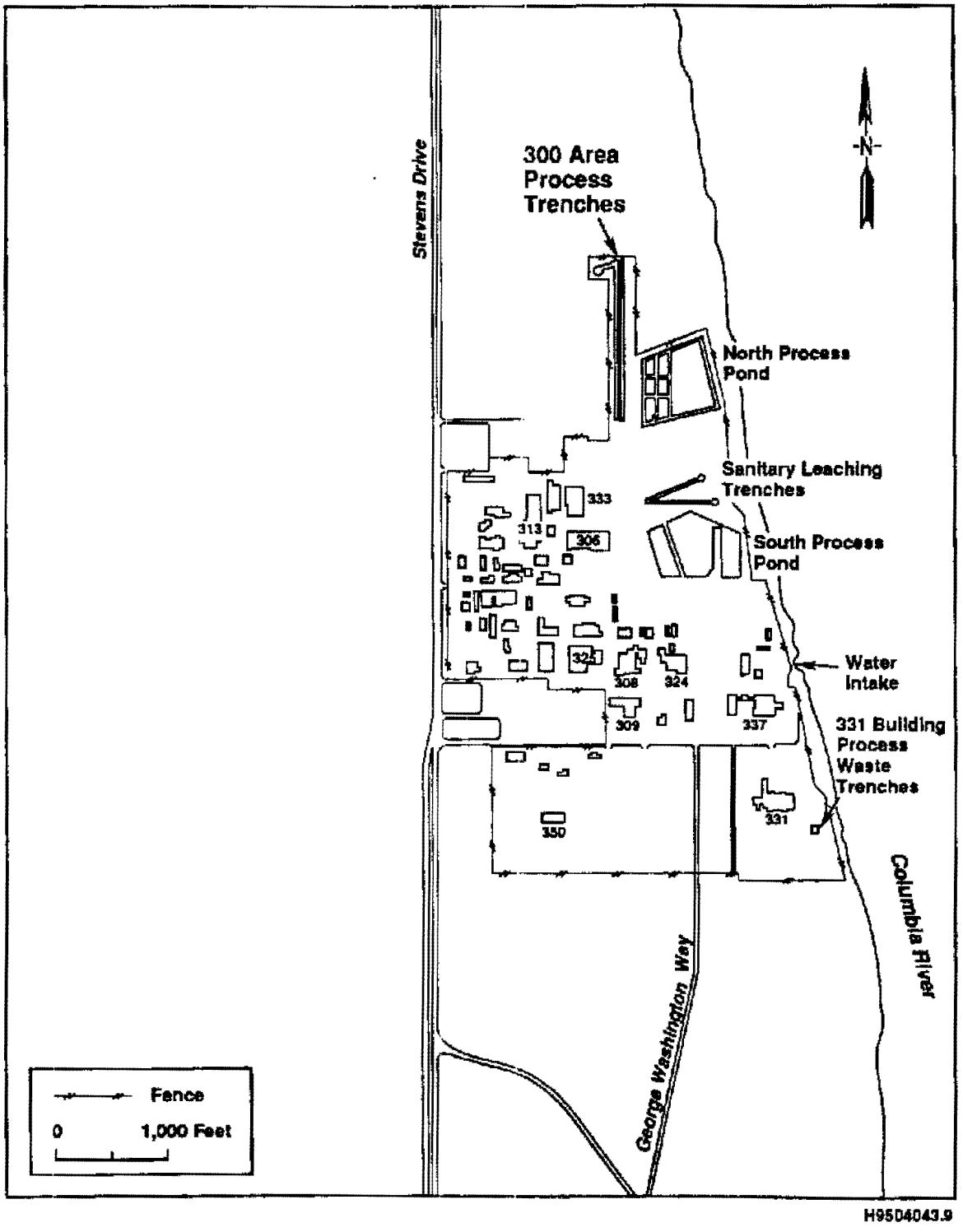
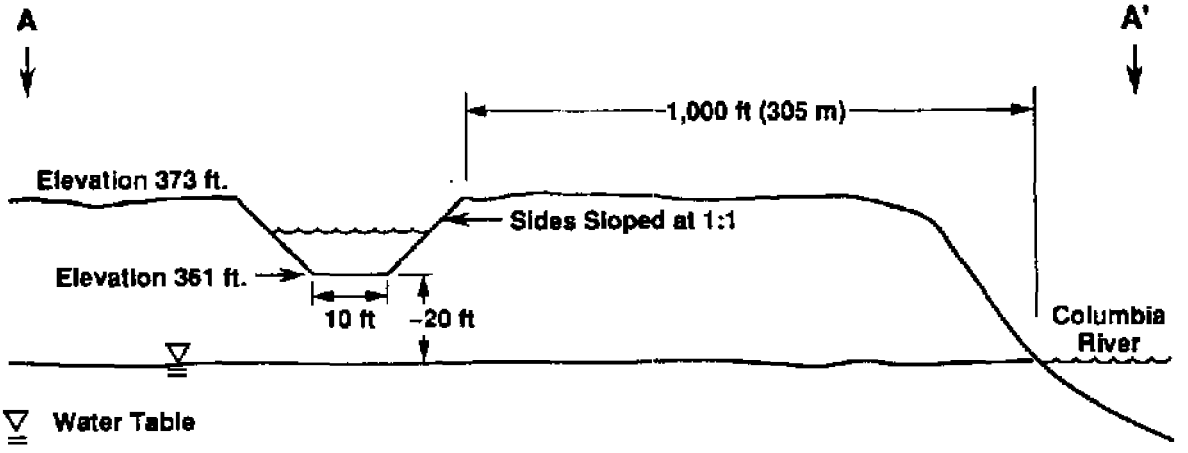


Figure 2-3. Schematic Cross Section of the 300 Area Process Trenches (modified from Schalla et al. 1988b).



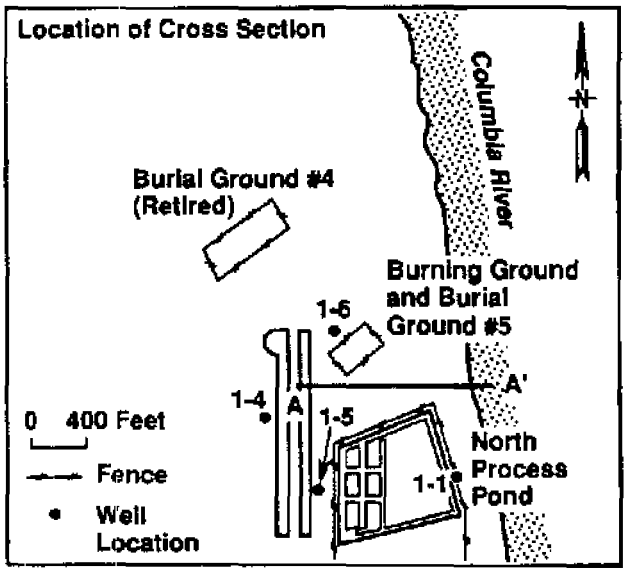


Figure 2-4. Topography in the Vicinity of the 300 Area Process Trenches.

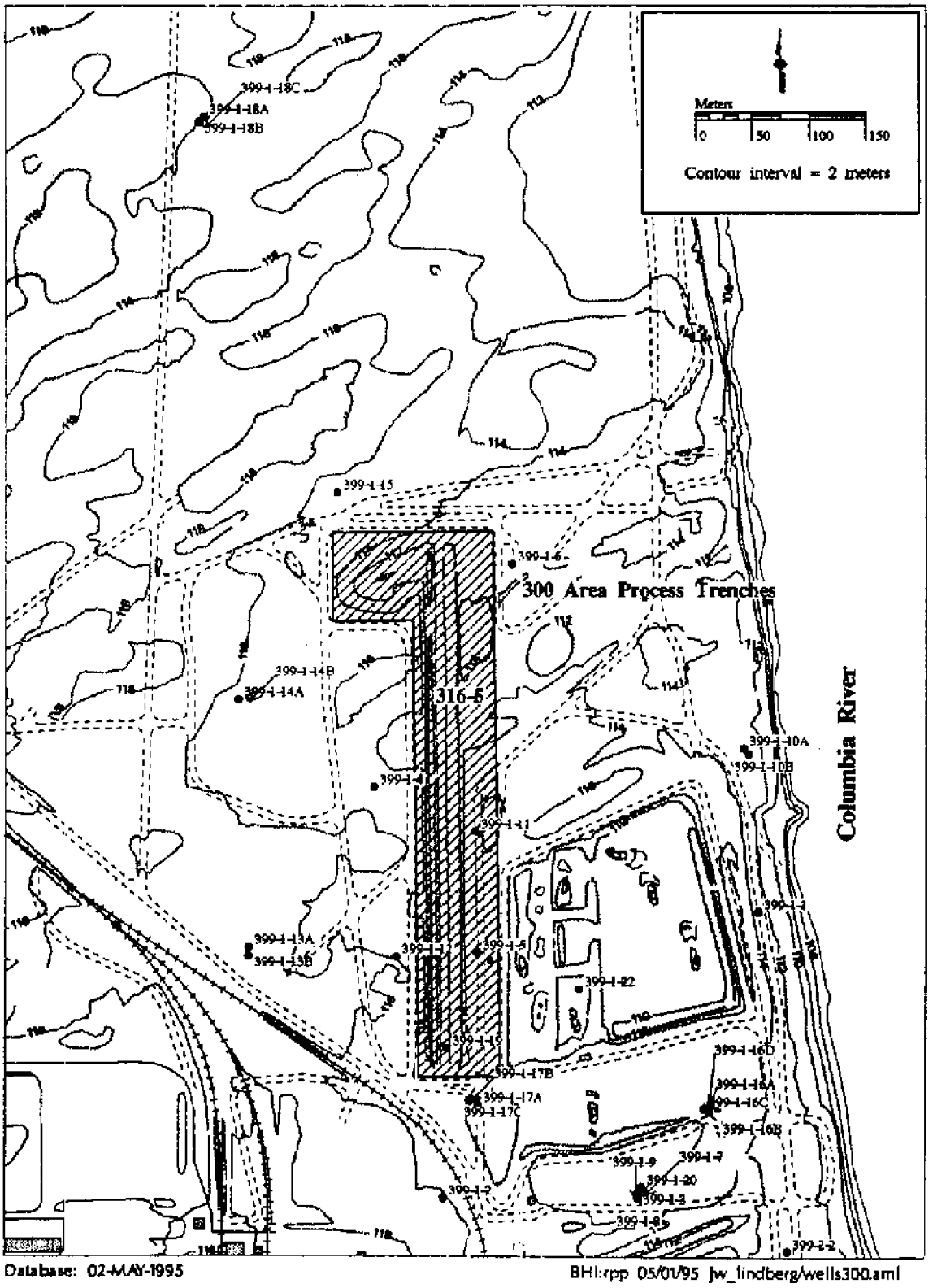


Table 2-1. An Estimate of Chemicals Discharged to the 300 Area Process Trenches Prior to February 1, 1985 (modified from Schalla et al. 1988a).

Intermittent Discharges		Later Discharges[a]	
<Grams	<Kilograms		
Ammonium bifluoride	Benzene	Copper	30 kg/mo[b]
Antimony	Carbon tetrachloride	Detergents	≤30 kg/mo[b]
Arsenic	Chromium	Ethylent glycol	≤200 L/mo
Barium	Chlorinated benzenes	Hydrofluoric acid	100 kg/mo[b]
Cadmium	Degreasing solvents	Nitrates	≤2,000 kg/mo
Dioxane	Formaldehyde	Nitric acid	≤300 L/mo
Dioxin[c]	Formic acid	Sodium hydroxide	≤300 L/mo
Hydrocyanic acid	Hexachlorophene	Paint solvents	≤100 L/mo
Pyridine	Kerosene	Photo chemicals	≤700 L/mo[b]
Selenium & compounds	Lead	Sodium chloride	75 tons/yr
Thiourea	Methy ethyl ketone	Uranium	20 kg/mo[b]
Misc. laboratory chemicals	Mercury	Perchloroethylene	450 L[d]
	Napthalene	Heating oil	300 L[d]
	Nickel		
	Phenol		
	Silver		
	Sulfuric acid		
	Tetrachloroethylene (perchlorethylene)		
	Toluene		
	Tributylphosphate (paraffin hydrocarbon solvents)		
	1,1,1-Trichloroethane (methyl chloroform)		
	Trichloroethylene		
	Xylene		

[a]These discharges were relatively continuous.
[b]Discharged at least through 1988.
[c]Included only because of the potential for dioxin to exist as a trace impurity in chlorinated benzenes.
[d]Known spills.

beginning of operations in 1975 until October 1993, a continuous, composite sampler was located at the headwall to analyze the wastewater at the point of discharge to the trenches. Since 1993, the effluent has been analyzed by a sampler located outside the unit.

In 1991 an ERA was undertaken at the 300 APT. This action was initiated because of concerns about analytical results of trench sampling in 1986 (DOE-RL 1990, Table 15). The ERA objective was to reduce the potential migration of contaminants in the soil at the bottom of trenches to groundwater. The specific ERA goal was to reduce the measurable level of radiation in the trenches to less than three times the upper tolerance limit of background. This was accomplished by removing contaminated sediments, using them to fill in the north end of the trenches, and immobilizing them. In the process much of the inorganic constituents (including heavy metals) were removed as well (DOE-RL 1992).

Approximately 5,400 m^3 (7,000 yd^3) of sediment were removed from the trench and relocated to the north ends of the trenches. About [illegible] of chemically and radioactively contaminated soil from the sides [illegible] 1.3 m (4 ft) from the bottom of each trench were removed. The less radioactively contaminated sediments (<2,000 cpm) were relocated to the north end of each trench. The more radioactively contaminated sediments (>2,000 cpm) were consolidated in the depression located at the northwest corner of the west trench. Contaminated soils in the depression were isolated from the effluent and then covered with a plastic barrier and a layer of clean aggregate. Results of pre- and post-ERA sampling and analysis (DOE-RL 1992) indicate that the ERA successfully reduced trench contamination at all areas of the trenches other than the position where contaminated soils were stockpiled. Results of groundwater sampling and analysis after the ERA also show a drop in constituents of concern. As an example, uranium concentrations in well 399-1-17A declined following ERA (see Section 3.3).

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3.0 HYDROGEOLOGY AND GROUNDWATER MONITORING RESULTS

Information about geology, groundwater hydrology, and groundwater contamination in the vicinity of the 300 APT has been derived predominantly from wells. Since the first 300 Area groundwater monitoring well was installed in 1943 (399-3-6), many additional wells of a variety of construction types have been installed to monitor the groundwater and characterize the geology. Most wells fit into one of two types: (1) a pre-1985 type that is nominal 0.15 to 0.30 m (6 in. up to 12 in. diameter) carbon steel casing that was perforated (early design) or screened (later design) in the saturated zone and (2) a 1985 to recent type that meets the requirements of WAC 173-160, *Minimum Standards for Construction and Maintenance of Wells* (REFERENCE). These more modern regulatory-compliant wells have nominal 10-cm (4-in.) stainless steel casing with stainless steel, wire-wrap screens in the saturated zone, and extensive annular and surface seals. Figure 3-1 is a map of the 300 Area showing well locations. Table 3-1 provides well construction details.

3.1 GEOLOGY

This section summarizes the geology in the vicinity of the 300 APT. More detailed discussions are found in Lindberg and Bond (1979), Schalla et al. (1988b), Delaney et al. (1991), Gaylord and Poeter (1991), and Swanson et al. (1992). From youngest to oldest, the geologic units found beneath the 300 Area are:

- Holocene surficial deposits
- Hanford formation
- Ringold Formation
- Saddle Mountains Basalt.

These units are discussed in the following sections.

A stratigraphic column (Figure 3-2) and a series of geologic cross sections (Figures 3-3 through 3-6) show the distribution and characteristics of geologic units within the 300 Area. The 300 Area is located within one of the broad, flat synclines (Pasco syncline) within the larger Pasco Basin. The basalts and overlying sediments are essentially horizontal. The following sections discuss the geologic units beneath the 300 Area in more detail.

3.1.1 Holocene Surficial Deposits

Holocene surficial deposits in the vicinity of the 300 Area include eolian sandy silts and fluvial deposits associated with the Columbia River. The eolian deposits are in the form of thin (0 to 2 m [0 to 6.6 ft]) sheets and thicker (2 to 5 m [6.6 to 16 ft]) dunes. Dunes are especially well developed and remain active in the area to the north of the 300 Area. Inside the perimeter fence of the 300 Area the eolian deposits are mostly absent or reduced in thickness as a result of construction activities. Recent fluvial deposits such as overbank silts and channel deposits of sand and gravel are found in areas immediately adjacent to the Columbia River.

Figure 3-1. Location Map of 300 Area Wells.

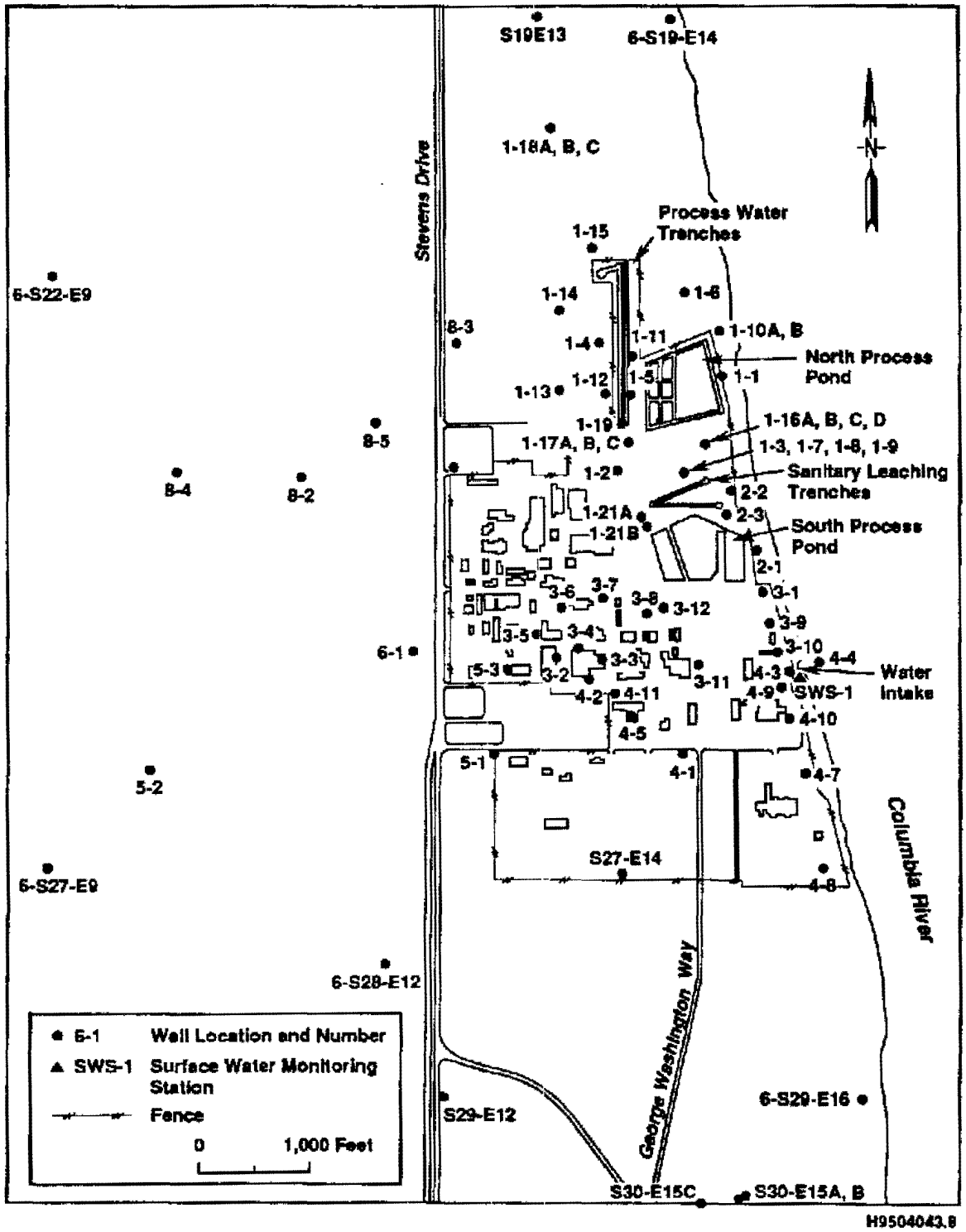


Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
Original 16 Wells in Groundwater Monitoring Plan (Schalla 1988b)							
699-S19E13	11/71	50	51	78	P	TU	N
399-1-6	2/75	22	33	43	S	TU	N
399-1-4	5/50	23	38	70	P	TU	N
399-1-5	2/75	23	35	45	S	TU	N
399-1-1	11/48	40	33	75	P	TU	N
399-8-2	5/50	43	50	72	P	TU	N
399-1-2	4/50	25	42	75	P	TU	N
399-1-3	4/50	25	34	70	P	TU	N
399-1-7	3/85	25	37	70	S	TU	N
399-1-8	8/85	85	40	105	S	BU	N
399-2-1	11/48	18	34	75	P	TU	N
399-3-7	1/44	45	---	60	P	TU	N
399-3-10	9/76	34	40	49	S	TU	N
399-4-1	2/51	25	50	80	P	TU	N
399-4-7	11/61	21	36	46	P	TU	N
699-S30E15A	10/71	58	65	78	S	TU	N
Wells Completed in 1986 and 1987 in Response to the *Tri-Party Agreement*							
399-4-11	11/26/86	55	63	70	S	TU	Y
399-1-9	2/12/87	170	10	178	S	C	Y1
399-1-10A	12/23/86	23	31	39	S	TU	Y2
399-1-11	11/20/86	26	35	47	S	TU	Y
333-1-12	11/3/86	45	42	60	S	TU	Y
399-1-13A	11/5/86	38	46	53	S	TU	Y2
399-1-14A	11/14/86	31	39	47	S	TU	Y2
399-1-15	11/17/86	29	36	44	S	TU	Y
399-1-16A	12/5/86	32	39	48	S	BU	Y2
399-1-16B	2/10/87	105	38	115	S	C	Y
399-1-16C	1/16/87	167	40	178	S	TU	Y
399-1-17A	11/13/86	25	35	40	S	BU	Y

Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
399-1-17B	12/19/86	100	33	110	S	C	Y
399-1-17C	1/16/87	161	3	171	S	TU	Y
399-1-18A	11/12/86	38	47	54	S	BU	Y2
399-1-18B	1/23/87	109	43	119	S	C	Y
399-1-18C	1/6/87	130	45	140	S	TU	Y
399-1-19	5/23/86	--	33	--	--	TU	N1
Miscellaneous Wells							
399-1-10B	10/8/91	105	38	115	S	BU	Y
399-1-14B	10/31/91	99	38	110	S	BU	Y
399-2-2	10/3/76	35	39	55	S	TU	N
399-2-3	10/4/76	45	40	55	S	TU	N
399-3-1	10/26/48	20	40	65	P	TU	N
399-3-2	10/13/47	40	51	75	P	TU	N
399-3-3	2/9/48	52	51	81	P	TU	N
399-3-6	8/43	42	49	55	P	TU	N
399-3-8	3/17/70	28	44	48	P	TU	N
399-3-9	8/30/76	45	55	55	S	TU	N
399-3-11	9/17/76	45	53	65	S	TU	N
399-4-9	9/26/76	38	38	58	S	TU	N
399-4-10	9/27/76	30	34	50	S	TU	N
399-5-1	2/19/51	23	51	58	P	TU	N
399-6-1	6/2/50	25	45	50	P	TU	N
399-8-1	6/6/50	35	52	60	P	TU	N

Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
399-8-3	3/7/51	25	50	72	P	TU	N
699-S27-E14	4/15/48	45	58	1005	P	TU	N
699-S29-E12	11/5/71	59	38	79	S	TU	N

Aquifer = Which aquifer screened or casing perforated in which aquifer?
B = Depth to bottom of screen or perforations in feet.
BU = Bottom of unconfined aquifer.
C = Confined aquifer.
Completed = Completion date.
N1 = Carbon steel casing, not perforated or screened, open at hole bottom.
P = Access to aquifer through perforations in casing.
S = Access to aquifer through well screen.
S/P = Screen or perforations in carbon steel casing?
T = Depth to top of screen or perforations in feet.
TU = Top of unconfined aquifer.
WAC = Well construction complies with WAC 173-160?
WL = Depth to water in feet.
Y/N = Yes/No.
Y1 = Well has a 10-in. carbon steel casing that was left in hole to 100 ft.
Y2 = Two screens, telescoping screen left in hole.

Figure 3-2. Generalized Geologic Column for the 300 Area Near the Process Trenches.

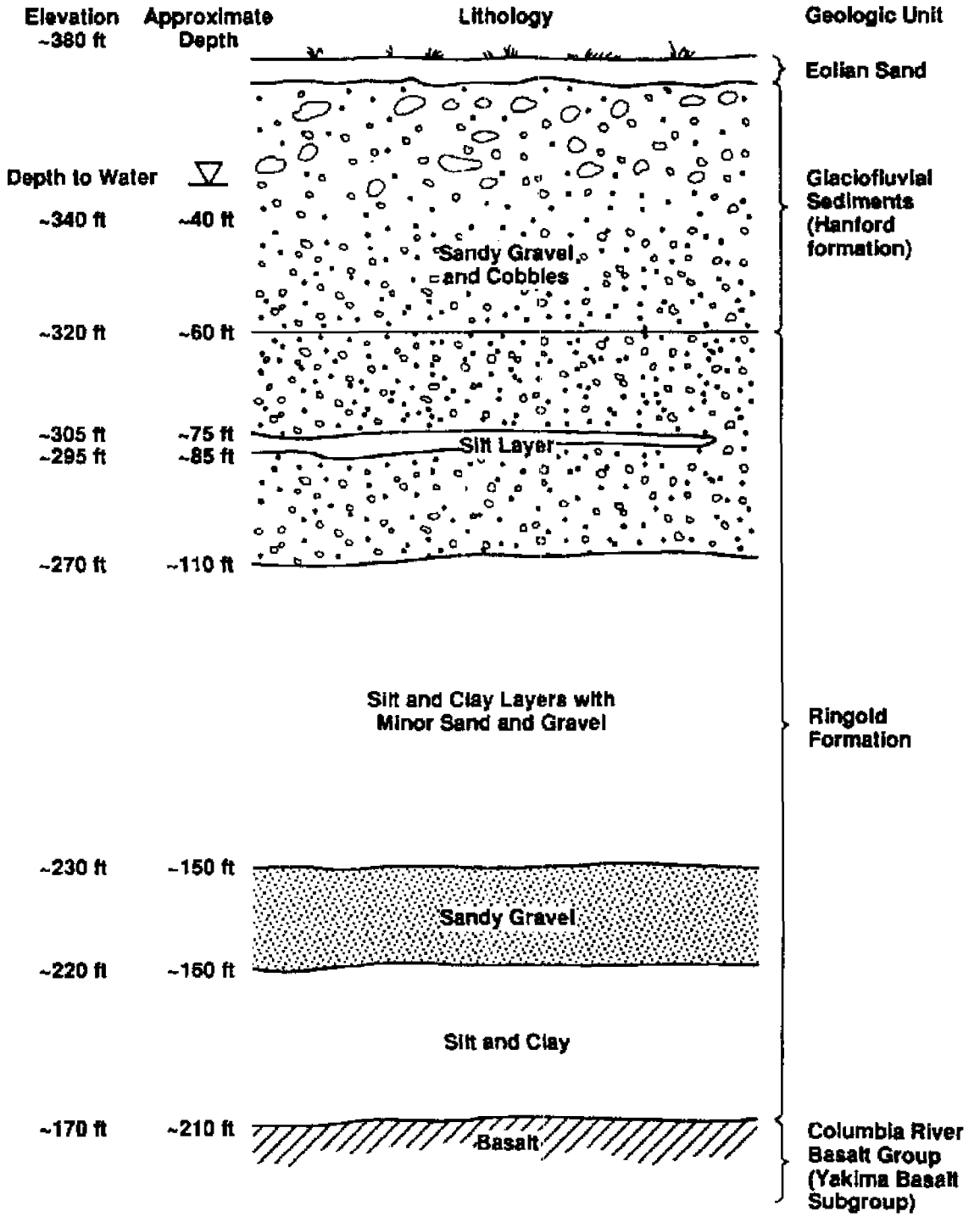


Figure 3-3. Location Map for the Geologic Cross Sections.

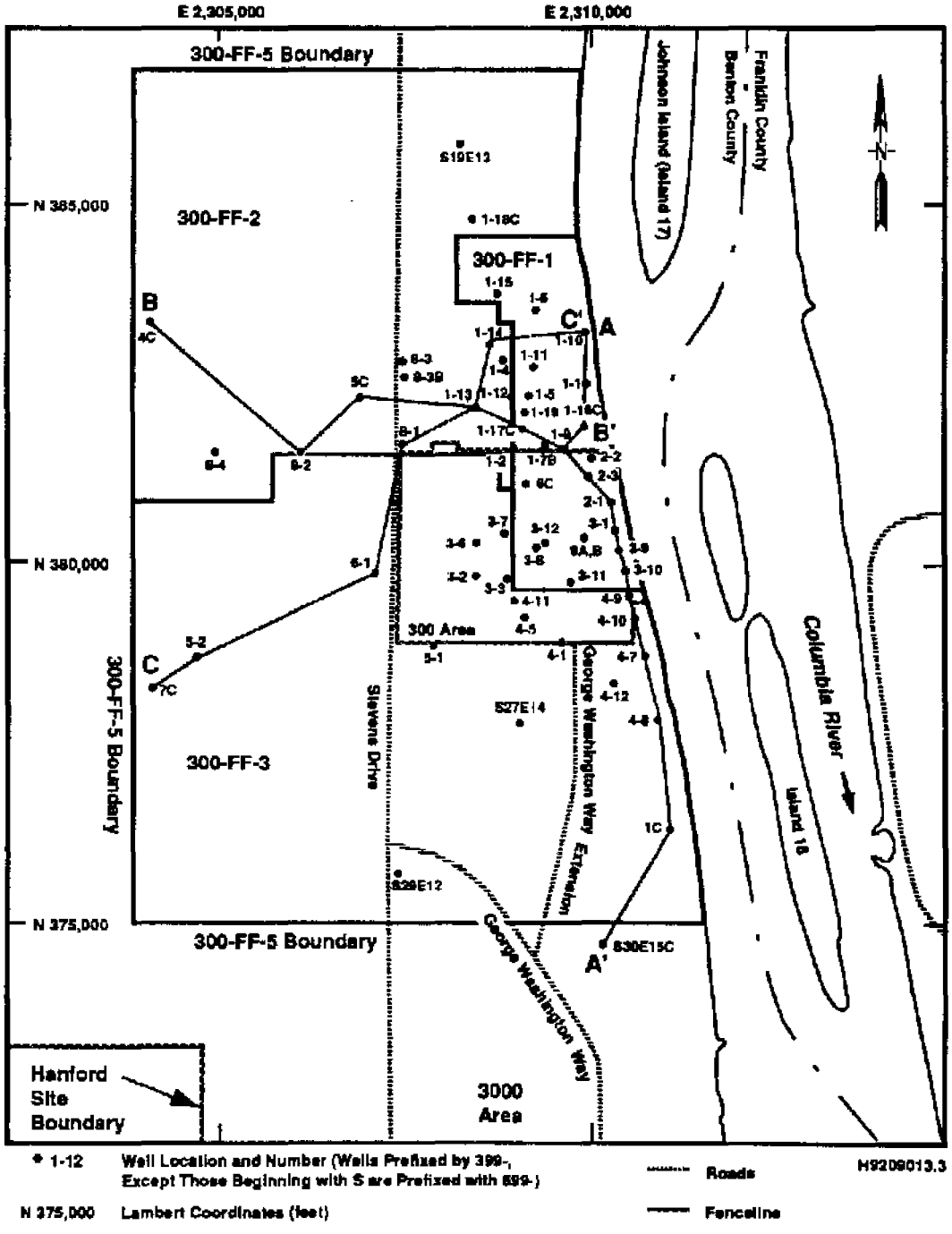


Figure 3-4. Geologic Cross Section A-A'.

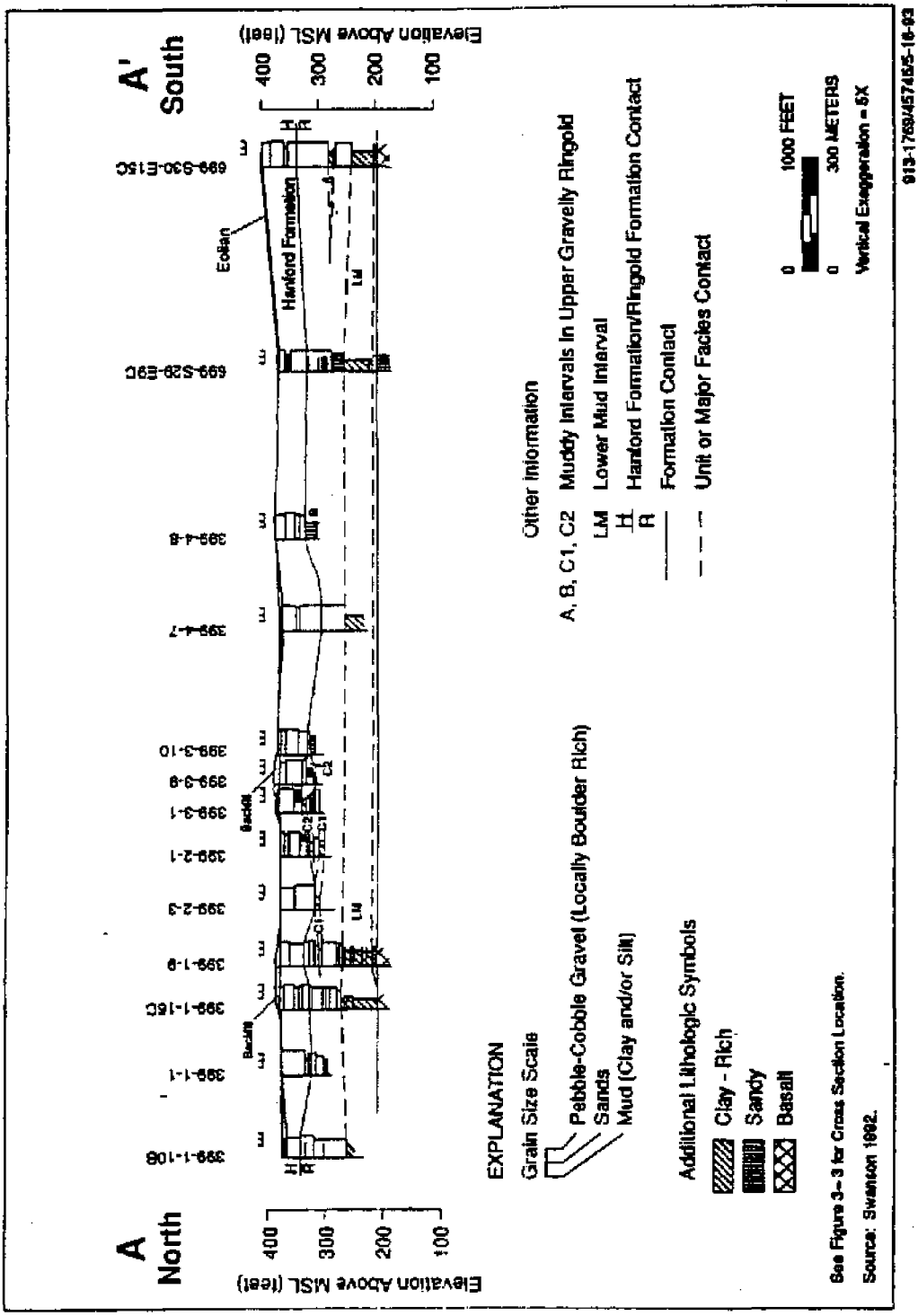


Figure 3-5. Geologic Cross Section B-B'.

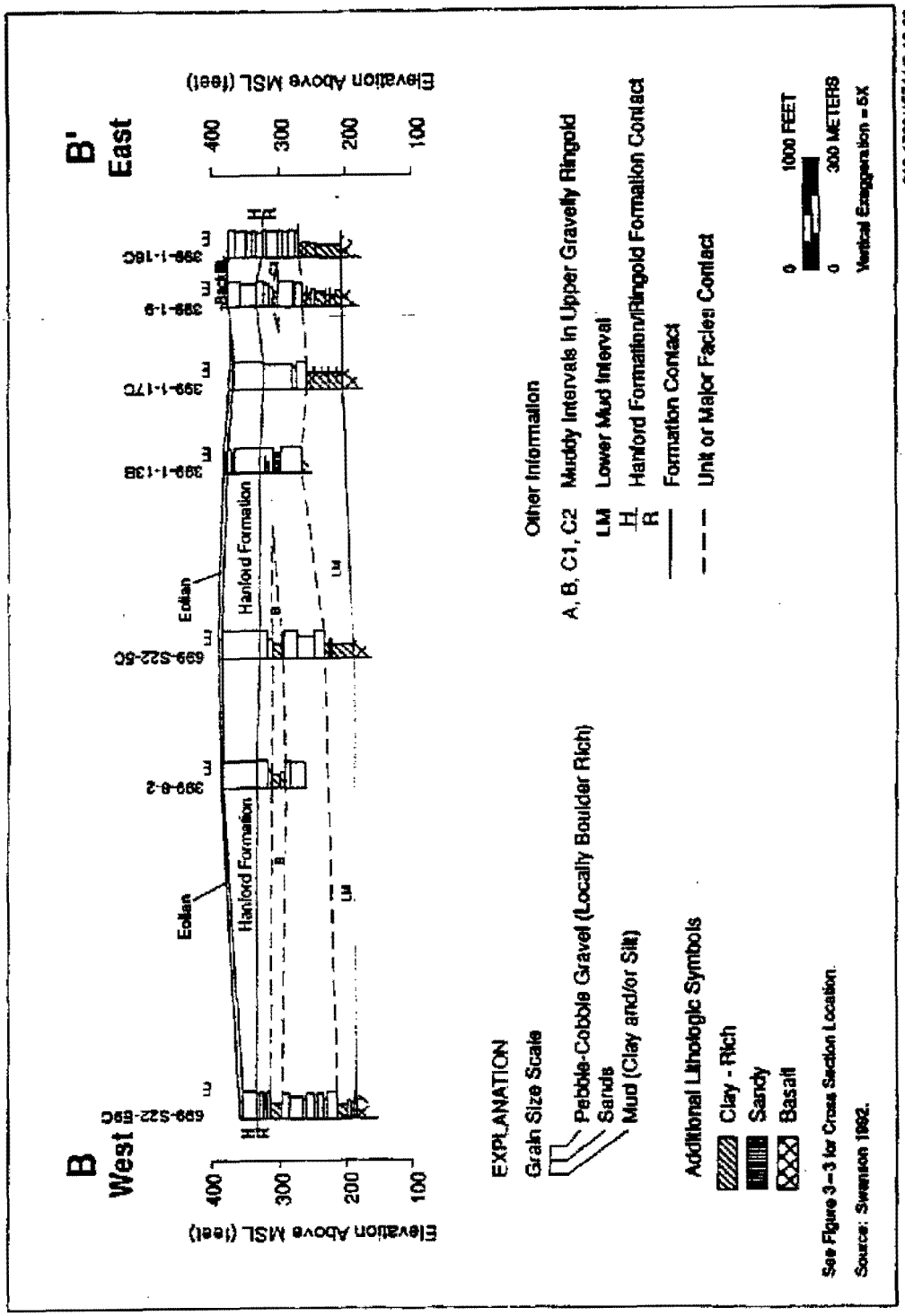
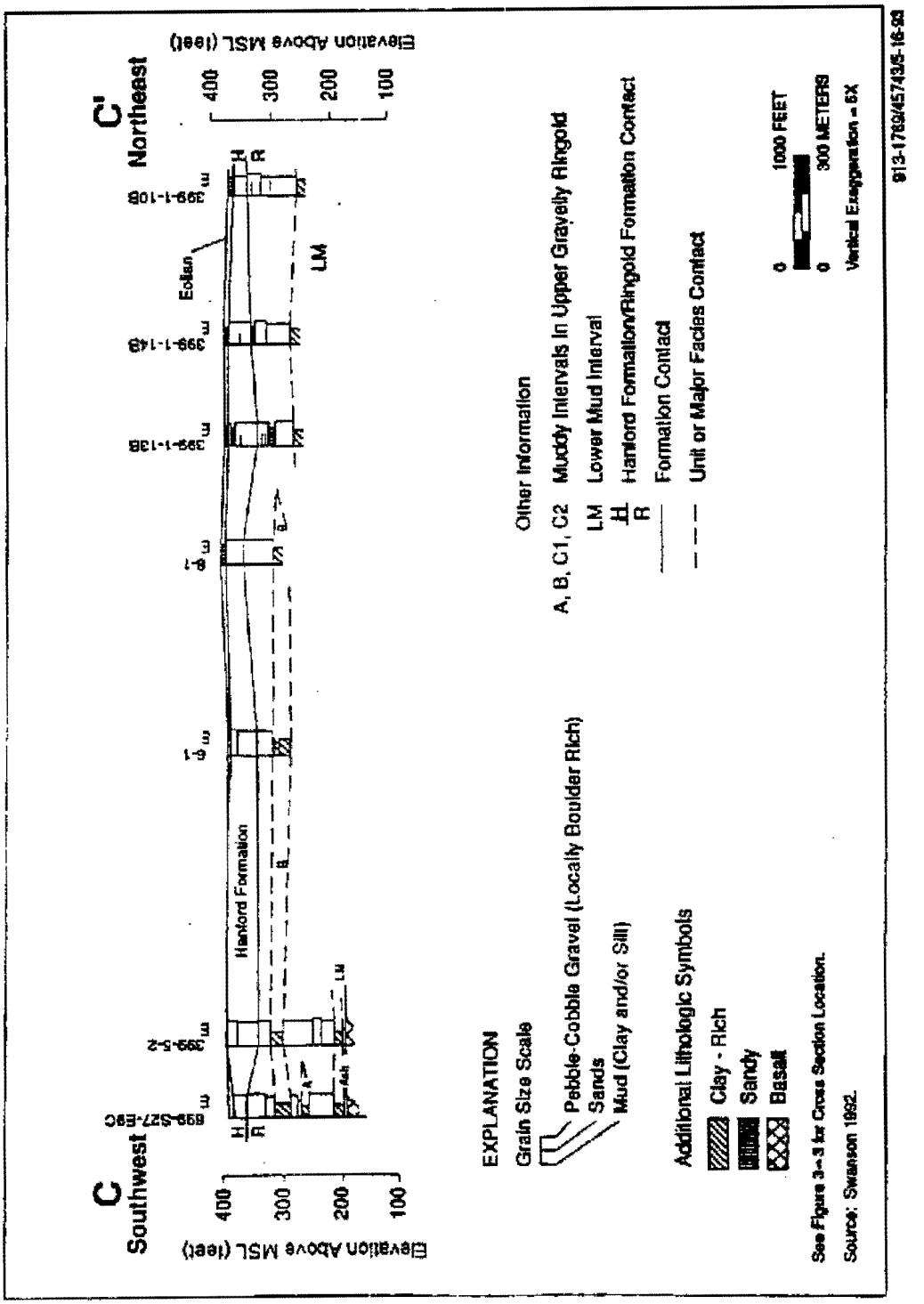


Figure 3-6. Geologic Cross Section C-C'.



3.1.2 Hanford Formation

Delaney et al. (1991) discuss three main facies associated with the Hanford formation: (1) gravel-dominated facies, (2) sand-dominated facies, and (3) slackwater deposits composed of interbedded silts and fine sands. The Hanford formation in the vicinity of the 300 Area contains two of the three facies, (1) first and (2) second. Slackwater deposits composed of interbedded silts and fine sands, the third facies discussed in Delaney et al. (1991), are absent, although silts occasionally occur as minor portions of the other two facies. The main characteristics of the two facies that comprise the Hanford formation in the 300 Area are summarized as follows:

1. Gravel-dominated. The gravel-dominated facies generally consists of granule to boulder gravel with a dominantly sandy matrix. These sediments display massive and planar to low-angle bedding, and large-scale scour cut-and-fill structures (such as channels) and foreset bedding in outcrops. They are usually matrix poor and sometimes display open-framework texture. Lenticular sand and silt beds sometime are intercalated throughout the facies. Gravel clasts are predominantly basalt (50-80%). Other clast types include Ringold Formation and Plio-Pleistocene unit rip-ups, coarse-grained plutonic rocks such as granites, and metamorphic clasts composed of quartzite and gneiss. The gravel-dominated facies was deposited by relatively high-energy floodwaters within main channelways associated with Pleistocene cataclysmic flooding.

2. Sand-dominated. The sand-dominated facies is characterized by fine- to coarse-grained sand and granule gravel displaying plane lamination and cross bedding and sometimes channel-fill sequences. These sands may contain small pebbles and rip-up clasts in addition to pebble-gravel interbeds and silty interbeds less than 1 m (3.3 ft.) thick. The silt content of these sands is variable, but where it is low, an open framework texture is common. These sands are usually composed of predominantly basaltic grains and are often referred to as black, gray, or salt-and-pepper sands. The sand-dominated facies was deposited adjacent to main flood channelways during the waning stages of cataclysmic flooding or in areas of reduced velocity as water spread out in more open areas downstream of flow restrictions such as canyons or channelways.

The Hanford formation in the vicinity of the 300 APT is about 15.2 m (50 ft) thick and is mostly the gravel-dominated facies. Locally the gravel-dominated facies can be further divided into two types, pebble to cobble gravel and boulder gravel. The pebble to cobble gravel type is the most abundant Hanford formation sediment in the 300 Area. Except for minor interbedded strata consisting of boulder-rich deposits and a few sand-rich horizons (sand-dominated facies), this sediment type makes up the bulk of the Hanford formation. The boulder-rich gravels are distinguished from the pebble to cobble gravels on the basis of increased boulder content. Boulder-rich gravels contain greater than approximately 25% boulder-sized clasts (>25.6 cm [>10 in.] diameter). The thickest occurrence of boulder-rich gravels in the 300 Area is found between boreholes 399-1-16ABC and 399-3-9 where up to 18 m (60 ft) of such strata have been logged. These gravels do not extend west of boreholes 399-1-17ABC, although they may extend to the southwest. A second

boulder-rich zone up to 6 m (20 ft) is located at or near the uppermost portions of the Hanford formation in the southern portion of the 300 Area, and a third one occurs in the northernmost part of the 300 Area. The first and second zones may interfinger near wells 399-3-3, 399-2-3, and 399-2-1, but the third zone appears to be separate from the other boulder-rich zones by pebble to cobble gravels.

The sand-dominated facies of the Hanford formation in the 300 Area consists largely of basaltic coarse-grained sand and granules with an open-framework texture. Silt content is low. Thick occurrences of this facies are rare in the 300 Area, and the thinner horizons that do occur are too thin to be easily shown on the cross sections (Figures 3-4 to 3-6). However, thin beds of the sand-dominated facies are common and often intercalated with layers in the pebble to cobble gravel of the gravel-dominated facies.

3.1.3 Ringold Formation

The Ringold Formation near the 300 APT is about 37 m (120 ft) thick and contains three of the five Ringold Formation facies. The three occurring Ringold Formation facies are (1) fluvial gravel, (2) overbank deposits, and (3) lacustrine deposits. These facies are described in detail in Delaney et al. (1991) and Lindsey (1991). They can be summarized as follows:

1. Fluvial gravel. Clast-supported granule-to-cobble gravel with a sandy matrix dominates the facies. Intercalated lenses of sand and mud are common. Clast lithologies are dominated by quartzite and basalt with subordinate lithologies including silicic plutonic rock, intermediate to silicic volcanic rocks, gneiss, volcanic breccias, and greenstone. Matrix sand is sublithic, subarkosic, and arkosic with the feldspars being dominated by plagioclase. Sand beds in the association generally are quartz-felspathic, with basalt content usually ranging between 5% and 25%. Low-angle to planar stratification, massive bedding, wide shallow channels, and large-scale cross bedding are found in outcrops. Compaction and cementation are highly variable with most cementation consisting of $CaCO_3$ and iron oxides. The association was deposited in a gravelly fluvial braidplain characterized by wide, shallow, shifting channels.

2. Overbank deposits. This facies dominantly consists of laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of pedogenic calcium carbonate. Overbank deposits occur as thin (<0.5 to 2 m [1.6 to 6.6 ft]) lenticular interbeds in the fluvial gravel facies and as thick (up to 10 m [33 ft]) laterally continuous sequences. These sediments record deposition in proximal levee to more distal floodplain conditions.

3. Lacustrine deposits. Plane laminated to massive clay with thin silt and silty sand interbeds displaying some soft-sediment deformation characterize this association. Coarsening upward sequences less than 1 to 10 m (3.3 to 33 ft) thick are common. Strata comprising the association were deposited in a lake under standing water to deltaic conditions.

Ringold Formation strata in the 300 Area are generally divided into a lower, mud-dominated sequence and an upper, gravelly sequence (Figures 3-4 to 3-6). The lower 17 m (55 ft) composed of mud is laterally extensive and consists of lacustrine deposits overlying overbank deposits. It is correlated to the lower mud sequence found elsewhere throughout the Pasco Basin near the bottom of the Ringold Formation. The gravelly sequence overlying the lower mud sequence is composed dominantly of the fluvial gravel facies and is roughly correlated to Ringold Formation gravel units (B, C, and E) (Delaney et al. 1991, Lindsey 1991).[1] Two mud-dominated intervals are found in the upper gravel sequence in the 300 Area. They are discontinuous, pinch out, and are not found in the immediate vicinity of the 300 APT. However, they do occur to the west and south and consist dominantly of paleosols typical of overbank deposits.

There is evidence of erosion and channelization of the top of the Ringold Formation throughout the 300 Area (Lindberg and Bond 1979, Schalla et al. 1988b, and Swanson et al. 1992). These channels cause the upper Ringold Formation surface (and overlying Hanford gravels) to be lower by approximately 3 to 9 m (10 to 30 ft) in the channels. One of these channels may occur in the vicinity of wells 399-1-17ABC and 399-1-16ABC as inferred by Lindberg and Bond (1979). However, well spacing in the 300 Area is too large to resolve structural details of these channels (such as size and orientation) on the Hanford-Ringold Formation contact.

3.1.4 Saddle Mountains Basalt

Underlying the 52 m (or 170 ft) of Hanford and Ringold formation sediments is the Saddle Mountains Basalt. The uppermost basalt member of this formation in the vicinity of the 300 Area is the approximately 24 m (80 ft) thick Ice Harbor Member, which contains three flows that erupted from vents near Ice Harbor Dam east of Pasco, Washington (Helz 1978, Swanson et al. 1979, DOE 1988). These basalt flows are typical in that they have rubbly or scoriacious flow tops and bottoms and relatively dense interiors. Locally, these flows have an abundant amount of palagonite indicating they were in contact with wet conditions as they were emplaced. Underlying the lowest Ice Harbor Member flow is the Levey interbed, which is one of the intercalated members of the Ellensburg Formation. The Levey interbed locally is about 5 m (or 17 ft) thick and, like other Ellensburg Formation interbeds, consists of a mix of volcaniclastic and silisiclastic sediments usually as sands, gravelly sands, or sandy silts. Underlying the Levey interbed is the Elephant Mountain Member (two basalt flows) and below that the Rattlesnake Ridge interbed of the Ellensburg Formation.

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[1]Note: The letters A, B, and C are also used to identify muddy units on the geologic cross sections (Figures 3-4, 3-5, and 3-6). This is a unique usage. The letters A, B, and C after Delaney et al. (1991) and Lindsey (1991) are in more widespread use and refer to gravelly units in the Ringold Formation throughout the Hanford Site.

3.2 GROUNDWATER HYDROLOGY

This section discusses the different aquifers within the suprabasalt aquifer system (Delaney et al. 1991). Aquifers below the suprabasalt aquifer system, although mentioned, are not relevant to this groundwater monitoring plan and are not discussed in detail.

3.2.1 Aquifers

Aquifers within the suprabasalt aquifer system are those that are above the uppermost, regionally extensive, confining layer (Figure 3-7). In the 300 Area the uppermost, regionally extensive, confining layer (aquitard, aquiclude) is the lower mud unit of the Ringold Formation. Other mud units (designated A, B, C on the geologic cross sections [see Figures 3-4 through 3-6]) exist within the Ringold Formation, but they are discontinuous.[2]

In the 300 Area the muds that exist above the lower mud unit pinch out and are not present below the 300 APT. Therefore, the unconfined aquifer extends from the water table (at about 10.1 m [33 ft] below ground surface) to the top of the Ringold Formation lower mud unit. Elsewhere in the 300 Area where one or more of the upper muds are present, the aquifer(s) between the partially confining mud units is (are) partially confined. In the immediate vicinity of the 300 APT the unconfined aquifer is composed of the lowermost 5 m (17 ft) of Hanford formation and approximately 20 m (65 ft) of Ringold Formation. The Hanford formation there is composed primarily of the gravel-dominated facies, and the Ringold Formation above the lower mud unit is dominantly the fluvial-gravel facies.

Aquifers below the Ringold Formation lower mud unit are completely confined. These confined aquifers include any coarse-grained Ringold Formation sediments below the lower mud unit, high permeability zones within basalt flows such as rubbly or scoriacious flow tops and bottoms, and interbeds of the Ellensburg Formation if the permeability is high. These confined aquifers are intercalated with- and confined by- dense interiors of the basalt flows.

3.2.2 Aquifer Properties

The most recent aquifer tests and laboratory tests of borehole samples are reported in Swanson et al. 1992. The following are pertinent conclusions of the testing reported in that report.

- The best estimate for unconfined aquifer properties came from multiple-well analysis of constant discharge tests. Test results for the uppermost portion of the unconfined aquifer at well

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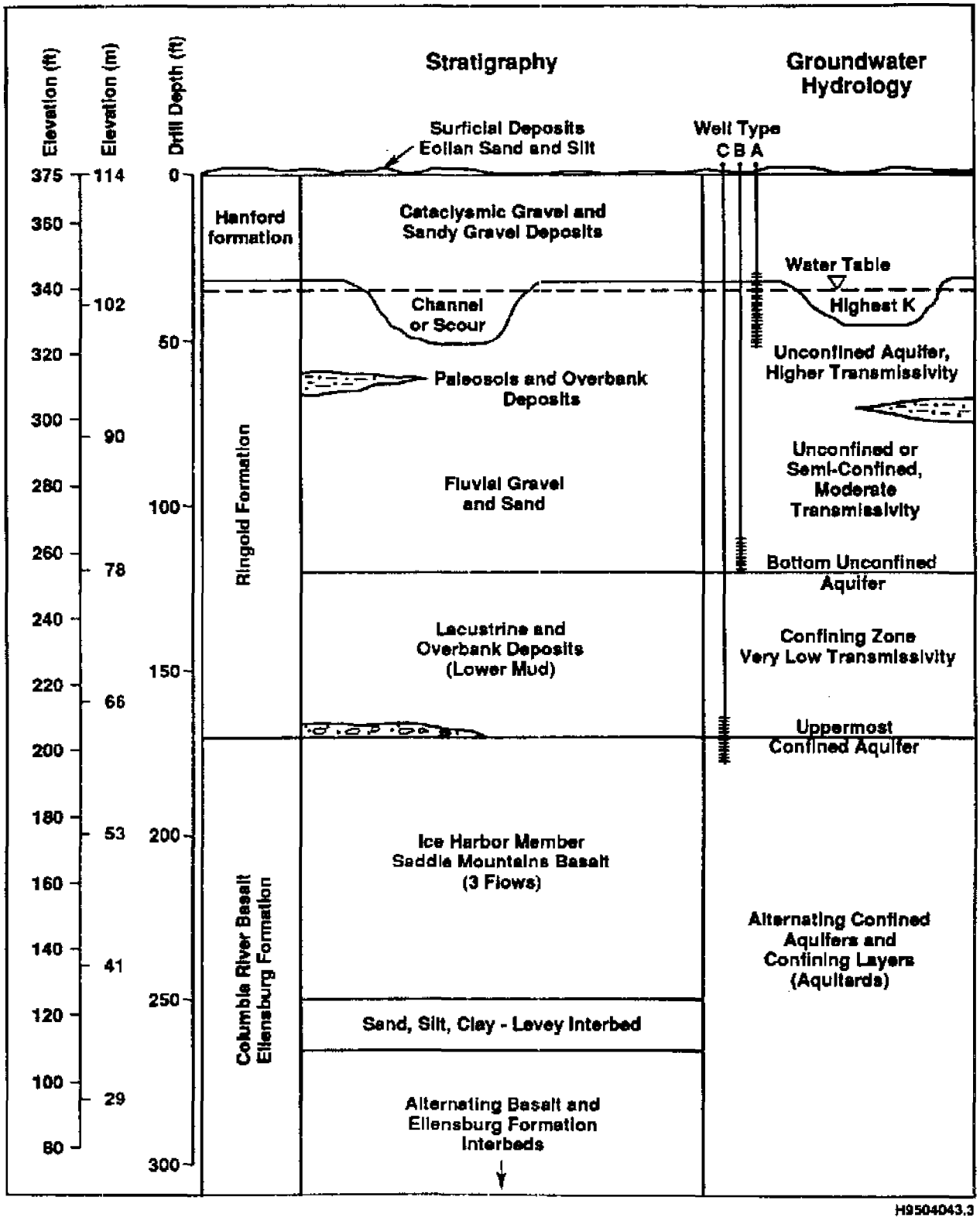
[2]Note: The letters A, B, and C are also used to identify gravel units in the Ringold Formation. The use of the letters for muddy units is unique to the 300 Area. The letters A, B, and C after Delaney et al. (1991) and Lindsey (1991) are in more widespread use throughout the Hanford Site for the gravelly units.

Figure 3-7. Generalized Hydrogeology Comparison of Geologic and Hydrologic Units in the 300 Area.



clusters 699-S22-E9ABCD and 699-S27-E9ABCD (Figure 3-1) were 36 and 49 m/d (120 and 161 ft/d) for horizontal hydraulic conductivity, 2.1 and 5.5 m/d (7 and 18 ft/d) for vertical hydraulic conductivity, 0.37 and 0.02 for specific yield, and 0.013 and 0.005 for storativity.

- Water levels measured at the two sites (cluster wells in lower Ringold Formation confined aquifer, lower unconfined aquifer, and upper unconfined aquifer) show an upward hydraulic gradient, demonstrating that the this area is probably a discharge area for the semiconfined and confined aquifers below the unconfined aquifer. (The unconfined aquifer, in turn, discharges to the Columbia River.)

- Barometric efficiencies estimated for wells screened at the bottom of the unconfined aquifer (B wells) are 10% and 18% for the two cluster sites. For the uppermost confined aquifer (C wells) the efficiencies are 28% and 22% for the two cluster sites. These results indicate that the bottom of the unconfined aquifer, and, of course, the uppermost confined aquifer in the Ringold Formation, are at least partially confined in the vicinity of the 699-S22-E9 and 699-S27-E9 well cluster sites. (Because the two upper mud units in the Ringold Formation are missing in the vicinity of the 300 APT, the bottom of the unconfined aquifer in the vicinity of the 300 APT may not show the same results.)

- The specific yield result of 0.02 may indicate a semiconfining condition.

- Laboratory test results on split-tube samples yielded vertical hydraulic conductivities that were at least one order of magnitude lower than the best estimated horizontal values.

The well clusters used for the aquifer testing reported in Swanson et al. (1992) are effectively screened entirely in the Ringold Formation because the water table is either at or lower than the Ringold/Hanford formation contact at those well sites. However, the water table near the 300 APT is within the Hanford formation, possibly because of channeling in the top of the Ringold Formation.

Table 3-2 shows previously collected hydraulic conductivity data derived from well pumping tests (Schalla et al. 1988b, Appendix D). These data are from wells that are closer to the 300 APT than the wells reported in Swanson et al. (1992). As expected, hydraulic conductivities at the top of the unconfined aquifer in wells near the 300 APT are higher. It is suspected that these higher hydraulic conductivities in the wells closer to the 300 APT are the result of a greater contribution of groundwater from the Hanford formation which generally has a higher hydraulic conductivity than the Ringold Formation.

Table 3-2. Hydraulic Conductivities Estimated from Aquifer Tests in Wells Near the 300 Area Process Trenches (from Schalla et al. 1988b).

Well	Hydraulic Conductivity m/d (ft/d)		Aquifer
A-Wells			
399-1-13	3353	(10,998)	Top of Unconfined*
399-1-18A	15240	(49,987)	Top of Unconfined*
399-1-16A	152	(499)	Top of Unconfined*
B-Wells			
399-1-18B	0.58	(1.90)	Bottom of Unconfined
399-1-17B	3.66	(12.0)	Bottom of Unconfined
399-1-16B Test #1	0.61	(2.00)	Bottom of Unconfined
399-1-16B Test #2	0.91	(2.98)	Bottom of Unconfined
C-Wells			
399-1-18C	1.83	(6.00)	Uppermost Confined
399-1-17C	79.2	(260)	Uppermost Confined
399-1-16C	2.72	(8.92)	Uppermost Confined
399-1-9	1.83	(6.00)	Uppermost Confined

*Top of the unconfined aquifer at this well is within the lower portion of the Hanford formation.

3.2.3 Groundwater Flow

Groundwater flow direction in the unconfined aquifer near the 300 APT is predominantly to the east or southeast with slight changes caused by fluctuations in Columbia River stage. This determination is made from depth-to-water measurements taken monthly from 33 wells in the 300 Area. Figure 3-8 shows the elevation of the water table from September 20 to 21, 1994, during the low stage period of the Columbia River. Flow direction was to the southeast in the immediate vicinity of the 300 APT. Figure 3-9 shows the elevation of the water table June 22 to 23, 1994, when the river stage was very near the high for the year. Sometimes a localized flow reversal occurs when the river stage is higher than the water level in the unconfined aquifer. The area involved in these flow reversals depends on the elevation of the high river stage and its duration. On June 22 and 23, 1994, the reversal was only experienced along the shore of the river and inland in the area of wells 399-3-12. In the area of the 300 APT the flow direction in the unconfined aquifer remained mainly toward the southeast, but the southern portion of the 300 APT had a more south to southwesterly flow. However, if the rise in river stage is more than 1 m (3.3 ft) for a sufficient duration (a week or more) the groundwater flow direction throughout most of the area of the 300 APT can be to the south or southwest (Schalla et al. 1988b, Figure 3-12).

Previous estimates of flow direction in the unconfined aquifer near the 300 APT have been based mainly on water table maps. Water table maps of the area of the 300 APT generally show a groundwater mound or southeast-trending lobe due to the discharge of water from the trenches. This mound or lobe may have a significant effect on the direction of groundwater flow in the area. However, as of January 1995, all discharges of water to the 300 APT have ceased. If the mound or lobe due to water discharge did indeed affect groundwater flow direction while the 300 APT was in operation, then shutting off the water will have an undetermined effect that will be evident in future water table maps.

There is an upward gradient between the uppermost confined aquifer and the unconfined aquifer. At wells 399-1-17A and 399-1-17C the head difference is about 11 m (35 ft). This supports the conclusion of Swanson et al. (1992) that the 300 Area is within a discharge area for the uppermost confined aquifer, and that, if communication is established between the confined aquifer and overlying unconfined aquifer, the flow direction is upward.

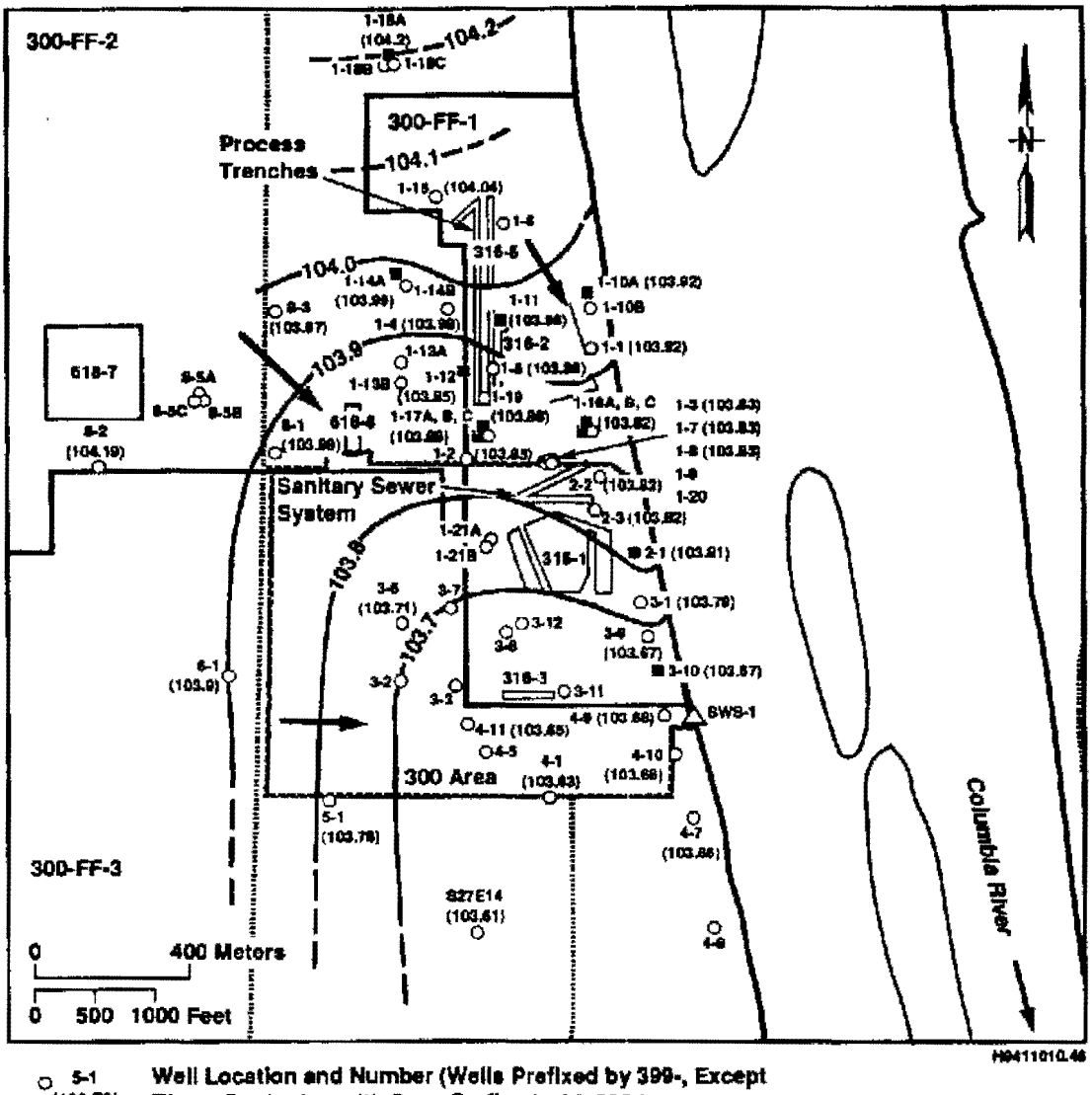
The flow rate in the top of the unconfined aquifer has been reported as about 10.7 m/d (35 ft/d) near the 300 APT based on a perchloroethylene spill (Cline et al. 1985). The rate of flow can also be estimated roughly by using the Darcy equation.

$$v = \frac{Ki}{n_e} \qquad (1)$$

where:

v = average linear groundwater velocity
K = hydraulic conductivity
i = hydraulic gradient
n_e = effective porosity.

Figure 3-8. 300 Area Water Table Map, September 20-21, 1994.



○ 5-1 (103.78) — Well Location and Number (Wells Prefixed by 399-, Except Those Beginning with S are Prefixed with 699-) (Number in parenthesis is water table elevation in meters)

■ 1-12 (103.85) — Monitoring Network Well (Number in parenthesis is water table elevation in meters)

△ SWS-1 — Surface-Water Monitoring Station

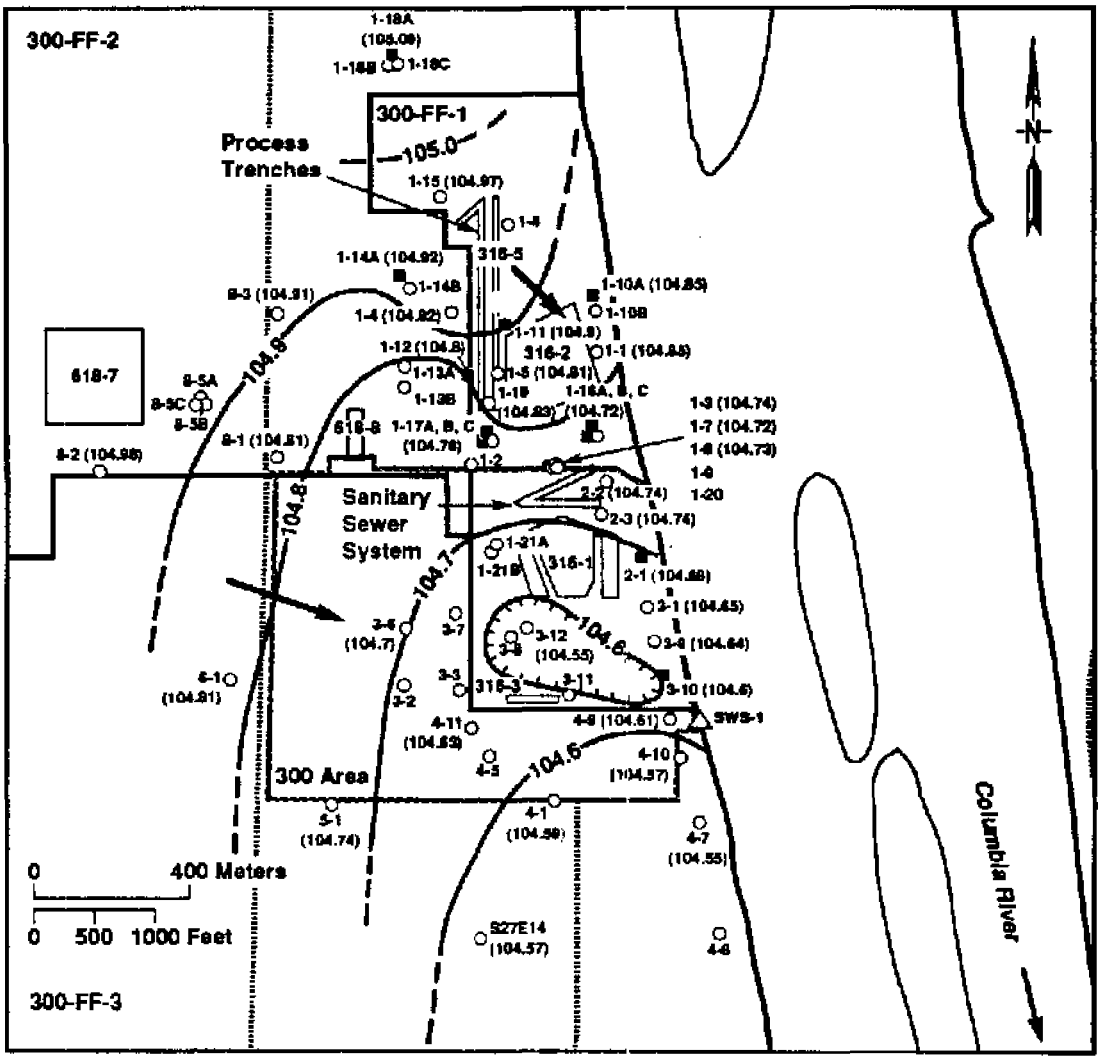
Roads

103.8 — Water Table Contour in Meters. Contour Interval = 0.1 Meters. (Note: Change meters to feet by multiplying by 3.28).

Generalized Groundwater Flow Direction

Gradient 0.0004.

Figure 3-9. 300 Area Water Table Map, June 22-23, 1994.



H9411010.46

○ 5-1 (104.74) — Well Location and Number (Wells Prefixed by 399-, Except Those Beginning with S are Prefixed with 699-) (Number in parenthesis is water table elevation in meters)

■ 1-14A (104.92) — Monitoring Network Well (Number in parenthesis is water table elevation in meters)

△ SWS-1 — Surface-Water Monitoring Station

Roads

104.7 — Water Table Contour in Meters. Contour Interval = 0.1 Meters. (Note: Change meters to feet by multiplying by 3.28).

→ Generalized Groundwater Flow Direction

Gradient 0.0003.

Schalla et al. (1988b) reported values of hydraulic conductivity for the unconfined aquifer in the vicinity of the 300 APT from 150 to 15,000 m/d (500 to 50,000 ft/d) (Table 3-2). Swanson et al. (1992) reported hydraulic conductivities for the Ringold Formation as 36 and 49 m/d (120 and 161 m/d) for two well sites southwest of the 300 APT. The hydraulic gradient near the 300 APT was 0.0003 for the water table depicted in Figure 3-9 (June 22-23, 1994) and 0.0004 for the water table depicted in Figure 3-8 (September 20-21, 1994). Estimates of effective porosity for the unconfined aquifer range from 0.10 and 0.30. Using the above-stated values for input parameters to the Darcy equation, the range of average linear groundwater velocity is 0.036 m/d (0.11 ft/d) to 61.0 m/d (200 ft/d). The large range in flow velocity values is a result of the large range in values of hydraulic conductivity reported for the aquifer. If it is assumed that the Hanford formation is a major contributor to the hydraulic conductivity parameter in the vicinity of the 300 APT (because of the presence of channels that cause the water table to be within the Hanford formation), then the average flow velocity may be closer to the upper portion of the range, which is supported by the estimate of Cline et al. (1985).

The estimates of groundwater flow rate are based on aquifer conditions in the vicinity of the 300 APT when at least 800 L/min (215 gal/min) are discharged to the trenches. However, flow rates in the future may be much lower than those calculated, since wastewater discharges to the trenches have ceased. After discharges cease, the entire volume of groundwater available in the unconfined aquifer near the trenches must come through the less permeable Ringold Formation sediments upgradient (northwest) of the trenches. Without the mounding effect due to 300 APT discharge, the water table gradient may decrease enough to significantly lower the flow rate (DOE-RL 1995c). Water table maps constructed in the future, after the local unconfined aquifer has adjusted to the lack of 300 APT discharges, will be helpful in determining any significant change in gradient.

3.3 GROUNDWATER CONTAMINATION HISTORY

3.3.1 Geohydrology and Ground-Water Quality Beneath the 300 Area, Hanford Site, Washington (Lindberg and Bond 1979)

The earliest major study of groundwater contamination in the 300 Area is reported in Lindberg and Bond (1979). In that study, groundwater samples were collected monthly for one year (during calendar year 1977) from 29 wells in the 300 Area (see Figure 3-10). The samples were analyzed for the following constituents.

Radioactive Constituents	Nonradioactive Constituents
Gross alpha	Bicarbonate
Gross beta	Carbonate
Gamma scan	Calcium
Uranium	Magnesium
Tritium	Sodium
	Chloride
	Sulfate
	Nitrate
	Chromium
	Copper
	Potassium
	Fluoride
	pH
	Specific conductivity

The 29 wells in the sampling network at that time were all constructed of perforated carbon steel casing with dedicated submersible electric pumps. This well type does not meet current regulatory standards (WAC 173-160).

Results showed that calcium, magnesium, sodium, bicarbonate and sulfate were lower in concentration near the 300 APT than in background wells (dilution). Constituents that were found to be in higher concentrations near and downgradient of the 300 APT were gross alpha, uranium, chloride, and nitrate. Presumably, discharges to the trenches were responsible for the constituents with higher concentrations.

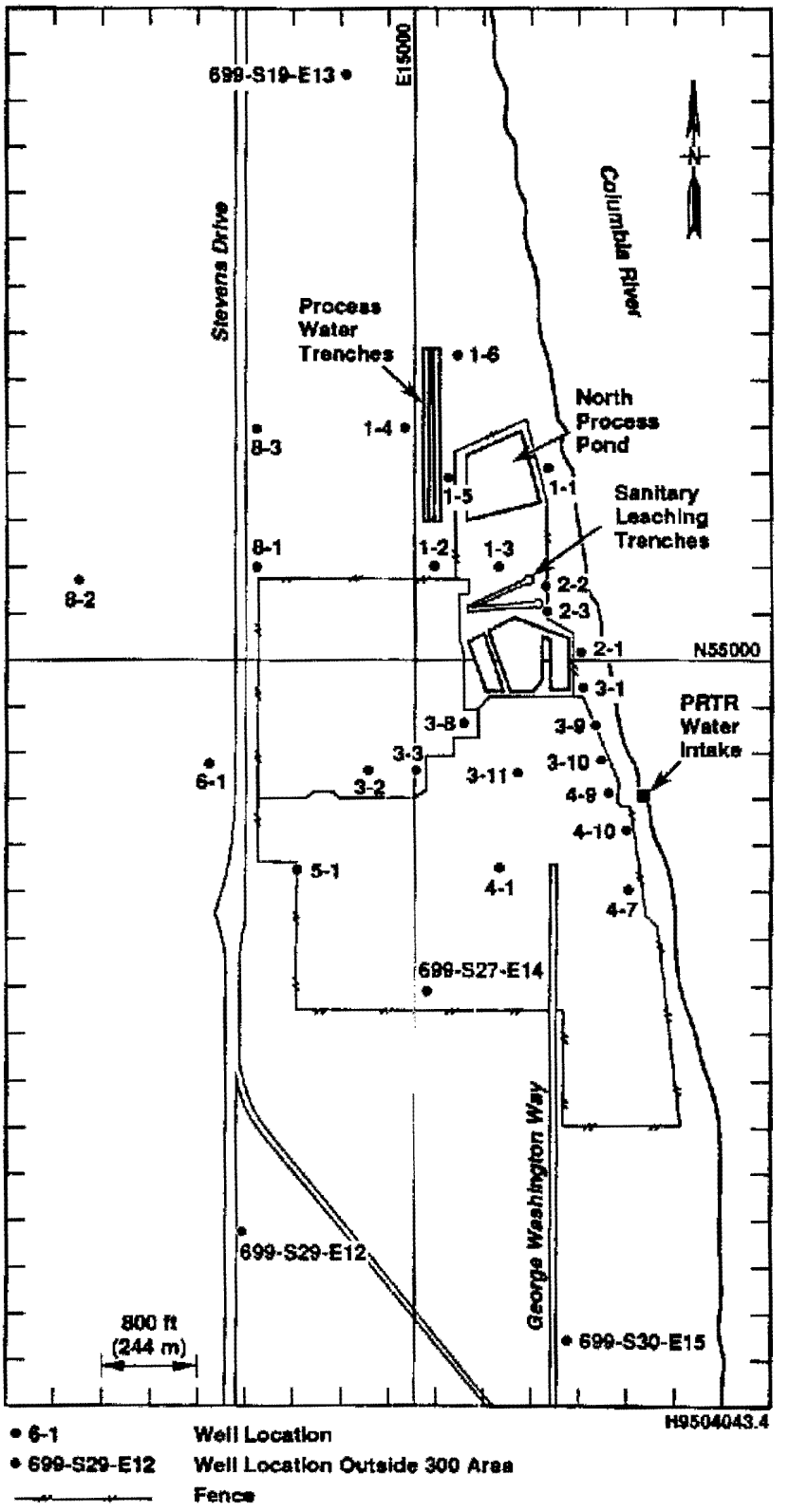
3.3.2 Perchloroethylene Plume (Cline et al. 1985)

Following two accidental releases of perchloroethylene (PCE) to the 300 APT (454 L [120 gal] on November 4, 1982, and 76 L [20 gal] on July 6, 1984), several wells were closely monitored to track the plume. The following wells showed elevated levels of PCE: 399-1-5, -1-2, -1-3, -2-1, -2-2, -3-1, -4-7, and -4-10. Peak concentration of PCE (1,840 ppb) was found in well 399-1-5 about 5 days after the first release. Movement of the peak concentration was estimated at 10.7 m/d (35 ft/d) (Cline et al. 1985).

3.3.3 Early Resource Conservation and Recovery Act of 1976 Monitoring (Schalla et al. 1988a and 1988b)

By 1985, a RCRA interim-status groundwater monitoring program for the 300 APT was in effect. The effort was based on the groundwater monitoring requirements in 40 CFR 265.90 (EPA 1984), WAC 173-303-400 (Ecology 1986), and past groundwater monitoring conducted in the 300 Area. The well network,

Figure 3-10. Location Map for Wells Used in the Study by Lindberg and Bond 1979.



which was sampled monthly, consisted of the following 16 wells. Fourteen monitored the upper portion of the unconfined aquifer and two (399-1-8 and -4-1) monitored the base of the unconfined aquifer. The wells are shown on Figure 3-1):

399-1-1	399-1-5	399-2-1	399-4-10
399-1-2	399-1-6	399-3-7	399-8-2
399-1-3	399-1-7	399-3-10	699-S19-E13
399-1-4	399-1-8	399-4-1	699-S30-E16A

Six of the wells have stainless-steel screens, and the other 10 have perforated casings (Table 3-1).

Based on instructions given in *Test Methods for Evaluating Solid Waste* (EPA 1986) and information provided by the facility manager concerning the composition of the wastes, the constituents listed in Table 3-3 were analyzed in the groundwater samples collected from the 16 wells. The U.S Environmental Protection Agency (EPA) guidance suggested that analyses should be conducted for the Primary Drinking Water Standards (DWS) and for specific dangerous waste constituents known to have been discharged to the unit. Additional parameters, such as the contamination indicator parameters that are required for a detection-level program (but not necessary for an alternate or assessment-level program), were added to provide consistency with other interim-status programs. In addition, samples from two wells sampled quarterly were also being analyzed for some additional parameters, including the dangerous waste constituents in WAC 173-303-9905 (Ecology 1986). These additional analyses (Table 3-4) provided information needed for the permitting process and to further ensure that potential contaminants are not being overlooked. The two wells chosen for the extra analyses included one upgradient well (699-S19-E13) and one downgradient (399-1-3).

The dangerous waste constituents list in WAC 173-303-9905 is very similar to the Appendix IX list of 40 CFR 264, Subpart F. However, there are some differences. Those constituents in Appendix IX that are not in WAC 173-303-9905 are listed in Table 3-6. All of the constituents listed in Table 3-6 were analyzed later in all 11 of the wells of the current 300 APT program.

Results of the early analyses under the interim-status program are documented in Schalla et al. (1988a, Tables 6 and 7) and Schalla et al. (1988b). Schalla et al. (1988a), Table 6, (Summary of Constituents Sampled to Date) shows that the herbicides and pesticides on the Interim Primary DWS list were never reported above detection limits nor were the phenols in the list of water quality parameters. Very few of the constituents in the site-specific list and almost none of the additional constituents sampled as part of the WAC 173-303-9905 list were detected. Several other constituents have only been reported above detection limits sporadically. Among those constituents that are regularly reported as being above the detection limit are gross alpha, gross beta, barium, nitrate, sodium, iron, sulfate, chloride, copper, ammonium, vanadium, potassium, chloroform, and methylchloride.

Schalla et al. (1988a), Table 7, (Analytical Data, June 1988-May 1986), compiles the results for those constituents that had at least one value reported above detection limits. Gross alpha and beta both exceeded their

Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Barium Cadmium Chromium Silver Sodium Nickel Copper Aluminum Manganese Iron Calcium Zinc	P, HNO_3 to pH <2	SW-846, #6010	6 2 10 10 100 10 10 150 5 50 50 5
Arsenic	P, HNO_3 to pH<2	SW-846, #7060	5
Mercury	P, HNO_3 to pH<2	SW-846, #7470	0.1
Selenium	P, HNO_3 to pH<2	SW-846, #7740	5
Lead	P, HNO_3 to pH<2	SW-846, #7421	5
Nitrate Sulfate Fluoride Chloride	P, None	70-IC[e,f]	500 500 500 500
Cyanide	P, NaOH to pH>12	SW-846, #9010	10
Sulfide	P, zinc acetate + NaOH to pH>9	SW-846, #9030	1,000
Radium	P, HNO_3 to pH<2	EPA Method #903.0	1 pCi/L
Gross alpha	P, HNO_3 to pH<2	EPA Method 680/4-75-001	4 pCi/L
Gross beta	P, HNO_3 to pH<2	EPA Method 680/4-75-001	8 pCi/L
Natural uranium[g]	P, HNO_3 to pH<2	20-U-03[h]	4 pCi/L
Strontium-90[g]	P, HNO_3 to pH<2	20-Sr-02[h]	5 pCi/L
Gamma scan[g]	P, HNO_3 to pH<2	30-GS & 40-07[h]	20 pCi/L (Cs)
Total organic halogen	G, No headspace	SW-846, #9020	100
Total organic carbon	G, H_2SO_4 to pH<2	Std. Methods #505	1,000

Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Ammonium ion	G, H_2SO_4 to pH<2	Std. Methods #417 A-E	50
Hydrazine	G, None	70-DAI[e,k]	3,000
Endrin Methoxychlor Toxaphene Lindane (4 isomers)	G, None	SW-846, #8080[i]	1 1 1 1
2,4-D 2,4,5-TP silvex	G, None	SW-846, #8150[i]	1 1
1,1,1-trichloroethane Perchloroethylene Chloroform Methylene chloride 1,1,2-trichloroethane 1,1,2-trichloroethylene Methylethyl ketone	G, No headspace	SW-846, #8240	10 10 10 10 10 10 10
Coliform bacteria	P, None	Std. Methods #908A	2.2 MPN[j]
Temperature	Field measurement		0.1°C

Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Specific conductance	Field measurement		1 μmho
pH	Field measurement		0.01 pH unit

[a]P = plastic, G = glass.
[b]All samples cooled to 4°C upon collection.
[c]Constituents grouped together within brackets are analyzed by the same method.
[d]Detection limit units except where indicated.
[e]In-house analytical method (PNL).
[f]IC = ion chromatography.
[g]Analyzed quarterly on selected wells.
[h]From US Testing Company Procedure Manual, UST-RD-PM-9-80
[i]Analyzed on quarterly basis only.
[j]MPN = most probable number.
[k]DAI = direct aqueous injection.

Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Beryllium Osmium Strontium Antimony Vanadium Potassium	P, HNO_3 to pH<2	SW-846, #6010	5 300 300 100 5 100
Thallium	P, HNO_3 to pH<2	SW-846, #7840	200
Thiourea 1-acetyl-2-thiourea 1-(o-chlorophenyl) thiourea Diethylstilbesterol Ethylenethiourea 1-naphthyl-2-thiourea N-phenylthiourea	G, None	SW-846, #8330 (modified)	200 200 200 200 200 200 200
DDD DDE DDT Heptachlor Heptachlor epoxide Dieldrin Aldrin Chlordane Endosulfan I Endosulfan II Chlorobenzilate	G, None	SW-846, #8180	1 1 1 1 1 1 1 1 1 1 100
2,4,5-T	G, None	SW-846, #8150	1
Perchlorate Phosphate	P, None	70-IC[e,f]	1,000 1,000
Carbophenothion Tetraethylpyrophosphate Disolfoton Dimethoate Methyl parathion Parathion	G, None	SW-846, #8140	2 100 2 5 2 2
Citrus red #2	G, None	AOAC, #34.015B	1,000

Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Paraldehyde	G, None	DAI[e,g]	3,000
Cyanogen bromide			3,000
cyanogen chloride			3,000
acrylamide			3,000
Allyl alcohol			3,000
Chloral			3,000
Chloroacetaldehyde			3,000
3-chloropropionitrile			3,000
Cyanogen			3,000
Dichloropropanol			3,000
Ethyl carbamate			3,000
Ethyl cyanide			3,000
Ethylene oxide			3,000
Fluoroacetic acid			3,000
Glycidylaldehyde			3,000
Isobutyl alcohol			3,000
Methyl hydrazine			3,000
n-propylamine			3,000
2-propyn-1-ol			3,000
1,1-dimethyl hydrazine			3,000
1,2-dimethyl hydrazine			3,000
Acetronitrile			3,000
Tetrachloromethane	G, None	SW-846, #8240	10
Xylene-o,p			10
Xylene-m			10
Formaldehyde			500
Additional volatiles			10

Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Hexachlorophene	G, None	SW-846, #8270	10
Naphthalene			10
Phenol			10
Kerosene			10 ppm
Hexachlorobenzene			10
Pentachlorobenzene			10
1,2-dichlorobenzene			10
1,3-dichlorobenzene			10
1,4-dichlorobenzene			10
1,2,3-trichlorobenzene			10
1,3,5-trichlorobenzene			10
1,2,3,4-tetrachlorobenzene			10
1,2,3,5-tetrachlorobenzene			10
1,2,4,5-tetrachlorobenzene			10
Additional semi-volatiles			10
Ethylene glycol	G, None	GC/FID[e,h]	10 ppm

[a]P = plastic, G = glass.
[b]All samples cooled to 4°C upon collection.
[c]Constituents grouped together within brackets are anlyzed by the same method.
[d]Detection limit units except where indicated.
[e]In-house analytical method (PNL).
[f]IC = ion chromatography.
[g]DAI = direct aqueous injection.
[h]GC/FID = gas chromatography/flame ionization detector.

screening limit for Interim Primary DWS. Gross alpha and uranium are closely correlated (Schalla et al. 1988b). However, subtraction of uranium from gross alpha would probably bring gross alpha to below the "adjusted " gross alpha limit (15 pCi/L). Chromium, mercury, selenium, and fluoride were reported as being above Interim Primary DWS at least once.

3.3.4 Recent Resource Conservation and Recovery Act of 1976 Groundwater Monitoring

In 1986 and 1987, 18 new wells (Figure 3-11) were installed to enhance the understanding of hydrogeology at the 300 APT and to help characterize the direction and extent of contamination in Hanford and Ringold Formation sediments. The new wells, which were designed to meet WAC 173-160 standards, included three well clusters (399-1-16ABC, 399-1-17ABC, and 399-1-18ABC) and eight single wells. Each well cluster included one well in the upper portion of the unconfined aquifer ("A" well), one well at the bottom of the unconfined aquifer ("B" well), and one well in the uppermost confined aquifer below the Ringold Formation lower mud unit ("C" well). Total number of wells in the network temporarily rose to 34 (16 original plus 18 new wells). The samples from the network of 34 monitoring wells were analyzed for a list of constituents, which included the list of dangerous waste constituents in WAC 173-303-9905 (PNL 1988). Later some wells were dropped because they did not meet WAC 173-160 standards. However, other wells (e.g., 399-2-1 and 399-3-10) were added even though they did not meet WAC 173-160 standards. They were added because they were in good positions to intercept contaminants flowing southeast from the 300 APT that had passed wells closer to the trenches. Wells added that did not conform to WAC 173-160 standards provided data for information and supplementary purposes only. Important RCRA unit decisions could not be made based on data from wells that did not meet the WAC 173-160 standards.

Since 1989, wells were periodically dropped from the network and the sampling schedule was changed from monthly to quarterly and eventually to semiannually. These changes were made because data quality objectives (DQO) in the groundwater monitoring plan (Schalla et al. 1988a) regarding hydrogeology and contamination were satisfied, the ERA in 1991 significantly reduced contamination in the trenches, and fewer wells sampled less frequently would still provide adequate groundwater monitoring. Currently the well network has been reduced to 11 wells sampled semiannually (Figure 3-12). Table 3-5 lists the 11 wells, the aquifers screened, sampling frequency, frequency of water level measurements, and compliance with WAC 173-160 standards. Table 3-7 lists the contaminant constituents analyzed in the current monitoring well network and the frequency of the sampling. One well (399-1-17A) is still sampled quarterly in order to comply with regulatory requirements for quarterly sampling for sites under groundwater quality assessment programs and to provide a rapid detection or early warning for any new contaminants inadvertently discharged to the 300 APT prior to January 1995 when lines to the trenches were "blanked" off.

Figure 3-11. Locations of Monitoring Wells Added to the Network in 1986 and 1987.

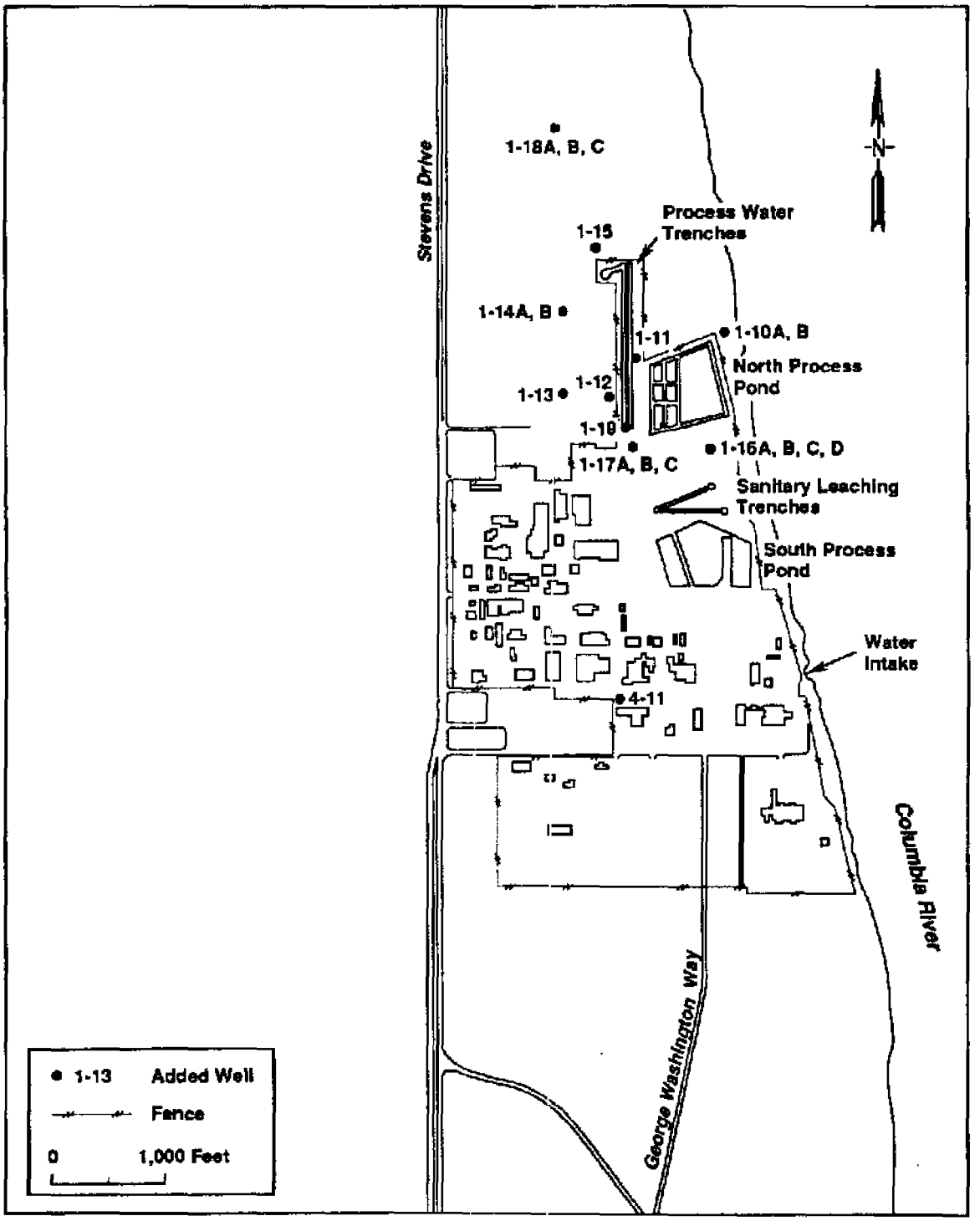


Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Acenaphthalene	8270
Acenaphthylene	8270
Acetone	8240
Allyl chloride	8240
Aniline	8270
Anthracene	8270
Antimony	6010
Aramite	8270
Benzo[k]fluoranthene	8270
Benzo[ghi]perylene	8270
Benzyl alcohol	8270
alpha-BHC	8080
beta-BHC	8080
delta-BHC	8080
gamma-BHC; Lindane	8080
Bis(2-chloro-1-methyl-ethyl) ether; 2,2'-Dichlorodiisopropyl ether	8270
Bromodichloromethane	8240
4-Chlorophenyl phenyl	8270
Chloroprene	8240
Cobalt	6010
Copper	6010
Dibenzofuran	8270
Dibromochloromethane; Chlorodibromomethane	8240
1,2-Dibromo-3-chloro-propane; DBCP	8240
p-(Dimethylamino) azobenzene	8270
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	8270
Ethylbenzene	8240

Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Fluorene	8270
Isodrin	8270
Isophorone	8270
Methoxychlor	8270
Methylene bromide; Dibromomethane	8240
Methylene chloride; Dichloromethane	8240
2-Methylnaphthalene	8270
4-Methyl-2-pentanone; Methyl isobutyl ketone	8240
o-Nitroaniline	8270
m-Nitroaniline	8270
Nitrobenzene	8270
p-Nitrophenol	8270
N-Nitrosodiphenylamine	8270
N-Nitrosodipropylamine; Di-n-propylnitrosamine	8270
Phenanthrene	8270
Pyrene	8270
Safrole	8270
Styrene	8240
Sulfide	9030
Tin	6010
Vanadium	6010

Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Vinyl acetate	8240
Xylene	8240
Zinc	6010

*Constituents listed here were analyzed in all 11 wells of the 300 APT (Figure 3-12) by the methods listed.

*SW-846 Methods.

6010 - ICP Metals (see Table 4-1, this document).

8240 - Volatile Organic Analysis (Gas Chromatograph since 1994, Gas Chromatograph/Mass Spectrometer before 1994 - See Table 4-4, this document).

8270 - Semi-Volatile Organic Analysis (Analyzed in all eleven 300 APT wells during the period 5/88-5/90).

8080 - Pesticides (see Table 4-1, this document).

9030 - Sulfide (Analyzed in all 11 300 APT wells 2/87-5/90).

Table 3-7. Constituents Analyzed in the Current Monitoring Well Network.

Semiannual Schedule - All 11 300 APT Network Wells

Alkalinity
Gross Alpha
Gross Beta
Uranium
Coliform
Specific Conductance (Lab)
ICP Metals (including arsenic, selenium, and lead) - unfiltered
ICP Metals (including arsenic, selenium, and lead) - filtered
Mercury - unfiltered
Mercury - filtered
pH (Lab)
Radium
TOC
TOX
Tritium
Volatile Organics Analysis (GC)

Quarterly Schedule - Well 1-17C Only

Anions
Specific Conductance (Lab)
Gamma Scan
pH (Lab)
Strontium-90
TOX
TOC
Isotopic Uranium
Uranium
Volatile Organics Analysis (GC)

Results of groundwater sampling and analysis since Schalla et al. (1988a; 1988b) are reported quarterly (data only) and annually (including interpretations) as RCRA reports by the Westinghouse Hanford Company (WHC) Groundwater Management Group for the U.S. Department of Energy (DOE). The following is a summary of results since 1987.

Only chromium, lead, selenium, lindane, and gross alpha have values larger than the maximum contaminant levels (MCLs). Chromium exceedances (Appendix C) may be the result of an excessive amount of suspended particles (turbidity) in groundwater samples because the exceedances are associated with unfiltered samples. Lead exceedances occurred prior to the ERA (1991) in two wells that did not meet WAC 173-160 standards for construction. Since the ERA, lead concentrations have been below the MCL of 50 μg/L. Exceedances of selenium and lindane may actually be analytical problems due to detection limits that are higher than respective MCLs. Other constituents of interest such as gamma-emitting radionuclides and strontium-90, copper, sulfate, zinc, chloride, and silver were all below the Primary and Secondary DWS or the 4 mrem/yr equivalent concentration for radionuclides (Appendix C). (Gross alpha and uranium are discussed later).

Volatile Organic Analysis (VOAs) results indicate that several constituents are detected in downgradient wells of the 300 APT well network. The detected VOA constituents include PCE, toluene, xylene, benzene, TCE, chloroform, ethylbenzene, and cis-DCE (Appendix C). However, only TCE and cis-DCE are consistently above the DWS of 5 and 70 μg/L, respectively. The well showing the exceedances of TCE and cis-DCE is 399-1-16B, which is a downgradient well screened at the bottom of the unconfined aquifer (Figures 3-13 and 3-14).

Concentrations of iron and manganese in filtered samples are consistently higher than DWS for two wells, iron in well 399-1-17B and manganese in well 399-1-16B and 399-1-17B (Appendix C). Both wells are screened at the bottom of the unconfined aquifer. These results may be due to reducing conditions and the effect on well structures such as stainless steel casing and the effects of drilling. A similar relationship between sampling depth and concentration profiles for redox-sensitive species has been documented in Johnson et al. (1994).

Uranium continues to be detected in several wells in the vicinity of the 300 APT and is correlated with gross alpha (Schalla et al. 1988b, Section 7.2; Appendix C; Figure 3-15). The 1991 ERA reduced the concentrations of gross alpha and uranium (Appendix C) significantly in wells downgradient of the 300 APT. Currently, uranium concentrations at wells 399-1-17A and 399-1-10A are above the EPA (proposed) guidance value of 20 μg/L for total uranium (EPA 1991). The MCL for gross alpha is based on the exclusion of the uranium component, which is referred to as "adjusted" gross alpha. In a few cases, the adjusted gross alpha concentrations have exceeded the 15 pCi/L (adjusted) gross alpha standard (EPA 1991; 40 CFR 141.15). However, on the average, the standard is not exceeded in any of the downgradient wells. The occasional exceedances of the adjusted gross alpha standard are attributed to random fluctuations in the measurement of gross alpha and uranium, and/or perhaps due to the presence of some residual radon decay products. Specific isotopic analyses (e.g., plutonium-238, 239, 240 and americium-241) would be needed to

Figure 3-13. Trichloroethene Plume.

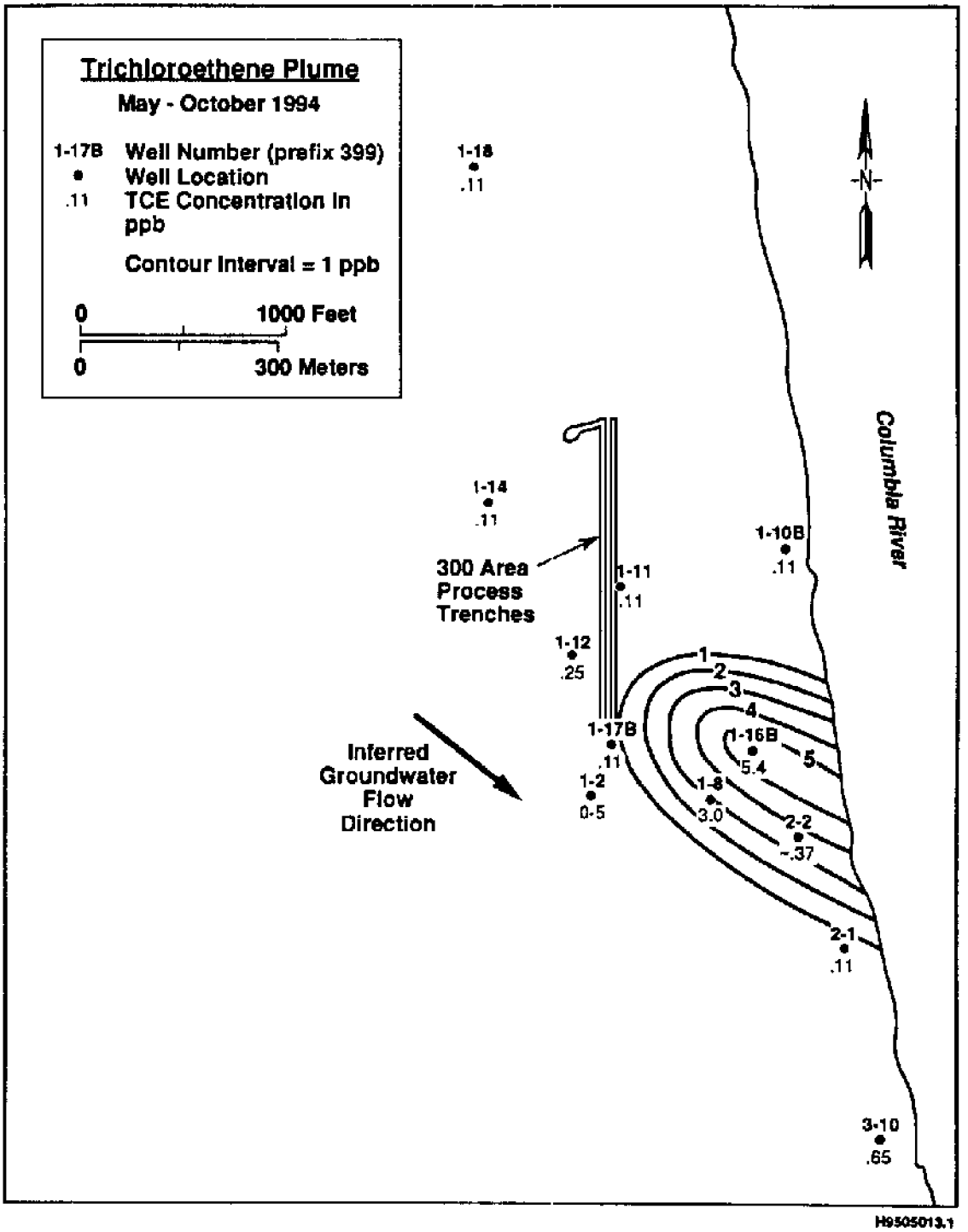


Figure 3-14. CIS 1,2-Dichloroethene Plume.

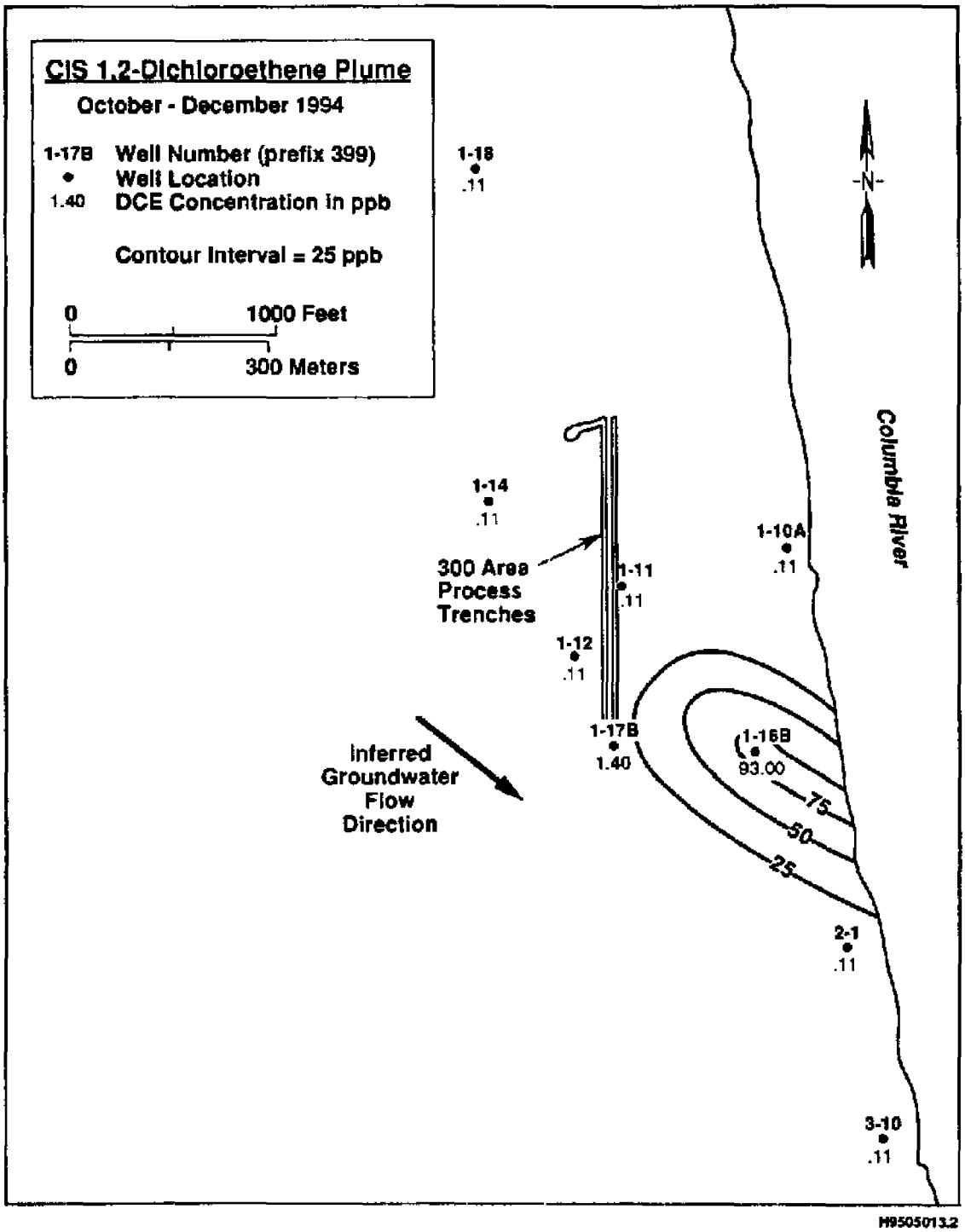
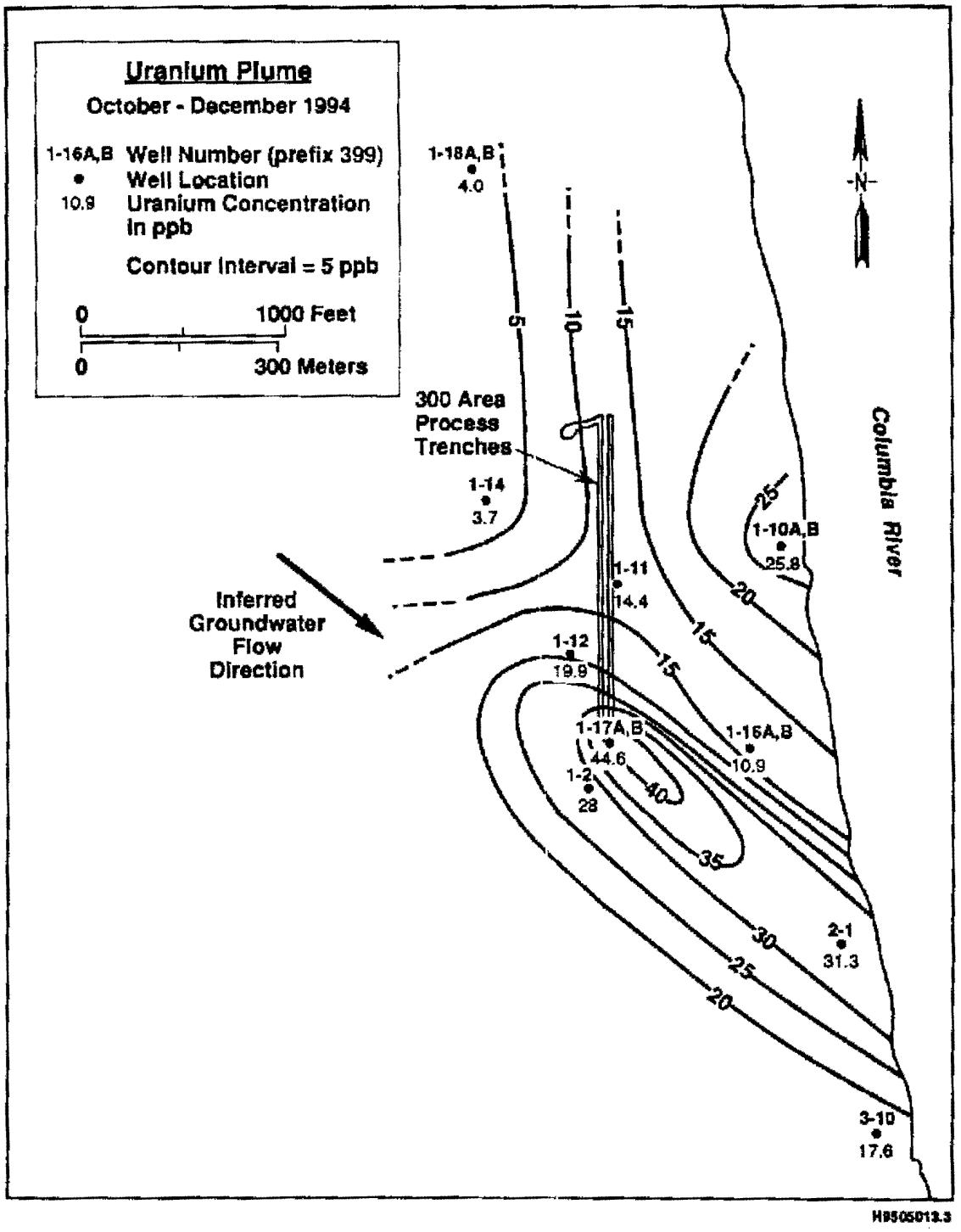


Figure 3-15. Uranium Plume.



rule out the presence of other alpha emitters in groundwater at this site since they have not been previously excluded on the basis of direct measurements in groundwater at the 300 APT. However, based on soil column analytical results (DOE-RL 1995a, Appendix 7D) and the expected chemical behavior of plutonium and americium, it is highly unlikely that transuranics are present in groundwater beneath the 300 APT.

3.4 CONCEPTUAL MODEL FOR LOCALIZED "DEEP" AQUIFER OCCURRENCE OF CHLORINATED HYDROCARBONS

A conceptual model is needed to explain the persistent occurrence of TCE and related degradation products in one downgradient well completed at the bottom of the unconfined aquifer (-16B) (Figures 3-13 and 3-14). One possible explanation is that a liquid phase of PCE (density 1.6 g/ml) settled to the bottom of the aquifer beneath the 300 APT. Slow dissolution and microbial degradation of the free phase would then provide a long-term source of PCE and degradation products (TCE and DCE) to the deeper zone of the unconfined aquifer. Since well -16B is downgradient from the trenches, this well would be in the contaminant plume from such a source. If this explanation is correct, it should be consistent with the hydrogeology and hydraulic setting previously discussed.

For example, the Darcy velocity, see Equation (1), is 0.0016 m/d using an average hydraulic conductivity of 1.4 m/d for the bottom of the unconfined aquifer at 300 APT (Table 3-2), an average gradient of 0.00035, and an effective porosity of 0.3. The observation well is over 300 m (984 ft) downgradient from the trench, suggesting a travel time of greater than 500 years. Since the recorded spills occurred in 1982 and 1984, the computed travel time is inconsistent with this conceptual model. It is also noteworthy that PCE and degradation products were detected shortly after well -16B was installed in 1987 (Appendix C).

Thus, it seems unlikely that the observed chlorinated hydrocarbons in -16B are related to the recorded spills in 1982 and 1984. One alternative possibility is that, during the early years of operations, undocumented ground disposal occurred in the upgradient vicinity of the well. Since this is currently the only well with a persistent occurrence of significant concentrations of chlorinated hydrocarbons, a local source near the well is suggested.

Additional field work would be needed to investigate the possibility of soil dump sites near well -16B and or to distinguish among other possible alternatives. These possibilities should be considered if the groundwater MCL exceedances for TCE and related degradation products persist.

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4.0 GROUNDWATER MONITORING PROGRAM

Chapter 4.0 describes the groundwater monitoring activities to be conducted at the 300 APT during the compliance period (including the closure period) for this unit. The groundwater monitoring program is designed to (1) protect human health and the environment; (2) comply with the intent of final status groundwater monitoring requirements of WAC 173-303-645 (Ecology 1986) and 40 CFR 264 Subpart F; and (3) conduct groundwater investigations or remediation, should it become necessary, in a technically sound and cost effective manner.

Three levels of groundwater monitoring programs are identified under final status regulations: (1) detection monitoring, (2) compliance monitoring, and (3) corrective action (Figure 4-1). Each monitoring program is briefly described below.

Detection level monitoring program. Indicator parameter data (e.g., pH, specific conductance, TOC, TOX, or heavy metals, waste constituents, or reaction products) from downgradient compliance point wells are compared with background wells data semiannually to determine if the unit is impacting the groundwater quality.

Compliance level monitoring program. If groundwater sampling during the detection level monitoring program reveals a statistically significant increase (or pH decrease) over upgradient background concentrations for groundwater, a compliance level monitoring program is established. The monitoring objective is to determine whether groundwater concentration limits have been exceeded at the downgradient (compliance) wells.

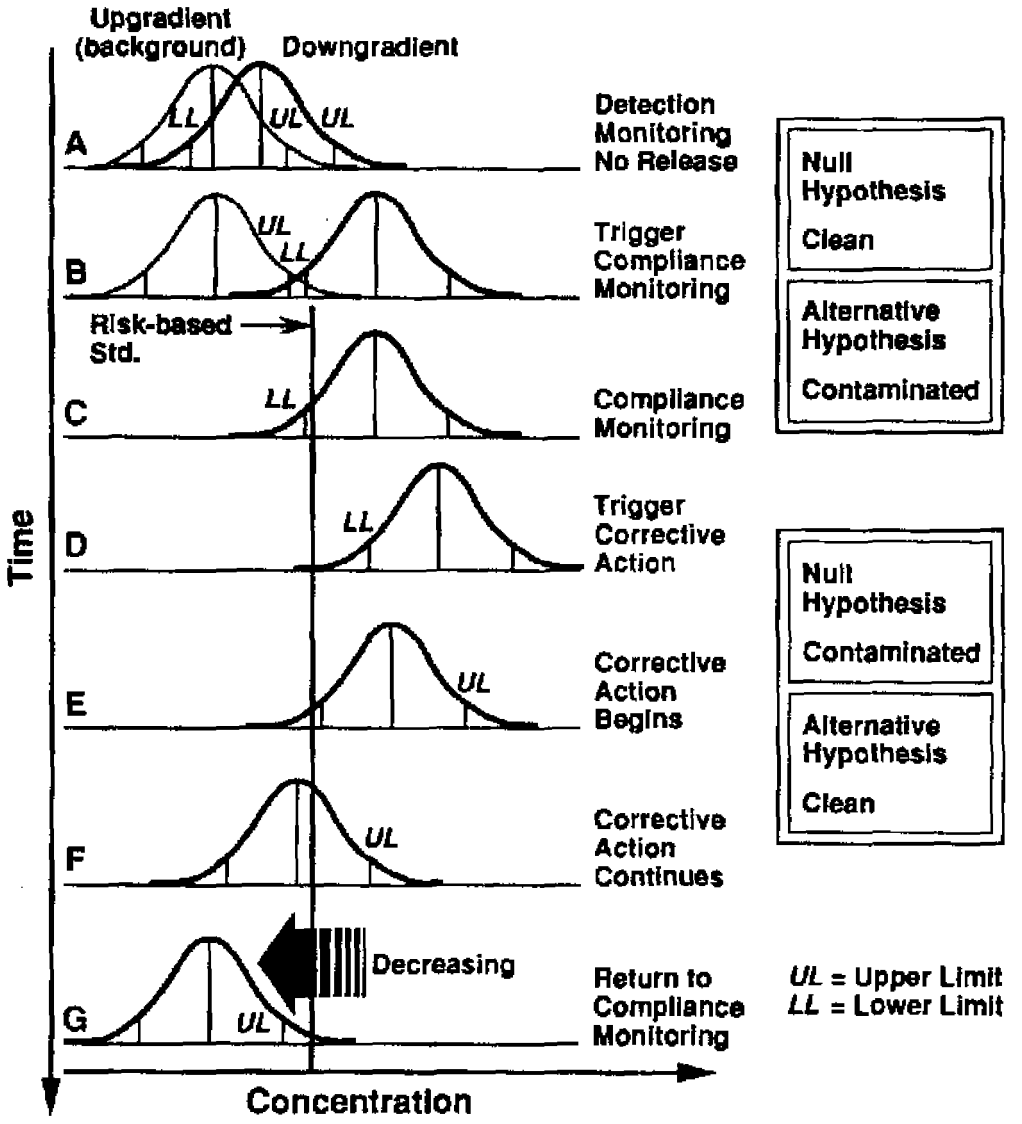
Corrective action level monitoring program. If the referenced concentration limit(s) for a given groundwater parameter or parameters are significantly exceeded during compliance monitoring, a corrective action level monitoring program will be developed and implemented to protect human health and the environment.

4.1 OBJECTIVES OF GROUNDWATER MONITORING PROGRAM

The 300 APT groundwater monitoring program bypassed the detection-level stage and went directly into a RCRA interim-status (assessment) level program in June 1985. The detection-level monitoring program was bypassed because groundwater was already known to be contaminated. Monitoring wells were constructed in response to a Consent Agreement and Compliance Order issued jointly by Ecology and the EPA (Ecology and EPA 1986).

The 300 APT is scheduled to be included the final-status RCRA Permit as a TSD unit undergoing closure through the permit modification process in September 1995. The groundwater near the 300 APT needs to be monitored under a final status program that is comparable or equivalent to the assessment level initiated under the interim status. Hence, a compliance monitoring program is proposed for the 300 APT. The proposed compliance monitoring program will (1) obtain samples that are representative of existing groundwater conditions; (2) identity key monitoring constituents that are

Figure 4-1. A Statistical Perspective of the Sequence of Groundwater Monitoring Requirements Under the Resource Conservation



(Notice that until contamination above a risk standard is documented (D) the null hypothesis is that the facility is clean. Once the facility has been proven to be in exceedance of a health criteria then the null hypothesis is that the facility is contaminated until proven otherwise (G).

H9401016.1

attributable to past operations of the 300 APT; (3) determine applicable groundwater concentration limits (e.g., risk-based maximum concentration limits); and (4) determine whether referenced groundwater concentration limit(s) for a given parameter or parameters are exceeded. A DQO process is used to guide the groundwater monitoring activities to be conducted for the 300 APT. The primary purpose of the DQO process is to ensure that the type, quantity, and quality of groundwater monitoring data used in the decision-making process are appropriate for their intended applications. Details concerning the DQO process can be found in EPA (1993).

4.2 DANGEROUS WASTE CONSTITUENTS

Section 4.2 identifies constituents that are attributable to past operations of the 300 APT. Groundwater chemistry samples are collected quarterly from well 399-1-17A to provide near-trench monitoring of contaminants. All other wells in the monitoring network are sampled semiannually. Monitoring results have been reported in the RCRA quarterly and annual reports. Since 1987, a very large amount of hydrogeologic and contaminant data have been collected from the 300 APT wells. Consequently, the rate, extent, and concentrations of groundwater contaminants originating from the 300 APT are well understood (WHC 1990). Furthermore, an ERA was initiated in July 1991. The ERA removed a layer of contaminated sediments containing uranium, copper, chromium, and silver. In January 1995, the 300 APT was permanently isolated from the process sewer (its only source of effluent), therefore eliminating the trenches as a source of groundwater recharge.

Groundwater monitoring results are available from the Hanford Environmental Information System (HEIS) and the Geosciences Data Analysis ToolKit (GeoDAT). The following are considered when deriving a constituent list appropriate for the 300 APT:

- Inventory/process knowledge
- Driving force
- Contaminant mobility
- Preferential pathways
- Monitoring objectives
- Detection history at the unit.

Per WAC 173-303-645 and 40 CFR 264, Subpart F, groundwater concentration limits must be established in the facility permit (by the regulators). These limits are not to be exceeded. These concentration limits may be different than the risk-based groundwater cleanup standards as required by the Method C (industrial scenario) of the Model Toxics Control Act, WAC 173-340-720(4). Table 4-1 summarizes the status of 14 constituents where groundwater concentration limits have been established (see WAC 173-303-645(5)(a), Table 1).

Only chromium, lead, selenium, and lindane have values larger than the MCLs given in WAC 173-303-645(5)(a), Table 1. Chromium exceedances were isolated events that were probably caused by suspended particulate in the unfiltered samples. Lead exceedances were observed, prior to the 1991 ERA, in two non-RCRA wells. After the ERA, lead concentrations have been below the

Table 4-1. Status of Monitoring Results for Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Arsenic	0.05	50	N	<0.64 - 6.7 (unfiltered) <0.64 - 6.2 (filtered)
Barium	1.0	1,000	N	<2.0 - 70 (unfiltered) <2.0 - 70 (filtered)
Cadmium	0.01[c]	10[c]	Y[d]	<10 (unfiltered) <10 (filtered)
Chromium	0.05[c]	50[c]	Y	4 occurrences observed in unfiltered samples from wells 3-1-12 (150 ppb), 3-1-16A (147 ppb), 3-1-17A (140 ppb), 3-1-18A (120 ppb).
Lead	0.05	50	Y	2 occurrences (in 1985) observed in unfiltered samples from non-RCRA standards wells 3-2-1 (55 and 58 ppb) and 3-3-10 (77.5 and 73.5 ppb).
Mercury	0.002	2	N	<0.2 (unfiltered) <0.2 (filtered)
Selenium	0.01	10	Y[d]	<20 (unfiltered) <10 (filtered)
Silver	0.05	50	N	<20 (unfiltered) <20 (filtered)
Endrin	0.0002	0.2	Y[d]	<1 (all samples)
Lindane	0.004	4	N	<0.05 (all samples)
Methoxychlor	0.1	100	N	<2 (all samples)
Toxaphene	0.005	5	N	<2 (all samples)
2,4-D	0.1	100	N	<10 (all samples)
2,4,5-TP silvex	0.01	10	N	<2 (all samples)

MCL = maximum contaminant level. Y/N = yes/no.
[a]from WAC 173-303-645 (5)(a).
[b]from results analyzed by DataChem Laboratories (after 12/31/91).
[c]MCLs for chromium and cadmium have been revised to 0.1 mg/L (100 μg/L) and to 0.005 mg/L (5 μg/L), respectively, per 40 CFR 141.62 (b)(5), effective 7/30/92.
[d]all samples were essentially not detected (exceedances due to detection limits larger than required MCLs).

MCL of 50 μg/L. All samples analyzed for cadmium, selenium, and lindane were essentially non-detects and the exceedances were caused by detection limits that were higher than the respective MCLs. Other constituents of interest (e.g., copper, sulfate, zinc, chloride, silver, gamma-emitting radionuclides, and strontium-90) were all below the Primary and Secondary DWS or the 4 mrem/yr equivalent concentrations for radionuclides (see Tables 4-2 and 4-3). Gross alpha and uranium exceedances were observed in all wells in the monitoring network except for wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A. Gross beta exceedances were observed in wells 3-1-10A, 3-1-11, and 3-1-16A. In general, the excess beta can be accounted for by the beta decays associated with the uranium-238 present in the groundwater samples from the 300 APT wells that exhibit gross beta levels >50 pCi/L.

An evaluation of VOA results revealed that detected analytes include PCE, toluene, xylene, benzene, TCE, chloroform, ethylbenzene, and cis-DCE (see Table 4-4). Only TCE and DCE have been observed in well 3-1-16B consistently above the DWS of 5 and 70 μg/L, respectively. Unplanned releases (two spills) of PCE occurred in 1982 and 1984.

Concentrations of iron and manganese in filtered samples are consistently higher than the respective DWS in two wells (3-1-17B for iron, 3-1-16B and 3-1-17B for manganese) of the 300 APT network (see Table 4-3). These two wells were completed at the bottom of the unconfined aquifer. The elevated iron and manganese concentrations observed in the "deep" unconfined aquifer are probably influenced by chemical reducing conditions (i.e., the absence of oxygen and negative oxidation-reduction potentials). A similar relationship between sampling depth and concentration profiles for redox sensitive species has been documented in WHC (Johnson et al. 1994). A limited follow-up geochemical investigation is needed. Measurements of Eh (redox potential) and dissolved oxygen should be determined for these two wells to confirm that the hypothesized reducing conditions exist at these wells. Metals (iron and manganese) will be added to the list of monitoring constituents if it can be demonstrated that the elevated concentrations are caused by other than chemical reducing conditions.

Uranium was the most significant and widespread groundwater contaminant resulting from past operations of the 300 APT. The mitigating action of the ERA reduced uranium concentrations in well 3-1-17A significantly. Currently, uranium concentrations at wells 3-1-17A and 3-1-10A have remained above the EPA proposed guidance value of 20 μg/L for total uranium (EPA 1991). However, the EPA proposed standard of 20 μg/L applies to community and nontransient, noncommunity water systems. This may be ultra conservative for the 300 APT.

Based on the above considerations, the following constituents are proposed for the initial monitoring program to comply with WAC 173-303-645(4). The list will be reassessed periodically and revised should there be a need to update the monitoring list.

Table 4-2. Status of Monitoring Results for Other Hazardous Chemical Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Copper	1.0	1,000	N	<2.0 - 20.0 (unfiltered) <2.6 - 20.0 (filtered)
Iron	0.3	300	Y	3-1-17B (320 - 450), in filtered samples
Manganese	0.05	50	Y	3-1-16B (67 - 74), in filtered samples 3-1-17B (67 - 83), in filtered samples
Sulfate	250	250,000	N	(11,000 - 53,000)
Total Dissolved Solids (TDS)	500	500,000	N	(221,000 - 248,000), TDS data in well 3-1-10A only
Zinc	5	5,000	N	<3.44 - 24.0 (unfiltered) <3.44 - 23.0 (filtered)
Chloride	250	250,000	N	(4,600 - 150,000)

MCL = maximum contaminant level. Y/N = yes/no.
[a]from 40 CFR 143.3 Secondary Maximum Contaminant Levels.
[b]from results analyzed by DataChem Laboratories (after 12/31/91).

Table 4-3. Status of Monitoring Results for Radiological Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent	MCL (pCi/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Gross Alpha	15		Y	exceedance observed in all wells except for in wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A
Uranium		20[a]	Y	exceedance observed in all wells except for in wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A
Gross Beta	50		Y	exceedance observed in wells 3-1-10A (13.6 - 68), 3-1-11 (6.51 - 63), and 3-1-16A (20 - 88)
Sr-90	8		N	essentially all ND
Tc-99	900		N	(10 - 281) in 3-1-10A, where the upper value 281 was flagged with a "R" (rejected) for gross α and gross ß analyses
Tritium	20,000		N	highest range of concentrations were observed in well 3-1-18A, (10,900 - 11,500) indicating upgradient source of contamination
Cs-137	200		N	essentially all ND
Co-60	100		N	essentially all ND

MCL = maximum contaminant level.
Y/N = yes/no.
[a]From Federal Register, Vol. 56, No. 138, 7/18/1991, Proposed Rule: National Primary Drinking Water Regulations, Radionuclides (EPA 1991).
[b]From results analyzed by DataChem Laboratories (after 12/31/91).

Table 4-4. Status of Monitoring Results for Detected VOA Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Ethylbenzene	0.7	700	N	0.06 - 0.08
Toluene	1	1,000	N	0.03 - 0.06
Tetrachloroethylene	0.005	5	N	0.09 - 0.74
Xylenes	10	10,000	N	0.05 - 0.08
Cis-1,2-DCE	0.070	70	Y	exceedance observed in well 3-1-16B[c]
Chloroform	None	None	NA	0.06 - 9.30 (GC) 1.40 - 22.0 (GC/MS)
Benzene	0.005	5	N	0.02 - 0.06
TCE	0.005	5	Y	exceedance observed in well 3-1-16B[c]

MCL = maximum contaminant level.
Y/N = yes/no.
NA = not applicable.
[a]VOA analyzed by Gas Chromatography (GC) and/or Gas Chromatography/Mass Spectrometry (GC/MS).
[b]From results analyzed by DataChem Laboratories (after 12/31/91).
[c]See time vs concentration plots in Appendix C.

- Radionuclides--chemical uranium
- VOAs--TCE and DCE
- Metals--iron and manganese will be added to the list depending on the outcome of follow-up geochemical investigations (i.e., if elevated levels are not due to chemical reducing conditions.

Additional constituents will be collected (see Section 4.5.1).

4.3 GROUNDWATER MONITORING WELLS

The proposed groundwater monitoring network for the 300 APT contains eight wells set up as four pairs of deep and shallow wells for the unconfined aquifer (Table 4-5). Three of the well pairs are downgradient and one pair is upgradient (Figure 4-2). The wells were selected in order to fulfill the requirements for monitoring well networks for RCRA sites in compliance programs of final status (WAC 173-303-645). Appendix A contains the well construction and completion summaries, including schematics, for the eight wells. Specifically, the objective was to select wells that would monitor the appropriate portion of the aquifer for waste constituents of concern. In the case of the 300 APT the constituents of concern are TCE, DCE, uranium, and possibly iron and manganese (see Section 4.2). All but TCE and DCE are migrating through the upper portions of the unconfined aquifer. TCE and cis-DCE are detected in wells monitoring the base of the unconfined aquifer (see Section 3.4). Therefore, wells screened in the bottom portion of the aquifer are appropriate too, both down- and up-gradient. The three downgradient well pairs (399-1-10AB, 399-1-16AB, and 399-1-17AB) are east, southeast, and south, respectively, of the 300 APT to intercept any groundwater contaminants emanating from the 300 APT and flowing with the groundwater in directions consistent with historical data. Based on the Monitoring Efficiency Model (Jackson et al. 1991), the proposed downgradient wells should provide a monitoring efficiency of approximately 88%, assuming a groundwater flow direction of south-southeast (S.27°E or 153° azimuth). The upgradient well pair (399-1-18AB) was chosen because it was close to the 300 APT but not too close to the trenches to encounter contaminants temporarily flowing in a reverse direction when the Columbia River stage is high. All eight of the proposed wells were constructed to WAC 173-160 standards.

4.4 COMPLIANCE MONITORING

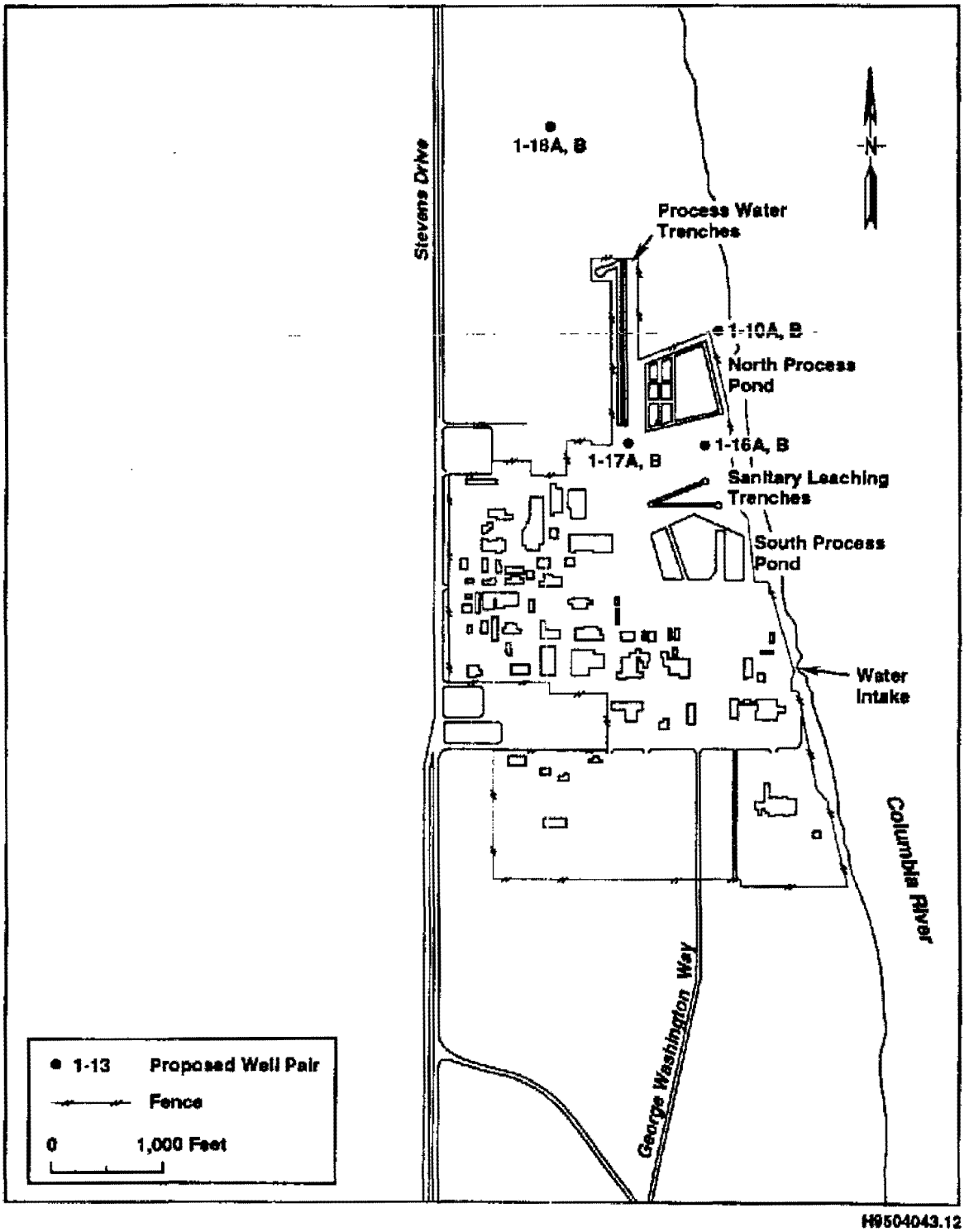
Groundwater protection regulations establish requirements concerning groundwater monitoring and corrective action standards for the permitted regulated units (e.g., surface impoundment, land disposal unit). Furthermore, for each dangerous waste constituent entering the groundwater from a regulated unit, the unit permit must include a concentration limit that cannot be exceeded. These concentration limits are the "triggers" that determine the need for further action.

Table 4-5. Proposed Wells for the 300 Area Process Trenches Monitoring Well Network.

Well	Aquifer	Sampling Frequency	Water Levels	Well Standards
399-1-10A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-10B[91]	Bottom Unconfined	Semiannual	Quarterly	WAC-173-160
399-1-16A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-16B[87]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-17A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-17B[86]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-18A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-18B[87]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160

Note: Superscript following well number denotes the year of construction.

Figure 4-2. Locations of Monitoring Wells Proposed for the Revised 300 Area Process Trenches Groundwater Monitoring Plan.



4.4.1 Concentration Limits

For the 300 APT constituents of concern, the proposal is to use the following MCLs as the concentration limits.

1. For TCE, the MCL is 5 μg/L. This limit is based on National Primary DWS (40 CFR 141.61(a)). This limit is also the MCL set forth in WAC 246-290-310.

2. For cis-DCE, the MCL is 70 μg/L. This limit is based on National Primary DWS (40 CFR 141.61(a)).

3. For uranium, there is no DWS established. However, 20 μg/L for total uranium in public drinking water supplies was included in proposed changes to 40 CFR 141 (EPA 1991). This value is proposed for the 300 APT until the rule containing the subject standard is promulgated.

Groundwater quality criteria for TCE is set at a different level, 3 μg/L, in WAC 173-303-200. However, the purpose of WAC 173-303-200 is to set groundwater quality standards that are (1) preventative in nature and (2) protective of existing and future beneficial uses through the reduction or elimination of contaminants discharged to the subsurface. Therefore, these standards are more stringent than other types of standards in order to control the source discharged to groundwater. Once contaminants have reached groundwater, the applicable standard should be set at the MCL and/or the state required cleanup standard.

4.4.2 Point of Compliance

The point of compliance (POC) is defined in 40 CFR 264.95 and WAC 173-303-645(6) as a "vertical surface" located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated unit. The POC is the place in the uppermost aquifer where groundwater monitoring takes place and the groundwater protection standard is set. For the 300 APT, the POC should be the downgradient monitoring wells as provided in Section 4.3. (i.e., monitoring wells 3-1-10A and -10B, 3-1-16A and -16B, 3-1-17A and -17B).

4.4.3 Compliance Period

The compliance period is defined as the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period). Typically, groundwater monitoring is required for a period of 30 years following completion of closure activities, although this time frame may be shortened or extended by the regulatory authority. If corrective action is engaged by the owner or operator (due to exceedance of groundwater concentration limit), then the compliance period will be extended until it can be demonstrated that the applicable limit has not been exceeded for a period of three consecutive years.

4.5 SAMPLING AND ANALYSIS

Section 4.5 describes or references procedures for sample collection, sample preservation and shipment, chain of custody requirements, analytical procedures, and quality assurance. Specific sampling and analysis procedures are referenced. Work by subcontractors shall be conducted to their equivalent approved standard operating procedures.

All field sampling activities will be recorded in the proper field logbook as specified in EII 1.5 and subsequent revisions (WHC 1988). Electric submersible or Hydrostar[3] pumps will continue to be used in existing monitoring wells for purging and sampling. Before sampling each well, the static water level will be measured and recorded as specified in EII 10.2 (WHC 1988). Based on the measured water level and well construction details, the volume of water in the well will be calculated and documented in the well sampling form or field notebook. These steps will be performed electronically in the field. As specified in EII 5.8, each well will be purged before sampling until the approved criteria are met (WHC 1988). Purge water will managed according to EII 10.3 (WHC 1988). In the situations where the well pumps dry because of very slow recharge, the sample will be collected after recharge. Samples will be collected and field preserved as specified in EII 5.8. Sampling equipment decontamination will follow procedures specified in EII 5.4 (WHC 1988).

Sample chain-of-custody, sample packaging, and shipping required by WAC 173-303-645(8)(d) are discussed in EII 5.1 and 5.11 (WHC 1988). The general quality assurance/control (QA/QC) protocols will include the site-specific analytes for this plan (WHC 1993). The purpose of the QC activities is to determine and documente that samples were carefully collected and transferred to an analytical laboratory, that the quality of the analytical results being produced by the laboratory are defensible, and that corrective actions will be taken as necessary.

Under the proposed compliance-level monitoring program, water-level elevation data will be evaluated annually to determine if the monitoring wells ae strategically located. If the evaluation indicates that existing wells are no longer adequately located, the groundwater monitoring network will be modified to bring it into compliance with WAC 173-303-645(8)(a). Descriptions of monitoring constituents, monitoring frequency, and analytical procedures specific to the 300 APT are provided below.

4.5.1 Constituents to be Analyzed

The constituents to be analyzed initially for the 300 APT include:

(1) The detected constituents of concern identified in Section 4.2 (incuding uranium and biodegradation products of tetrachloroethylene). These constituents of concern will be sampled independently four times in each sampling event (semiannually).

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[3]Hydrostar is a registered trademark of Instrumentation Northwest, Inc.

(2) Metals (iron and manganese). Groundwater samples will be analyzed semiannually for these metals together with dissolved oxygen and redox potential as part of the follow-up geochemical investigation (Section 4.2). They will be added to the constituents of concern list if elevated levels are not due to chemical reducing conditions.

(3) Four constituents required by Ecology including thallium, PCBs, chrysene, and benzo(a)pyrene. These four constituents are required by Ecology in response to their concern about dangerous wastes leaching from the relocated sediments stockpiled at the north ends of the trenches. Groundwater samples will be analyzed for these constituents semiannually for two years (four sampling periods). If the constituents are detected they will be added to the list of constituents of concern.

(4) Field parameters that are routinely measured at the well head (including pH, conductivity, turbidity, and temperature).

A large number of wells were sampled periodically during the 1988-1991 time period for dangerous waste constituents per WAC 173-303-9905 and site specific constituents (see Section 3.3). This effort established the constituents of concern for the interim remedial action and the final status monitoring plan. Since 300 APT discharges have ceased, only residual contaminants from past practice discharges should be present in groundwater in the vicinity of the trenches. Thus, previous groundwater characterization and monitoring data (historical data) are considered adequate for addressing the Appendix IX requirements for this final status monitoring plan.

4.5.2 Background Values

Background values (area) are defined as the levels of chemical, physical, biological, or radiological constituents or parameters upgradient of a unit, practice, or activity that have not been affected by the unit. Groundwater monitoring data obtained from upgradient wells will be used to track the encroachment of upgradient sources of contaminant plumes. Background data also will be reevaluated if changes in groundwater flow directions result in changes in definition of upgradient wells.

4.5.3 Sample Frequency

In compliance with regulations, all wells (compliance and background) will be sampled at least semiannually during the compliance period. During each semiannual sampling event, a sequence of at least four independent samples will be collected from compliance wells and results compared to the groundwater concentration limits established in Section 4.4.1. Statistical methods are discussed in Section 4.6.

The requirement of obtaining four independent samples could be accomplished by reference to the uppermost aquifer's effective porosity (n_e); horizontal hydraulic conductivity (K_h); and hydraulic gradient (i). The

minimum time interval between sampling events that will provide an independent sample of groundwater is estimated as follows (EPA 1989):

1. Calculate the horizontal component of the average linear velocity of groundwater (V_h) using the Darcy equation

$$V_h = \frac{(K_h * i)}{n_e}$$

with:

K_h = 43 m/d (Swanson et al. 1992)

i = 0.0003 or 0.0004 (DOE-RL 1995b, Figures 6.1-4 and 6.1-5)

n_e = 0.2

V_h = (43 m/d * 0.0003)/0.2 = 0.0645 m/d, or

V_h = (43 m/d * 0.0004)/0.2 = 0.086 m/d

2. The horizontal component of the average linear velocity of groundwater, V_h, has been estimated to be from 0.0645 to 0.086 m/d. Monitoring well diameters at the 300 APT are 0.1016 m. Therefore, the minimum travel time, T, to obtain an independent sample for this unit is:

T = (0.1016 m)/(0.0645 m/d) = 1.6 d (based on i = 0.0003)

or

T = (0.1016 m)/(0.086 m/d) = 1.2 d (based on i = 0.0004).

Based on the above calculations, sampling every other day would provide the required independent samples. However, a "disturbed zone" due to purging may create a larger "effective" diameter than used in the above calculation. Therefore, to account for the disturbed zone and/or to reduce the autocorrelation effects (which may happen if groundwater is sampled too close in time), a monthly sampling interval is recommended. Sampling will be accomplished in months when the water level is high (March, April, May, and June) and again when the water level is low (September, October, November, and December).

4.5.4 Analytical Procedures

The laboratory approved for the groundwater monitoring program will operate under the requirements of current laboratory contracts and will use standard laboratory procedures as listed in the SW-846 (EPA 1986) or an alternate equivalent. Alternate procedures, when used, will meet the guidelines of SW-846, Chapter 1.0. Analytical methods and quality control for the RCRA groundwater monitoring activities are described in WHC (1993).

4.5.5 Geochemical Evaluation of Iron and Manganese

The hypothesis that elevated iron and manganese is due to reducing conditions in certain wells completed at the bottom of the unconfined aquifer will be tested by analyzing key redox (oxidation-reduction) indicator parameters:

- Fe II
- dissolved oxygen
- Eh.

Under reducing conditions, low dissolved oxygen (<1 ppm) and low or negative redox potentials (Eh) (see Figure 4-3), iron and manganese associated with sediments as oxide coatings on mineral grains can be converted to lower oxidation states (Fe^{+2} and Mn^{+2}). This results in dissolution at the solid-liquid interface (i.e., between pore fluid and surfaces of the oxide coatings). The resultant manganese and iron dissolved in the pore fluid is thus free to pass through a membrane filter when the sample is pumped from the well and directly through the filter holder at the well head. The occurrence of elevated iron and manganese under the above conditions is thus a natural consequence of the aquifer host material (i.e, presence of oxide coatings) and the isolation of the test zone from atmospheric oxygen.

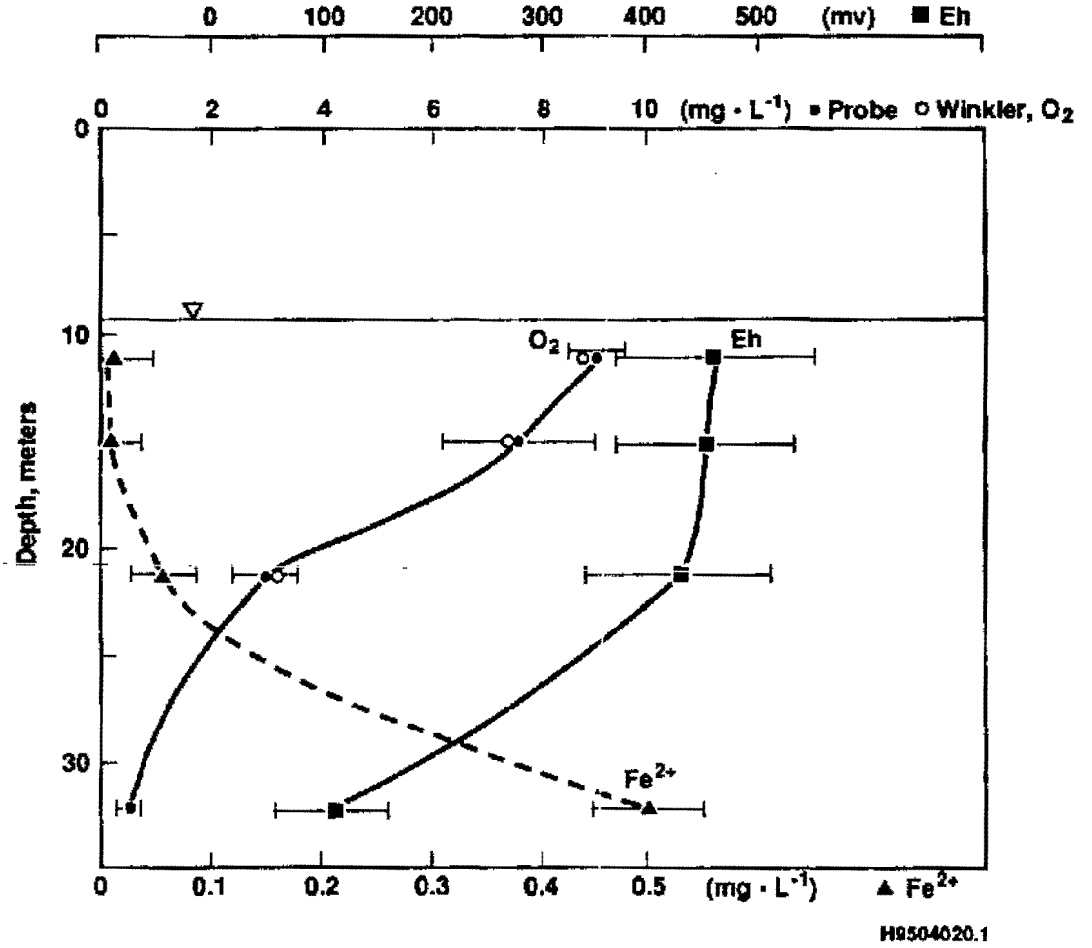
The location of the screened interval at the bottom of the aquifer for the two "deep" wells in the 300 APT with anomalous dissolved iron and manganese and the correspondingly low hydraulic conductivities (wells -16B and -17B) support the "redox" hypothesis. The additional hydrochemical measurements needed to test the hypothesis will be made in the field using (1) a special sample pump to ensure that in-leakage of air (oxygen) does not occur during sample extraction and (2) flow-through test equipment to record dissolved oxygen, Eh, temperature, and pH continuously during an extended purge cycle (up to six bore volumes). Confirmatory measurements of divalentiron will be made in the field using HACH™ kit methods. Low dissolved oxygen (<1 ppm) low or negative Eh potentials, and the presence of Fe^{+2}, will be taken as indirect evidence for accepting the hypothesized natural occurrence of elevated manganese and iron.

4.6 STATISTICAL METHODS

Section 4.6 proposes statistical evaluation procedures for use with the 300 APT monitoring program. Statistical evaluation of groundwater monitoring data will comply with requirements set forth in the WAC 173-303-645 (8)(h) final status regulations. Specifically, procedures outlined in the following EPA technical guidance documents will be followed:

- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Interim Final Guidance* (EPA 1989)
- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance* (EPA 1992).

Figure 4-3. Profiles of Eh, Dissolved Oxygen, and Ferrous Ion with Depth.



For a compliance-level groundwater monitoring program, the monitoring objective is to determine if a groundwater concentration limit such as an MCL has been exceeded. This is a very different problem than the detection-level monitoring where the objective is to detect leakage from the unit by employing upgradient/downgradient comparisons.

4.6.1 Tolerance Intervals

For a compliance-level groundwater monitoring program, the choice of an appropriate statistical test depends on the type of groundwater concentration limit. For health-based concentration values (e.g., an MCL or an ACL derived from health-based risk data), the tolerance interval approach is recommended (EPA 1992, page 50). A tolerance interval is constructed in such a way that it contains at least a specified proportion, P, of the population with a specified confidence coefficient, $100(1 - \alpha)\%$. The proportion of the population included, P, is referred to as the coverage. The probability, $100(1 - \alpha)\%$, with which the tolerance interval includes the proportion P% is referred to as the tolerance coefficient. If compliance data follow a normal or a log-normal distribution, an upper 95% one-sided tolerance limit with a 95% confidence is recommended to be calculated for each constituent of concern in each compliance well (EPA 1989, 1992). If the upper tolerance limit from any compliance well exceeds a MCL, it is interpreted as significant evidence that more than 5% of all compliance values exceed the fixed limit (e.g., MCL). Parametric tolerance limits (suitable for normally or log-normally distributed data) are of the form:

$$\bar{x} + ks \qquad (one\text{-}sided)$$

where $\bar{x}$ is the sample mean; s is the sample standard deviation; and k is a multiplier based on the coverage, the confidence level, and sample size. Values of k can be obtained from EPA (1989). To reduce uncertainty in the estimates of the mean and standard deviation, at least 8 to 10 samples (from each compliance well) are needed.

When the normal or log-normal distribution cannot be justified, especially when a large portion of the samples are non-detects, the use of nonparametric tolerance intervals should be considered. The upper tolerance limit is usually the maximum observed observation from each compliance well for each semiannual sampling event.

Because the parametric tolerance interval approach depends heavily on the normal or log-normal assumption, the adequacy of this assumption should be assessed by probability plots and/or statistical goodness-of-fit tests, such as the Shapiro-Wilk test or Lilliefors test of normality (Gilbert 1987, Conover 1980). Unfortunately, all of the available tests for normality of data do not exhibit high degrees of power when the sample size is small (i.e., <20 to 30 observations). In a compliance monitoring program, it is impractical to obtain 30 independent samples during each semiannual sampling event. Therefore, a nonparametric tolerance interval approach should be considered for the 300 APT. One advantage is that, unless all the sample data are non-detect, the maximum value will be a detected concentration, leading to

a well-defined upper tolerance. However, the nonparametric tolerance intervals require a large number of samples to provide a reasonable coverage and tolerance coefficient.

In order to have a minimum coverage of 95% with 95% confidence, 59 samples are needed. This means one would be 95% sure that at least 95% of the population measurements will fall below the maximum value based on 59 observations. When the maximum value (from four samples) is chosen as the upper tolerance limit, the average coverage (not the minimum coverage as discussed above) is 80%. That is, one would expect that on average that 80% of the population from that compliance well will be below the maximum value. More samples are needed to achieve a higher coverage. It can be shown that at least 19 samples (per compliance well per semiannual period) are necessary to achieve 95% coverage on average. For the purpose of this monitoring plan, it is assumed that a 80% average coverage is acceptable because (1) a very large amount of hydrogeologic and contaminant data have been collected from the 300 APT wells since 1987 and (2) the rate, extent, and concentrations of groundwater contaminants originating from the 300 APT are well understood.

4.6.2 Confirmation Sampling

For tolerance limits to be useful resampling has to be allowed before a decision is reached. This is because tolerance limits have a built-in failure rate of (1 - P)%. For example, one would expect 1 in every 20 samples to be outside of the upper 95% tolerance limit just by chance. To decrease the chance of a false positive decision because of either the built-in failure rate or the effects of gross errors in sampling or analysis, verification resampling is necessary. This is the best available approach to balance false positive and false negative decisions (Gibbons 1994). In case of an initial exceedance, a verification sampling is needed to determine if the exceedance is an artifact caused by an error in sampling, analysis, or statistical evaluation or natural variation in the groundwater. Recent EPA guidance (1992) encourages the use of resamples as a means to reduce the facility-wide false positive rate.

Confirmation retesting can be accomplished by taking a specific number of additional, independent samples from the well where a specific constituent triggers the initial exceedance. Because more independent data are added to the overall testing procedure, retesting of additional samples, in general, will make the statistical test more powerful and result in a more reliable determination of possible exceedance. Therefore, the objectives for the verification sampling are to ensure (1) quick identification and confirmation of contamination exceeding some standard, if any, and (2) the statistical independence of successive resamples from any well where initial exceedance occurred. The performance of the statistical retesting strategy depends substantially on the independence of the data from each well.

After considerations cited above, it is proposed to obtain two independent samples, split each sample, and send the splits to two different laboratories for independent verification. In this way, laboratory bias (if present) can be investigated. A statistically significant result will be declared only if all resamples are larger than the MCL. If all resamples are

below the MCL, the compliance monitoring program will continue. If results are inconclusive, another round of verification resamples will be initiated.

Finally, if the magnitude of the initial exceedance is small (e.g., <25%), special analysis may be requested in order to achieve lower detection limits and/or improved accuracy and precision.

4.6.3 Non-detects

Non-detects will be handled per recommendations stated in the EPA guidance documents (1989 and 1992). Non-detects will not present a problem in using a nonparametric method to evaluate compliance data if the detection limit is lower than the MCL. If a parametric statistical method is used, then the handling of non-detects will depend on the percentage of detected values. Basically, a substitution method (use 1/2 of the detection limit to replace non-detects) will be used if less than 15% of all samples are non-detects. If the percent of non-detects is between 15% to 50%, either Cohen's method or Aitchison's adjustments will be used. Detailed descriptions of these methods can be found in EPA (1989 and 1992). When more than 50% of the sample values are non-detects, the Poisson model may be used to derive a Poisson tolerance limit. Steps to calculate an upper tolerance limit using the Poisson model are given in EPA (1992).

4.6.4 Outliers

An outlier is an observation that does not conform to the pattern established by other observations in the data set. Possible reasons for its occurrence include contaminated sampling equipment, inconsistent sampling or analytical procedure, data transcribing error, and true but extreme measurements. Statistical methods such as Grubbs' methods (Grubbs 1969) for testing of outliers and/or the box-and-whisker plot (Ostle and Malone 1988) may be used. Once an observation is found to be an outlier, the following action should be taken:

- If the error can be identified and the correct value can be recovered through the Request for Analytical Data Review (RADE) process (see Section 5.1), replace the outlier value with the corrected value.
- If the error can be documented but the correct value cannot be recovered, the outlier should be deleted. Describe this deletion in the statistical report.
- If no error can be documented, then assume that the value is a valid measurement. However, obtain another sample to confirm the high value, if necessary.

4.7 DETERMINING RATE AND DIRECTION OF GROUNDWATER FLOW

Depth to water will be measured in 32 300 Area wells semiannually in order to construct water table maps. These maps will be used to interpret the direction of groundwater flow and to derive the water table gradient. The gradient, in turn, will be used with estimated values of hydraulic conductivity and effective porosity to calculate flow rate by using the Darcy equation (see Section 3.2). Because the 300 Area water table is significantly affected by Columbia River level, the semiannual measurements will be coordinated with seasonal fluctuations of Columbia River stage in order to construct water table maps corresponding to high and low stages. Historically, high river stage is somewhere in the months of May or June, and low river stage occurs in September. Therefore, the semiannual measurements will be in September and in either May or June. Exact times of measurement will be adjusted to ensure that high and low stages are represented. The wells measured semiannually for water level are listed in Table 4-6 and shown in Figure 3-1. Water levels will be measured and recorded as specified in EII 10.2 (WHC 1988).

In addition to the 32 wells measured semiannually for constructing water table maps, 8 other wells will be measured semiannually to determine hydraulic head of the lower portion of the unconfined aquifer (4 wells) and upper confined aquifer (4 wells). The wells measured in the lower portion of the unconfined aquifer are 399-1-10B, 399-1-16B, 399-1-17B, and 399-1-18B. Wells measured in the uppermost confined aquifer are 399-1-9, 399-1-16C, 399-1-17C, and 399-1-18C. Figure 3-1 shows the well locations.

Table 4-6. Wells Used for Semiannual Depth-to-Water Measurements.

Wells Monitoring the Top of the Unconfined Aquifer

399-1-1	399-1-18A	399-2-2	399-4-10
-1-10A	-1-19	-2-3	-4-11
-1-11	-1-3	-3-1	-5-1
-1-12	-1-4	-3-6	-6-1
-1-14A	-1-5	-3-9	-8-1
-1-15	-1-7	-3-10	-8-2
-1-16A	-1-8	-4-1	-8-3
-1-17A	-2-1	-4-7	699-S27-E14

Wells Monitoring the Bottom of the Unconfined Aquifer

399-1-10B	399-1-16B	399-1-17B	399-1-18B

Wells Monitoring the Uppermost Confined Aquifer

399-1-9	399-1-16C	399-1-17C	399-1-18C

5.0 DATA MANAGEMENT AND REPORTING

5.1 DATA VERIFICATION AND VALIDATION

All contract analytical laboratory results are entered into the HEIS database. Data from this larger database are downloaded to smaller data sets for data validation, data reduction, and trend analysis. Data verification and validation activities should follow WHC-CM-7-8, Section 2.6, "Validation and Verification of RCRA Groundwater Data" (WHC 1992). Suspected data are submitted for formal review and resolution through the RADE process per Section 4.2, "Evaluation of Requests for Analytical Data Review" (WHC 1992). Results of data verification and validation shall be reported in the RCRA quarterly and annual reports.

5.2 REPORTING

The results of statistical evaluation will be reported to Ecology in the RCRA quarterly and annual monitoring reports. The statistical results will include a list of groundwater parameters analyzed, detection limits, and analytical results. If a statistically significant exceedance (after the confirmation resampling evaluation process) is determined at any well at the POC, the following steps will be taken per WAC 173-303-645(10)(g)(i)(ii).

- Notify Ecology in writing within 7 days of the finding with a report indicating which concentration limits have been exceeded.
- Submit an application for a permit modification to establish a corrective action program to Ecology in 90 days.

In case of a false positive claim, the following procedures will be taken per WAC 173-303-645(10)(i)].

- Notify Ecology in writing within 7 days of the finding (i.e., exceedance) that a false positive claim will be made.
- Submit a report to Ecology within 45 days. This report should demonstrate that a source other than the 300 APT caused the standard(s) to be exceeded or that the apparent noncompliance with standard(s) resulted from error in sampling, analysis, or evaluation.
- Submit an application for a permit modification to make appropriate changes to the compliance monitoring program within 45 days.
- Continue monitoring in accordance with the compliance monitoring program.

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6.0 CORRECTIVE ACTION PROGRAM

If, at the POC, dangerous waste constituents of concern are measured in the groundwater at concentrations that exceed the applicable groundwater concentration limit, a corrective action level monitoring program will be established. The development of a corrective action level monitoring program will be initiated by integration of RCRA/CERCLA programs. Groundwater monitoring will continue as described in Chapters 4.0 and 5.0. Implementation of the corrective action will be deferred and integrated with the remediation of the 300-FF-1 (source) and 300-FF-5 (groundwater) operable units.
A description of the groundwater monitoring plan that will be used to assess the effectiveness of the corrective/remedial action measures will be submitted when the need for corrective action is first identified.

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7.0 REFERENCES

Cline, C. S., J. T. Rieger, J. R. Raymond, and P. A. Eddy, 1985, *Ground-Water Monitoring at the Hanford Site, January-December 1984*, PNL-5408, Pacific Northwest Laboratory, Richland, Washington.

Conover, W. J., Practical Nonparametric Statistics, Second Edition, John Wiley and Sons, New York, New York, pp. 357-367.

Delaney, C. D., K. A. Lindsey, and S. P. Reidel, 1991, *Geology and Hydrology of the Hanford Site: A Standardized Text For Use in Westinghouse Hanford Company Documents and Reports*, WHC-SD-ER-TI-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DOE, 1988, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Richland, Washington*, DOE/RW-0164, Volumes 1 through 9, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.

DOE-RL, 1990, *Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-88-31, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1991, *Expedited Response Action Proposal for the 316-5 Process Trenches*, DOE/RL-91-11, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992, *Expedited Response Action Assessment for the 316-5 Process Trenches*, DOE/RL-92-32, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995a, *300 Area Process Trenches Closure/Postclosure Plan* (Draft), DOE/RL-93-73, Rev. 0-B, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995b, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*, DOE/RL-94-136, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995c, *Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit*, DOE/RL-94-85, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, 1986 (Amended), *Dangerous Waste Regulations*, Washington State Department of Ecology, Washington Administrative Code, Chapter 173-303, Olympia, Washington.

Ecology and EPA, 1986, *Consent Agreement and Compliance Order*, Ecology No. DE 86-113, Washington State Department of Ecology and the U.S. Environmental Protection Agency, Olympia, Washington.

Ecology, 1994, *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*, Permit No. WA7890008967, Effective September 28, 1994, Washington State Department of Ecology, Olympia, Washington.

EPA, 1984, *Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, U.S. Environmental Protection Agency, 40 CFR Part 265, U.S. Government Printing Office, Washington, D.C.

EPA, 1986, *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1987, *Alternate Concentration Limit Guidance: Part I, ACL Policy and Information Requirements*, EPA/530/SW-87-017, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1989, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Interim Final Guidance*, PB89-151047, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991, *Proposed Rules for National Primary Drinking Water Regulations: Radionuclides*, Federal Register 56:138, July 18, 1991, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1992, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance*, EPA/530-R-93-003, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1993, *Data Quality Objectives Process for Superfund - Interim Final Guidance*, EPA/540-R-93-071, U.S. Environmental Protection Agency, Washington, D.C.

Gaylord, D. R., and E. P. Poeter, 1991, *Geology and Hydrology of the 300 Area and Vicinity, Hanford Site, South-Central Washington*, WHC-EP-0500, Westinghouse Hanford Company, Richland, Washington.

Gibbons, R. D., Statistical Methods for Groundwater Monitoring, John Wiley and Sons, New York, New York, pp. 15, 84-93.

Gilbert, R. O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold Company, New York, New York, pp. 157-162.

Grubbs, F. E., 1969, "Procedures for Detecting Outlying Observations in Samples," *Technometrics*, 11:1-21.

Helz, R. T., 1978, *The Petrogenesis of the Ice Harbor Member, Columbia Plateau, Washington*, Ph.D. Dissertation, Pennsylvania State University, University Park, Pennsylvania.

Jackson, R. L., C. M. Einbereger, R. B. Mercer, and C. R. Wilson, 1991, *Efficiency-Based Groundwater Monitoring Network Design for Hazardous Waste Sites*, WHC-SA-1157-FP, Westinghouse Hanford Company, Richland, Washington.

Johnson, V. G. and C. J. Chou, *Some Statistical Aspects of Background Based Groundwater Standards at an Arid Hazardous Waste Site*, WHC-SA-2358-FP, Westinghouse Hanford Company, Richland, Washington.

Lindberg, J. W., and F. W. Bond, 1979, *Geohydrology and Ground-Water Quality Beneath the 300 Area, Hanford Site, Washington*, PNL-2949, Pacific Northwest Laboratory, Richland, Washington.

Lindsey, K. A., 1991, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington*, WHC-SD-EN-EE-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Ostle, B. and L. C. Malone, 1988, Statistics in Research: Basic Concepts and Techniques for Research Workers, Fourth Edition, Iowa State University Press, Ames, Iowa, pp. 66-67.

PNL, 1988, *Groundwater Monitoring Compliance Projects for Hanford Site Facilities: Progress Report for the Period April to June 30, 1988*, PNL-6675, Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Schalla, R., R. L. Aaberg, D. J. Bates, J. V. M. Carlile, M. D. Freshley, T. L. Liikala, P. J. Mitchell, K. B. Olsen, and J. T. Rieger, 1988a, *Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches*, PNL-6671, Pacific Northwest Laboratory, Richland, Washington.

Schalla, R., R. W. Wallace, R. L. Aaberg, S. P. Airhart, D. J. Bates, J. V. M. Carlile, C. S. Cline, D. I. Dennison, M. D. Freshley, P. R. Heller, E. J. Jensen, K. B. Olsen, R. G. Parkhurst, J. T. Rieger, and E. J. Westergard, 1988b, *Interim Characterization Report for the 300 Area Process Trenches*, PNL-6716, Pacific Northwest Laboratory, Richland, Washington.

Swanson, D. A., T. L. Wright, P. R. Hooper, and R. D. Bentley, 1979, *Revised in Stratigraphic Nomenclature of the Columbia River Basalt Group*, Bulletin 1457-G, U.S. Geological Survey, Washington, D.C.

Swanson, L. C., G. G. Kelty, K. A. Lindsey, K. R. Simpson, R. K. Price, and S. D. Consort, 1992, *Phase I Hydrogeologic Summary of the 300-FF-5 Operable Unit, 300 Area*, WHC-SD-EN-TI-052, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990, *Liquid Effluent Study: Groundwater Characterization Data*, WHC-EP-0366, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *Environmental Engineering and Geotechnology Function Procedures*, WHC-CM-7-8, Vol. 4, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Quality Assurance Project Plan for RCRA Groundwater Monitoring Activities*, WHC-SD-EN-QAPP-001, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

SUMMARY OF CONSTITUENTS SAMPLED TO 1988
(Taken from Schalla et al. 1988a, Table 6)

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Constituent List-Contamination Indicators

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
101	CONDUCT	UMHO	.	173	0		.		Conductivity
100	PH		.	172	0		.		pH
C68	TOX	PPB	100	167	158		.		Total organic halogen
C69	TOC	PPB	1000	167	106		.		Total organic carbon

Constituent List-Drinking Water Standards

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
109	COLIFRM	MPN	3	211	196		1	EPA	Coliform bacteria
111	BETA	PCI/L	8	210	4		50	EPA	Gross beta
181	RADIUM	PCI/L	1	210	198		5	EPA	Radium
212	LOALPHA	PCI/L	4	210	3		15	EPA	Gross alpha
A08	BARIUM	PPB	6	216	17		1000	EPA	Barium
A07	CADMIUM	PPB	2	216	201		10	EPA	Cadmium
A88	CHROMIUM	PPB	10	216	200		50	EPA	Chromium
A10	SILVER	PPB	10	216	216		50	EPA	Silver
A20	ARSENIC	PPB	5	216	199		50	EPA	Arsenic
A21	MERCURY	PPB	.1	216	197		2	EPA	Mercury
A22	SELENIUM	PPB	5	216	212		10	EPA	Selenium
A33	ENDRIN	PPB	1	216	216	***	.2	EPA	Endrin
A34	METHLOR	PPB	1	216	216	***	100	EPA	Methoxychlor
A35	TOXAENE	PPB	1	216	216	***	5	EPA	Toxaphene
A36	a-BHC	PPB	1	216	216	***	4	EPA	Alpha-BHC
A37	b-BHC	PPB	1	216	216	***	4	EPA	Beta-BHC
A38	g-BHC	PPB	1	216	216	***	4	EPA	Gamma-BHC
A39	d-BHC	PPB	1	216	216	***	4	EPA	Delta-BHC
A61	LEADGF	PPB	5	216	192		20	EPA	Lead (graphite furnace)
C72	NITRATE	PPB	500	211	0		45000	EPA	Nitrate
C74	FLUORID	PPB	500	211	133		1400	EPA	Fluoride
H13	2,4-D	PPB	1	214	214	***	100	EPA	2,4-D
H14	2,4,5TP	PPB	1	214	214	***	10	EPA	2,4,5-TP silvex

Constituent List-Quality Characteristics

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
A11	SODIUM	PPB	100	216	0		.		Sodium
A17	MANGESE	PPB	6	216	182		.		Manganese
A19	IRON	PPB	50	216	66		.		Iron
C67	PHENOL	PPB	10	216	216	***	.		Phenol
C73	SULFATE	PPB	500	211	8		.		Sulfate
C75	CHLORID	PPB	600	211	0		.		Chloride

Constituent List=Site Specific

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REQAGEN	FULLNAME
A12	NICKEL	PPB	10	216	202		.		Nickel
A13	COPPER	PPB	10	216	130		1300	EPAP	Copper
A15	ANTIONY	PPB	100	216	216	***	.		Antimony
A16	ALUMNUM	PPB	150	216	169		.		Aluminum
A24	THIOURA	PPB	200	211	209		.		Thiourea
A61	TETRANE	PPB	10	216	216	***	5	EPAP	Tetrachloromethane
A62	BENZENE	PPB	10	216	216	***	5	EPAP	Benzene
A63	DIOXANE	PPB	680	216	216	***	.		Dioxane
A64	METHONE	PPB	10	216	215		.		Methyl ethyl ketone
A65	PYRIDIN	PPB	500	216	216	***	.		Pyridine
A66	TOLUENE	PPB	10	216	216	***	2000	EPAP	Toluene
A67	1,1,1-T	PPB	10	216	214		200	EPAP	1,1,1-trichloroethane
A68	1,1,2-T	PPB	10	216	214		.		1,1,2-trichloroethane
A69	TRICENE	PPB	10	216	212		5	EPAP	Trichloroethylene
A70	PERCENE	PPB	10	216	195		.		Perchloroethylene
A71	OPXYLE	PPB	10	216	216	***	440	EPAP	Xylene-o,p
B14	M-XYLE	PPB	10	216	216	***	440	EPAP	Xylene-m
B61	12-dben	PPB	10	216	216	***	.		1,2-dichlorobenzene
B62	13-dben	PPB	10	216	216	***	.		1,3-dichlorobenzene
B63	14-dben	PPB	10	216	216	***	.		1,4-dichlorobenzene
C26	PENTCHB	PPB	10	216	216	***	.		Pentachlorobenzene
C37	TETRCHB	PPB	10	216	216	***	.		1,2,4,5-tetrachlorobenzene
C43	TRICHLB	PPB	10	216	216	***	.		1,2,4-trichlorobenzene
C54	HEXACHL	PPB	10	216	216	***	.		Hexachlorophene
C66	NAPHTHA	PPB	10	216	216	***	.		Naphthalene
C68	123TRI	PPB	10	216	216	***	.		1,2,3-trichlorobenzene
C68	135TRI	PPB	10	216	216	***	.		1,3,5-trichlorobenzene
C69	1234TE	PPB	10	216	216	***	.		1,2,3,4-tetrachlorobenzene
C80	1236TE	PPB	10	216	216	***	.		1,2,3,5-tetrachlorobenzene
C70	CYANIDE	PPB	10	211	208		.		Cyanide
C71	FORMALN	PPB	500	216	216	***	.		Formalin
C78	SULFIDE	PPB	1000	211	206		.		Sulfide
C79	KERDSEN	PPB	10000	216	216	***	.		Kerosene
C00	AMMONIU	PPB	20	211	69		.		Ammonium ion
C01	ETHYGLY	PPB	10000	211	211	***	.		Ethylene glycol
C05	DIOXIN	PPB	.1	216	216	***	.		Dioxin

Constituent List=Tag-alongs

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REQAGEN	FULLNAME
A14	VANADUM	PPB	5	216	118		.		Vanadium
A18	POTASUM	PPB	100	216	3		.		Potassium
A60	CHLFORM	PPB	10	116	24		.		Chloroform
A93	METHYCH	PPB	10	66	14		.		Methylene chloride
B89	HEXCBEN	PPB	10	216	216	***	.		Hexachlorobenzene
C62	HEXAENE	PPB	10	164	164	***	.		Hexachloropropene
C82	CHLLATE	PPB	100	108	108	***	.		Chlorobenzilate
C76	PHOSPHA	PPB	1000	211	210		.		Phosphate
C91	STRYCHN	PPB	50	108	108	***	.		Strychnine
C92	MALHYDR	PPB	500	108	108	***	.		Maleic hydrizide
C93	NICOTIN	PPB	100	108	108	***	.		Nicotinic acid

Constituent List=WAC 173-303-9906

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MANLIMIT	REGAGEN	FULLNAME
A01	BERYLAN	PPB	5	16	16	***			Beryllium
A02	OSMIUM	PPB	300	16	16	***			Osmium
A03	STRONUM	PPB	300	16	16	***			Strontium
A04	ZINC	PPB	5	16	5				Zinc
A05	CALCIUM	PPB	50	16	0				Calcium
A23	THALIUM	PPB	10	16	15				Thallium
A25	ACETREA	PPB	200	16	16	***			1-acetyl-2-thiourea
A26	CHLOREA	PPB	200	16	16	***			1-(o-chlorophenyl) thiourea
A27	DIETROL	PPB	200	16	16	***			Diethylstilbesterol
A28	ETHYREA	PPB	200	16	16	***			Ethylenethiourea
A29	NAPHREA	PPB	200	16	16	***			1-naphthyl-2-thiourea
A32	PHENREA	PPB	200	16	16	***			N-phenylthiourea
A40	ODD	PPB	1	16	16	***			DDD
A41	ODE	PPB	1	16	16	***			DDE
A42	ODT	PPB	1	16	16	***			DDT
A43	HEPTLOR	PPB	1	16	16	***	0	EPAP	Heptachlor
A44	HEPTIDE	PPB	1	16	16	***	0	EPAP	Heptchlor epoxide
A46	DIELRIN	PPB	1	16	16	***			Dieldrin
A47	ALDRIN	PPB	1	16	16	***			Aldrin
A48	CHLDANE	PPB	1	16	16	***	0	EPAP	Chlordane
A49	ENDO1	PPB	1	16	16	***			Endosulfan I
A52	ENDO2	PPB	1	2	2	***			Endosulfan II
A72	ACROLIN	PPB	10	16	16	***			Acrolein
A73	ACRYILE	PPB	10	16	16	***			Acrylonitrile
A74	BISTHER	PPB	10	16	16	***			Bis(chloroethyl) ether
A75	BROMBNE	PPB	10	16	16	***			Bromoacetone
A76	METHBRD	PPB	10	16	16	***			Methyl bromide
A77	CARBIDE	PPB	10	16	16	***			Carbon disulfide
A78	CHLBENZ	PPB	10	16	16	***			Chlorobenzene
A79	CHLTHER	PPB	10	16	16	***			2-chloroethyl vinyl ether
A81	METHCHL	PPB	10	16	16	***			Methyl chloride
A82	CHMTHER	PPB	10	16	16	***			Chloromethyl methyl ether
A83	CROTONA	PPB	10	16	16	***			Crotonaldehyde
A84	DIBRCHL	PPB	10	16	16	***			1,2-dibromo-3-chloropropane
A86	DIBRETH	PPB	10	16	16	***			1,2-dibromoethane
A86	DIBRMET	PPB	10	16	16	***			Dibromomethane
A87	DIBUTEN	PPB	10	16	16	***			1,4-dichloro-2-butene
A88	DICDIFM	PPB	10	16	16	***			Dichlorodifluoromethane
A89	1,1-DIC	PPB	10	16	16	***			1,1-dichloroethane
A90	1,2-DIC	PPB	10	16	16	***	5	EPAP	1,2-dichloroethane
A91	TRANDCE	PPB	10	16	16	***	70	EPAP	Trans-1,2-dichloroethene
A92	DICETHY	PPB	10	16	16	***	7	EPAP	1,1-dichloroethylene
A94	DICPANE	PPB	10	16	16	***	0	EPAP	1,2-dichloropropane
A95	DICPENE	PPB	10	16	16	***			1,3-dichloropropene
A96	NNDIEHY	PPB	10	16	16	***			N,N-diethylhydrazine
A97	1,1-DIM	PPB	3000	16	16	***			1,1-dimethylhydrazine
A98	1,2-DIM	PPB	3000	16	16	***			1,2-dimethylhydrazine
A99	HYDRSUL	PPB	10	16	16	***			Hydrogen sulfide
B01	IODOMET	PPB	10	16	16	***			Iodomethane
B02	METHACR	PPB	10	16	16	***			Methacrylonitrile

Constituent List=WAC 173-303-9905

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REQAGEN	FULLNAME
B03	METHTHI	PPB	10	16	16	***	.		Methanethiol
B04	PENTACH	PPB	10	16	16	***	.		Pentachloroethane
B05	1112-tc	PPB	10	16	16	***	.		1,1,1,2-tetrachloroethane
B06	1122-tc	PPB	10	16	16	***	.		1,1,2,2-tetrachloroethane
B08	BROMOFM	PPB	10	16	16	***	.		Bromoform
B09	TRCMEOL	PPB	10	16	16	***	.		Trichloromethanethiol
B10	TRCMFLM	PPB	10	16	16	***	.		Trichloromonofluoromethane
B11	TRCPANE	PPB	10	16	16	***	.		Trichloropropane
B12	123-trp	PPB	10	16	16	***	.		1,2,3-trichloropropane
B13	VINYIDE	PPB	10	16	16	***	1	EPAP	Vinyl chloride
B15	DIETHY	PPB	10	16	16	***	.		Diethylarsine
B19	ACETILE	PPB	10	16	16	***	.		Acetonitrile
B20	ACETONE	PPB	10	16	16	***	.		Acetophenone
B21	WARFRIN	PPB	10	16	16	***	.		Warfarin
B22	ACEFENE	PPB	10	16	16	***	.		2-acetylaminofluorene
B23	AMINOYL	PPB	10	16	16	***	.		4-aminobyphenyl
B24	AMIISOX	PPB	10	16	16	***	.		5-(aminomethyl)-3-isoxazolol
B26	AMITROL	PPB	10	16	16	***	.		Amitrole
B26	ANILINE	PPB	10	16	16	***	.		Aniline
B27	ARAMITE	PPB	10	16	16	***	.		Aramite
B28	AURAMIN	PPB	10	16	16	***	.		Auramine
B29	BENZCAC	PPB	10	16	16	***	.		Benz[c]acridine
B30	BENZAAN	PPB	10	16	16	***	.		Benz[a]anthracene
B31	BENDICM	PPB	10	16	16	***	.		Benzene, dichloromethyl
B32	BENTHOL	PPB	10	16	16	***	.		Benzenethiol
B33	BENDINE	PPB	10	16	16	***	.		Benzidine
B34	BENZBFL	PPB	10	16	16	***	.		Benzo[b]fluoranthene
B35	BENZJFL	PPB	10	16	16	***	.		Benzo[j]fluoranthene
B36	PBENZQU	PPB	10	16	16	***	.		P benzoquinone
B37	BENZCHL	PPB	10	16	16	***	.		Benzyl chloride
B38	BIS2CHM	PPB	10	16	16	***	.		Bis(2-chloroethoxy) methane
B39	BIS2CHE	PPB	10	16	16	***	.		Bis(2-chloroethyl) ether
B40	BIS2EPH	PPB	10	20	16		.		Bis(2-ethylhexyl) phthalate
B41	BROPHEN	PPB	10	16	16	***	.		4-bromophenyl phenyl ether
B42	BUTBENP	PPB	10	16	16	***	.		Butyl benzyl phthalate
B43	BUTDINP	PPB	10	16	16	***	.		2-sec-butyl-4,6-dinitrophenol
B44	CHALETH	PPB	10	16	16	***	.		Chloroalkyl ethers
B46	CHLANIL	PPB	10	16	16	***	.		P-chloroaniline
B46	CHLCRES	PPB	10	16	16	***	.		P-chloro-m-cresol
B47	CHLEPOX	PPB	10	16	16	***	.		1-chloro-2,3-epoxypropane
B48	CHLNAPH	PPB	10	16	16	***	.		2-chloronaphthalene
B49	CHLPHEN	PPB	10	16	16	***	.		2-chlorophenol
B50	CHRYSEN	PPB	10	16	16	***	.		Chrysene
B51	CRESOLS	PPB	10	16	16	***	.		Cresols
B52	CYCHDIN	PPB	10	16	16	***	.		2-cyclohexyl-4,6-dinitrophenol
B53	DIBAHAC	PPB	10	16	16	***	.		Dibenz[a,h]acridine
B54	DIBAJAC	PPB	10	16	16	***	.		Dibenz[a,j]acridine
B55	DIBAHAN	PPB	10	16	16	***	.		Dibenz[a,h]anthracene
B56	DIBCGCA	PPB	10	16	16	***	.		7H-dibenzo[c,g]carbazole
B57	DIBAEPY	PPB	10	16	16	***	.		Dibenzo[a,e]pyrene

Constituent List=WAC 173-303-9906

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGADEN	FULLNAME
B58	DIBAHPY	PPB	10	10	10	***		.	Dibenzo[a,h]pyrene
B59	DIBAIPY	PPB	10	10	10	***		.	Dibenzo[a,i]pyrene
B60	DIBPHTH	PPB	10	10	10	***		.	Di-n-butyl phthalate
B64	DICHBEN	PPB	10	10	10	***		.	3,3'-dichlorobenzidine
B65	24-dchp	PPB	10	10	10	***		.	2,4-dichlorophenol
B66	26-dchp	PPB	10	10	10	***		.	2,6-dichlorophenol
B67	DIEPHTH	PPB	10	10	10	***		.	Diethyl phthalate
B68	DIHYSAF	PPB	10	10	10	***		.	Dihydrosafrole
B69	DIMETHB	PPB	10	10	10	***		.	3,3'-dimethoxybenzidine
B70	DIMEAMB	PPB	10	10	10	***		.	P-dimethylaminoazobenzene
B71	DIMBENZ	PPB	10	10	10	***		.	7,12-dimethylbenz[a]anthracene
B72	DIMEYLB	PPB	10	10	10	***		.	3,3'-dimethylbenzidine
B73	THIANBX	PPB	10	10	10	***		.	Thiofanox
B74	DIMPHAM	PPB	10	10	10	***		.	Alpha,alpha-dimethylphenethylamine
B76	DIMPHEN	PPB	10	10	10	***		.	2,4-dimethylphenol
B78	DIMPHTH	PPB	10	10	10	***		.	Dimethyl phthalate
B77	DINBENZ	PPB	10	10	10	***		.	Dinitrobenzene
B78	DINCRES	PPB	10	10	10	***		.	4,6-dinitro-o-cresol and salts
B79	DINPHEN	PPB	10	10	10	***		.	2,4-dinitrophenol
B80	24-dint	PPB	10	10	10	***		.	2,4-dinitrotoluene
B81	26-dint	PPB	10	10	10	***		.	2,6-dinitrotoluene
B82	DIOPHTH	PPB	10	10	10	***		.	Di-n-octyl phthalate
B83	DIPHAMI	PPB	10	10	10	***		.	Diphenylamine
B84	DIPHHYD	PPB	10	10	10	***		.	1,2-diphenylhydrazine
B86	DIPRNIT	PPB	10	10	10	***		.	Di-n-propylnitrosamine
B88	ETHMINE	PPB	10	10	10	***		.	Ethyleneimine
B87	ETHMETH	PPB	10	10	10	***		.	Ethyl methanesulfonate
B88	FLUORAN	PPB	10	10	10	***		.	Fluoranthene
B90	HEXCBUT	PPB	10	10	10	***		.	Hexachlorobutadiene
B91	HEXCCYC	PPB	10	10	10	***		.	Hexachlorocyclopentadiene
B92	HEXCETH	PPB	10	10	10	***		.	Hexachloroethane
B93	INDENOP	PPB	10	10	10	***		.	Indeno(1,2,3-cd)pyrene
B94	ISOSOLE	PPB	10	10	10	***		.	Isosafrole
B95	MALOILE	PPB	10	10	10	***		.	Malononitrile
B96	MELPHAL	PPB	10	10	10	***		.	Melphalan
B97	METHAPY	PPB	10	10	10	***		.	Methapyrilene
B98	METHNYL	PPB	10	10	10	***		.	Methelonyl
B99	METAZIR	PPB	10	10	10	***		.	2-methylaziridine
C01	METCHAN	PPB	10	10	10	***		.	3-methylcholanthrene
C02	METBISC	PPB	10	10	10	***		.	4,4'-methylenebis(2-chloroaniline)
C03	METACTN	PPB	10	10	10	***		.	2-methyllactonitrile
C04	METACRY	PPB	10	10	10	***		.	Methyl methacrylate
C06	METMSUL	PPB	10	10	10	***		.	Methyl methanesulfonate
C08	METPROP	PPB	10	10	10	***		.	2-methyl-2-(methylthio) propionaldehyde-o-
C07	METHIOU	PPB	10	10	10	***		.	Methylthiouracil
C08	NAPHQUI	PPB	10	10	10	***		.	1,4-naphthaquinone
C09	1-napha	PPB	10	10	10	***		.	1-naphthylamine
C10	2-napha	PPB	10	10	10	***		.	2-naphthylamine
C11	NITRANI	PPB	10	10	10	***		.	P-nitroaniline
C12	NITBENZ	PPB	10	10	10	***		.	Nitrobenzine

Constituent List=WAC 173-303-9906

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REQAGEN	FULLNAME
C13	NITPHEN	PPB	10	16	16	***			4-nitrophenol
C14	NNIBUTY	PPB	10	16	16	***			N-nitrosodi-n-butylamine
C15	NNIDIEA	PPB	10	16	16	***			N-nitrosodiethanolamine
C16	NNIDIET	PPB	10	16	16	***			N-nitrosodiethylamine
C17	NNIDIME	PPB	10	16	16	***			N-nitrosodimethylamine
C18	NNIMETH	PPB	10	16	16	***			N-nitrosomethylethylamine
C19	NNIURET	PPB	10	16	16	***			N-nitroso-N-methylurethane
C20	NNIVINY	PPB	10	16	16	***			N-nitrosomethylvinylamine
C21	NNIMORP	PPB	10	16	16	***			N-nitrosomorpholine
C22	NNINICO	PPB	10	16	16	***			N-nitrosonornicotine
C23	NNIPIPE	PPB	10	16	16	***			N-nitrosopiperidine
C24	NITRPYR	PPB	10	16	16	***			Nitrosopyrrolidine
C25	NITRTOL	PPB	10	16	16	***			5-nitro-o-toluidine
C27	PENTCHN	PPB	10	16	16	***			Pentachloronitrobenzene
C28	PENTCHP	PPB	10	16	16	***	220	EPAP	Pentachlorophenol
C29	PHENTIN	PPB	10	16	16	***	220	EPAP	Phenacetin
C30	PHENINE	PPB	10	16	16	***			Phenylenediamine
C31	PHTHEST	PPB	10	16	16	***			Phthalic acid esters
C32	PICOLIN	PPB	10	16	16	***			2-picoline
C33	PRONIDE	PPB	10	16	16	***			Pronamide
C34	RESERPI	PPB	10	16	16	***			Reserpine
C35	RESORCI	PPB	10	16	16	***			Resorcinol
C36	SAFROL	PPB	10	16	16	***			Safrol
C39	TETRCHP	PPB	10	16	16	***			2,3,4,6-tetrachlorophenol
C40	THIURAM	PPB	10	16	16	***			Thiuram
C41	TOLUDIA	PPB	10	16	16	***			Toluenediamine
C42	OTOLHYD	PPB	10	16	16	***			O-toluidine hydrochloride
C44	245-trp	PPB	10	16	16	***			2,4,5-trichlorophenol
C45	246-trp	PPB	10	16	16	***			2,4,6-trichlorophenol
C46	TRIPHOS	PPB	10	16	16	***			O,O,O-triethyl phosphorothioate
C47	SYMTRIN	PPB	10	16	16	***			Sym-trinitrobenzene
C48	TRIPHOS	PPB	10	16	16	***			Tris(2,3-dibromopropyl) phosphate
C49	BENZOPY	PPB	10	16	16	***			Benzo[a]pyrene
C50	CHLNAPH	PPB	10	16	16	***			Chlornaphazine
C51	BIS2ETH	PPB	10	16	16	***			Bis(2-chloroisopropyl)ether
C53	HYDRAZI	PPB	3000	16	16	***			Hydrazine
C61	TETEPYR	PPB	2	16	16	***			Tetraethylpyrophosphate
C63	CARBPHT	PPB	2	16	16	***			Carbophenothion
C64	DISULFO	PPB	2	16	16	***			Disulfoton
C65	DIMETHO	PPB	5	16	16	***			Dimethoate
C66	METHPAR	PPB	2	16	16	***			Methyl parathion
C67	PARATHI	PPB	2	16	16	***			Parathion
C87	CITRUSR	PPB	1000	16	16	***			Citrus red
C88	CYANBRB	PPB	3000	16	16	***			Cyanogen bromide
C89	CYANCHL	PPB	3000	16	16	***			Cyanogen chloride
C90	PARALDE	PPB	3000	16	16	***			Paraldegyde
C94	ACRYIDE	PPB	3000	16	16	***	0	EPAP	Acrylamide
C95	ALLYLAL	PPB	3000	16	16	***			Allyl alcohol
C96	CHLORAL	PPB	3000	16	16	***			Chloral
C97	CHLACET	PPB	3000	16	16	***			Chloroacetaldehyde

Constituent List=WAC 173-303-9905

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
C98	CHLPRBP	PPB	3000	18	18	***	.		3-chloropropionitrile
C99	CYANOGN	PPB	3000	18	18	***	.		Cyanogen
H01	DICPROP	PPB	3000	18	18	***	.		*Dichloropropanol*
H03	ETHCARB	PPB	3000	18	18	***	.		Ethyl carbamate
H04	ETHCYAN	PPB	3000	18	18	***	.		Ethyl cyanide
H05	ETHOXID	PPB	3000	18	18	***	.		Ethylene oxide
H06	ETHMETH	PPB	3000	18	18	***	.		Ethyl methacrylate
H07	FLUOROA	PPB	3000	18	18	***	.		*Fluoroacetic acid*
H08	GLYCIDY	PPB	3000	18	18	***	.		Glycidylaldehyde
H09	ISOBUTY	PPB	3000	18	18	***	.		Isobutyl alcohol
H10	METZINE	PPB	3000	18	18	***	.		Methyl hydrazine
H11	PROPYLA	PPB	3000	18	18	***	.		N-propylamine
H12	PROPYNO	PPB	3000	18	18	***	.		2-propyn-1-ol
H16	2,4,5-T	PPB	1	14	14	***	.		2,4,5-T
I01	ACETONE	PPB	.	2	0		.		
I02	HEXANE	PPB	0	2	0		.		
I03	MECYPEN	PPB	0	1	0		.		
I04	MEBUPHT	PPB	0	1	0		.		
I26	TAF	PPB	0	2	0		.		
I83	BHT	PPB	.	1	0		.		
I99	UNKNOWN	PPB	0	4	0		.		

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APPENDIX B

ANALYTICAL DATA, MAY 1986 - JUNE 1988
(Taken from Schalla et al. 1988a, Table 7)

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Constituent List=Contamination Indicators

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
191	CONDUCT	UMHO	173	.	0	.	282	287	86.7	30.7	145	566
199	PH		172	.	0	.	7.03	7.1	0.648	9.2	3.9	8.3
C68	TOX	PPB	167	100	156	.	246	30.9	1010	410.0	2.3	9160
C69	TOC	PPB	167	1000	108	.	1100	933	938	86.0	1	8030

Constituent List=Drinking Water Standards

CONSTIT			SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
L09	COLIFRM	MPN	211	3	195	1	9.82	3	76.4	793.6	0	1100
L11	BETA	PCI/L	210	8	4	50	14.7	12	9.16	62.4	0.719	68
181	RADIUM	PCI/L	210	1	198	5	0.0888	0.0462	0.129	192.4	-0.121	0.876
212	LOALPHA	PCI/L	210	4	3	15	15.8	13.9	11.5	73.8	1.31	67.1
A06	BARIUM	PPB	216	8	17	1000	40 8	33 5	54 4	134.0	8	719
A07	CADMIUM	PPB	216	2	201	10	2.13	2	0.616	29.0	2	7
A08	CHROMUM	PPB	216	10	200	50	11.7	10	17	146.6	10	257
A10	SILVER	PPB	216	10	216	50	10	10	0.612	6.1	10	19
A20	ARSENIC	PPB	216	5	199	50	5.26	5	1.56	29.5	5	23
A21	MERCURY	PPB	216	0.1	197	2	0.627	0.1	1.8	287.3	0.1	9.9
A22	SELENUM	PPB	216	5	212	10	5.14	5	1.08	21.1	5	17
A61	LEADGF	PPB	216	5	192	50	5.69	5	4.66	79.0	5	48
C72	NITRATE	PPB	211	500	0	46000	18900	19000	5770	30.5	2900	38000
C74	FLUORID	PPB	211	500	133	1400	678	500	178	30.5	500	1070

Constituent List=Quality Characteristics

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A11	SODIUM	PPB	216	100	0	.	16300	14700	5100	33.4	1220	29800
A17	MANGESE	PPB	216	5	182	.	8.67	5	25.8	298.5	5	367
A19	IRON	PPB	216	50	66	.	268	61	1080	423.2	0	14900
C73	SULFATE	PPB	211	500	0	.	21700	18200	9770	45.1	6700	53600
C75	CHLORID	PPB	211	500	0	.	14400	11600	10800	75.4	880	72200

Constituent List=Site Specific

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A12	NICKEL	PPB	216	10	202	.	11	10	6.96	63.1	10	95
A13	COPPER	PPB	216	10	130	1300	22.2	10	39.6	178.8	10	516
A16	ALUMNUM	PPB	216	150	169	.	221	150	486	219.8	150	7060
A24	THIOURA	PPB	211	200	209		208	200	80.6	38.8	200	1090
A64	METHONE	PPB	216	10	215	.	9.98	10	0.436	4.4	3.7	11
A67	1,1,1-T	PPB	216	10	214	200	10.4	10	4.81	46.1	10	72
A68	1,1,2-T	PPB	216	10	214	.	10.1	10	1	10.0	10	23
A69	TRICENE	PPB	216	10	212	5	9.73	10	1.43	14.7	2.4	14
A70	PERCENE	PPB	216	10	195	.	10.4	10	4.73	46.5	2	55
C70	CYANIDE	PPB	211	10	208	.	10	10	0.514	5.1	10	14
C78	SULFIDE	PPB	211	1000	206	.	1020	1000	167	16.4	1000	3000
C80	AMMONIU	PPB	211	50	89	.	120	118	79.2	66.0	30	360

Constituent List=Tag-alongs

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A14	VANADUM	PPB	218	5	110	.	8.05	5	6.46	87.7	5	36
A18	POTASUM	PPB	218	100	3	.	3850	3630	1600	38.8	100	8810
A80	CHLFORM	PPB	118	10	24	.	18.3	15	8.02	49.1	4.1	42
A93	METHYCH	PPB	66	10	14	.	787	115	3380	428.9	3	27500
C76	PHOSPHA	PPB	211	1000	210	.	1010	1000	154	15.3	1000	3240

Constituent List=WAC 173-303-9905

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A04	ZINC	PPB	16	5	5	.	31.6	14	44.4	141.0	5	178
A05	CALCIUM	PPB	16	50	0	.	51900	29500	12700	39.8	17900	61700
A23	THALIUM	PPB	16	10	15	.	10	10	0	0.0	10	10
B40	BIS2EPH	PPB	20	10	16		14.9	10	12.3	82.5	10	50
I01	ACETONE	PPB	2	.	0	.	20	20	8.49	42.4	14	26
I02	HEXANE	PPB	2	0	0	.	60	60	0	0.0	60	60
I03	MECYPEN	PPB	1	0	0	.	16	16	.	.	16	16
I04	MEBUPHT	PPB	1	0	0	.	9	9	.	.	9	9
I20	TAF	PPB	2	0	0	.	61.5	61.5	41.7	67.8	32	91
I63	BHT	PPB	1	.	0	.	3.2	3.2	.	.	3.2	3.2
I99	UNKNOWN	PPB	4	0	0	.	17.8	13	11.7	65.9	10	36

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APPENDIX C

CONCENTRATION VS. TIME PLOTS FOR DETECTED CONSTITUENTS AND CONSTITUENTS EXCEEDING MCLs

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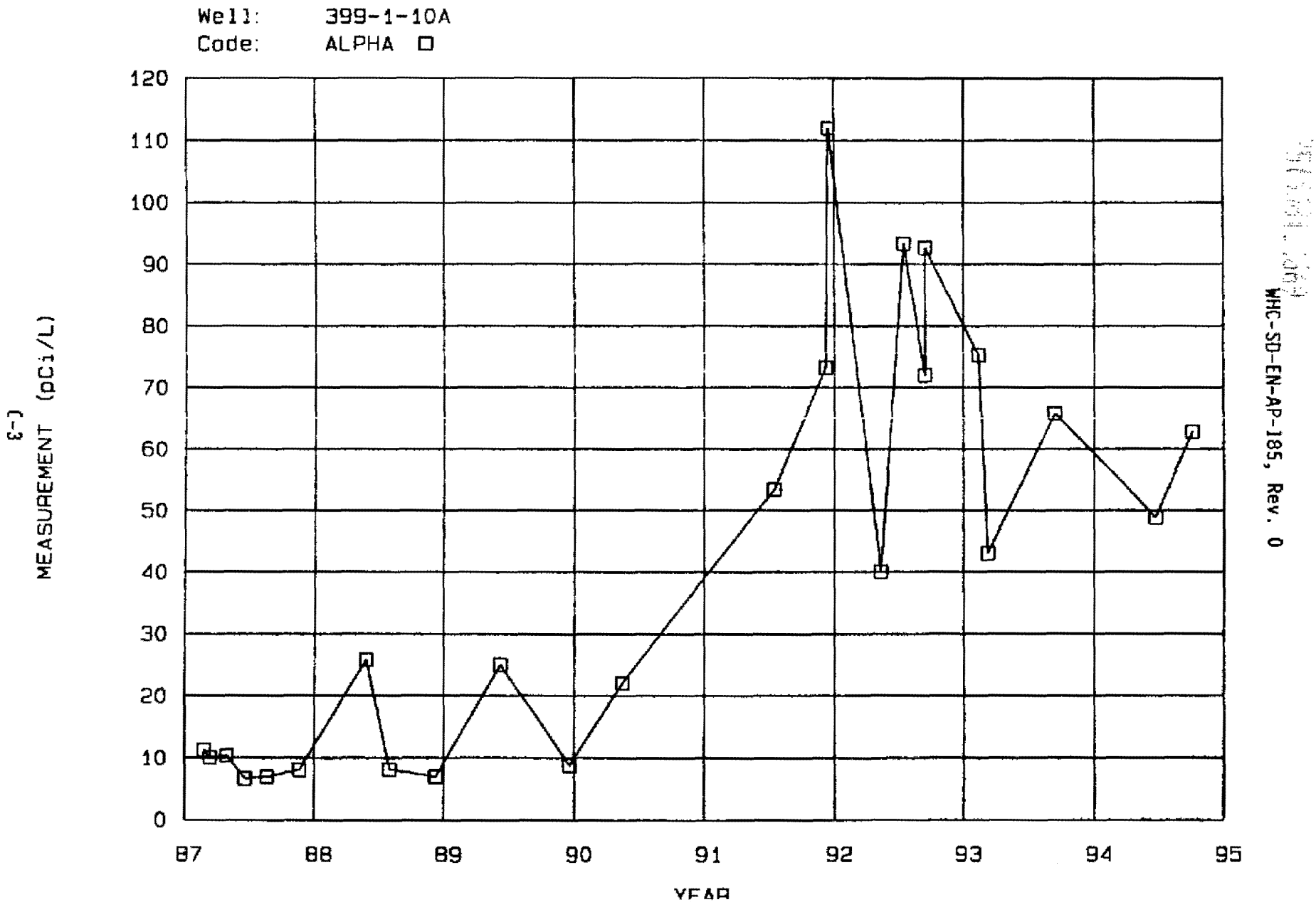
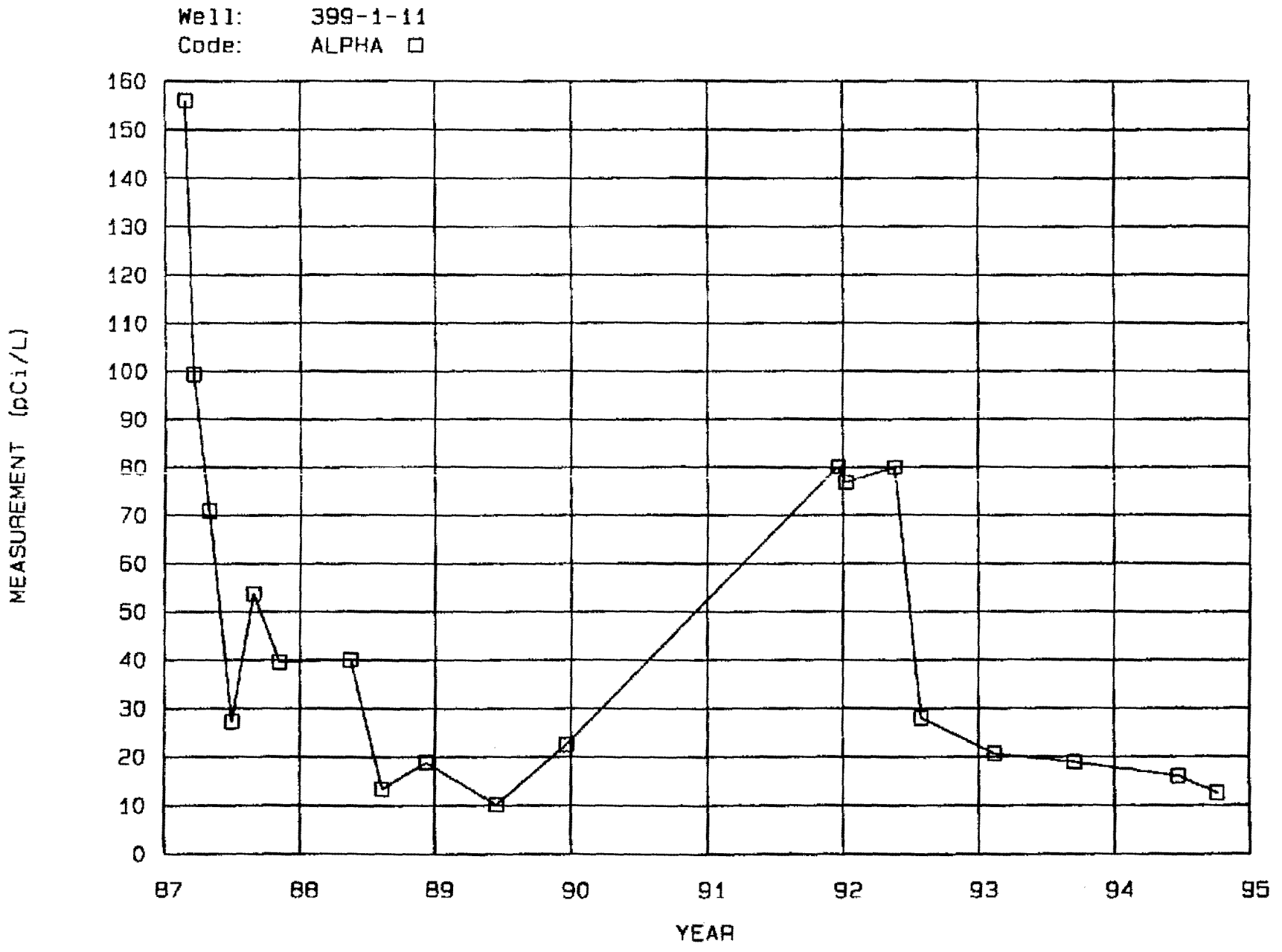
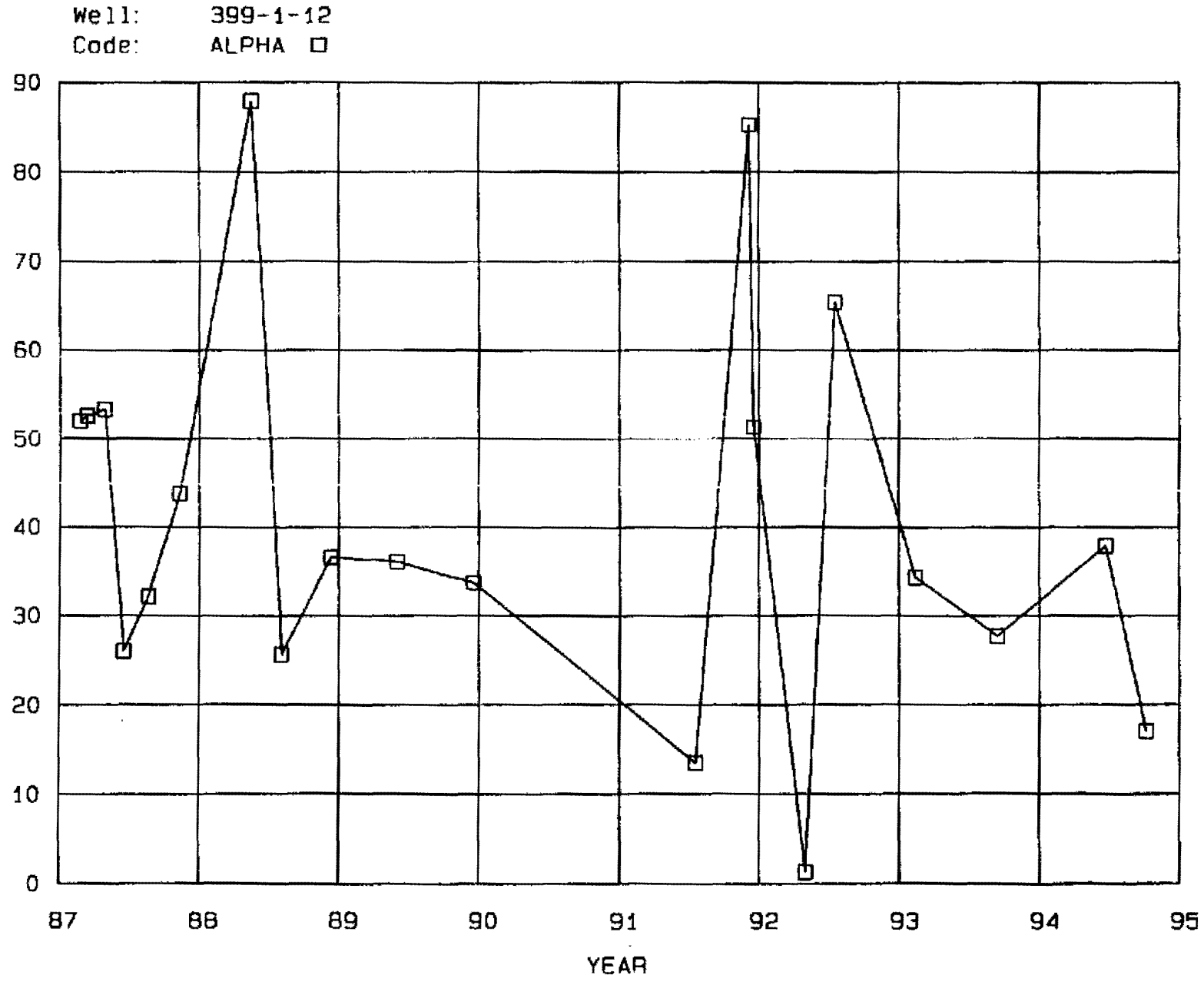
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



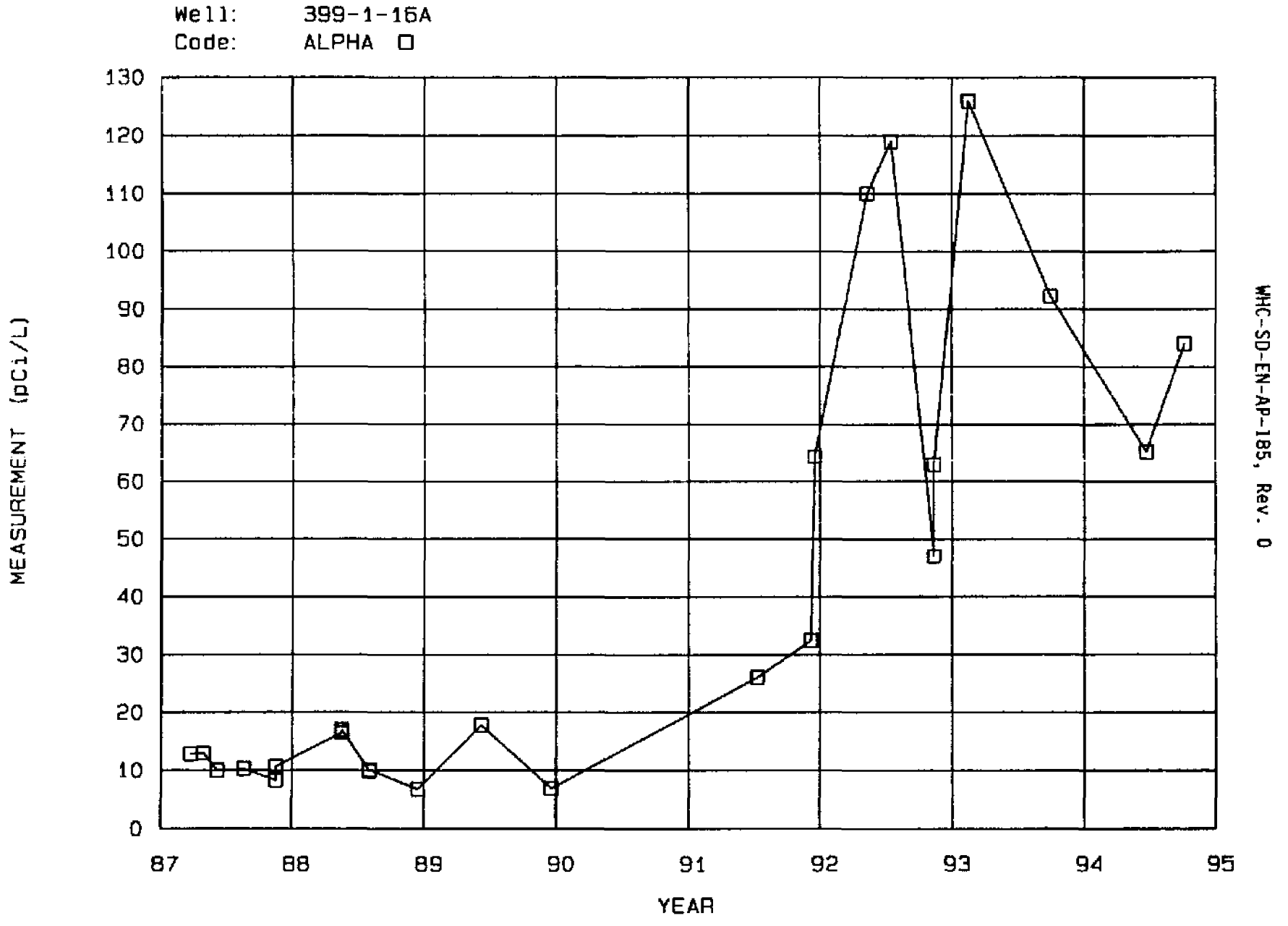
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



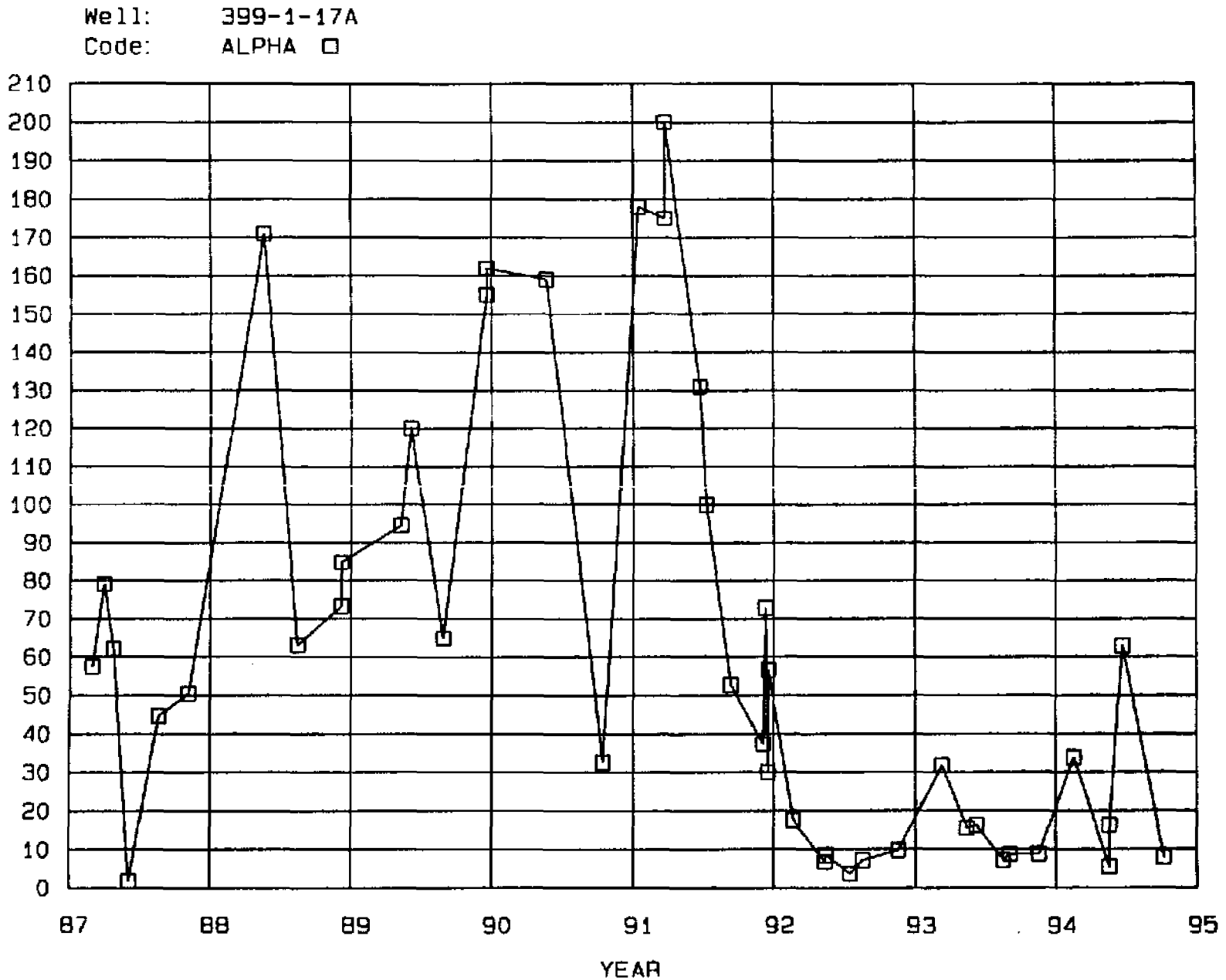
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



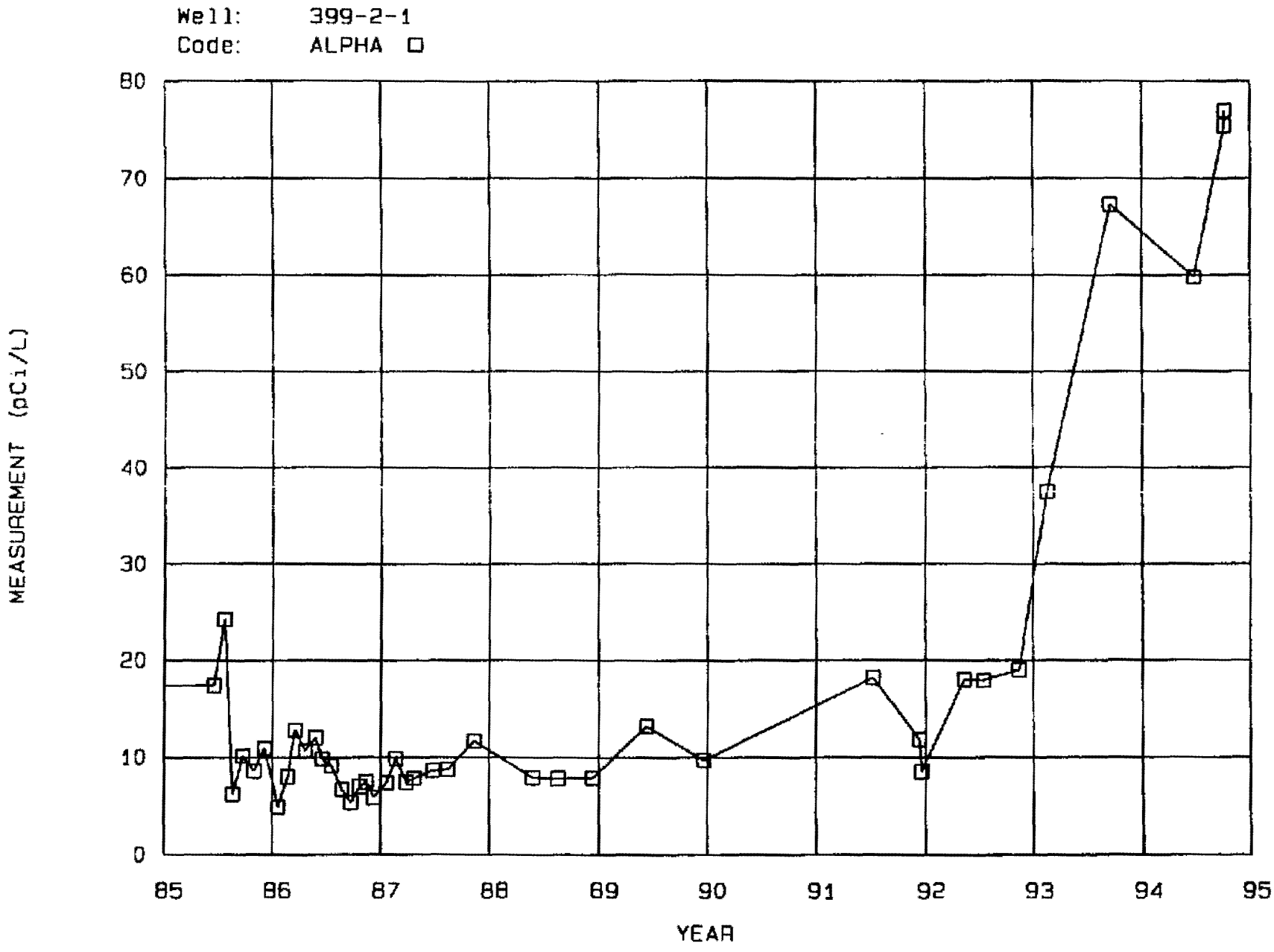
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



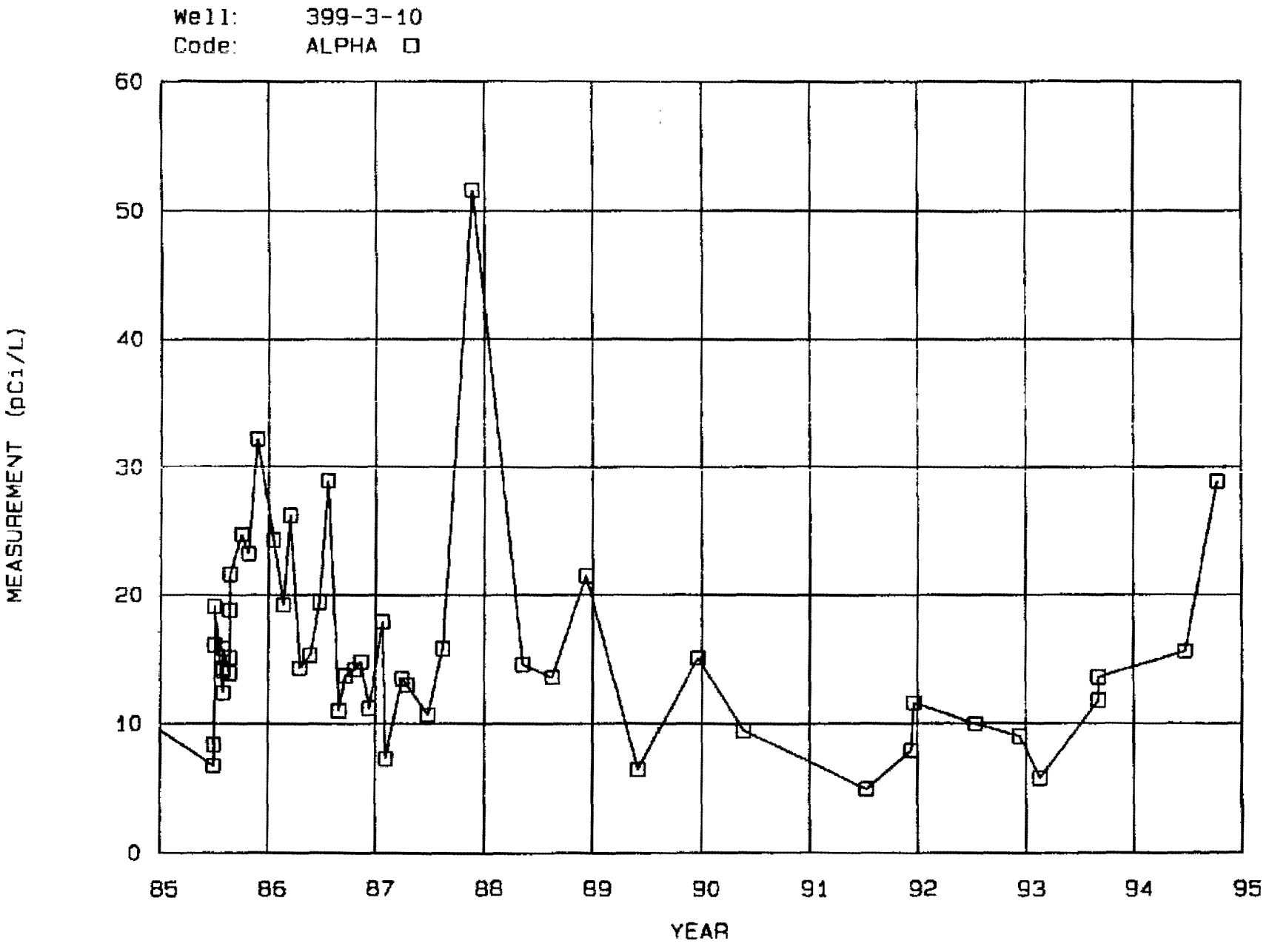
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



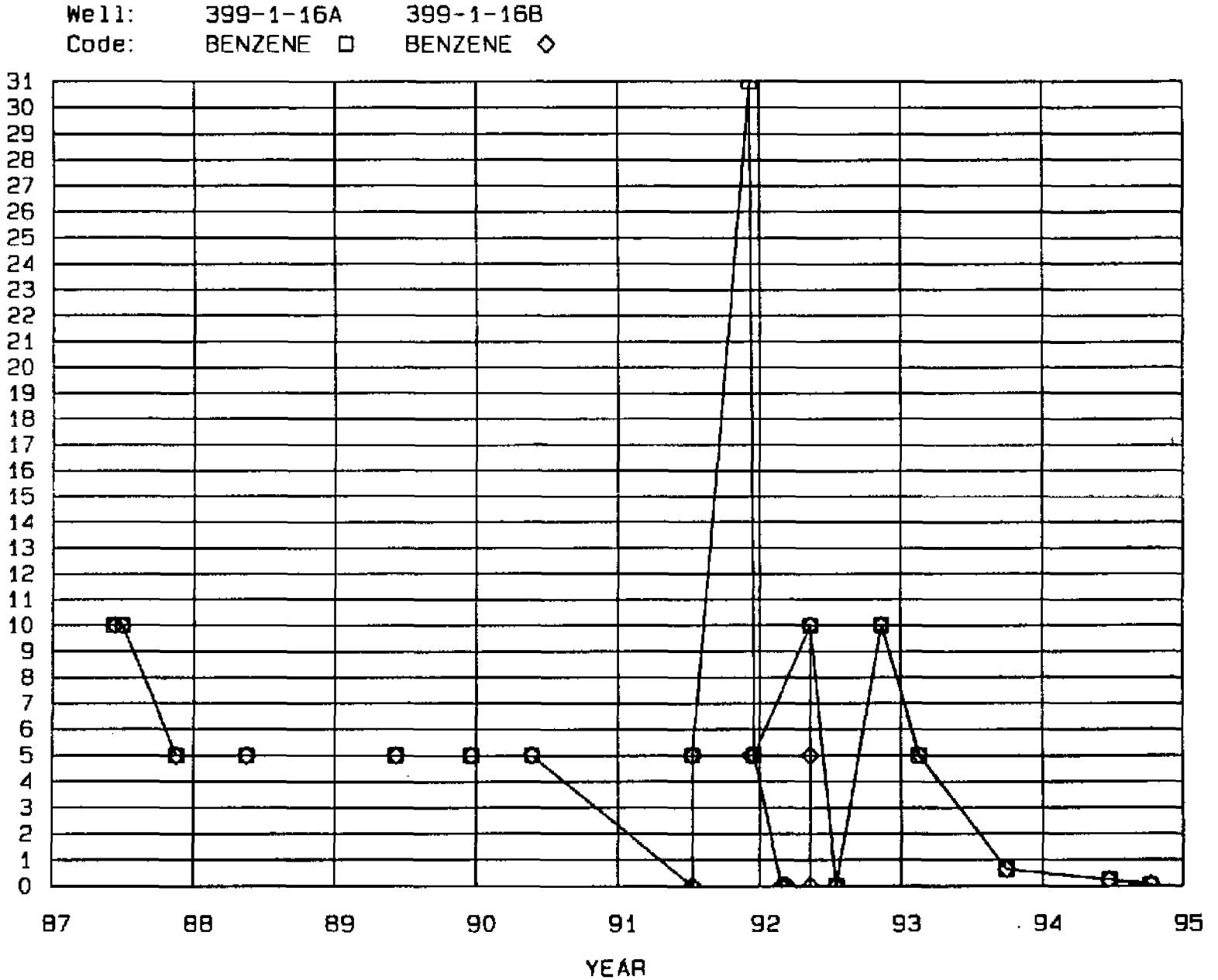
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



Gross Alpha w/U (MCL w/o U = 15 pCi/L)



Benzene (MCL = 5 ppb)



MEASUREMENT (ppb)

C-10

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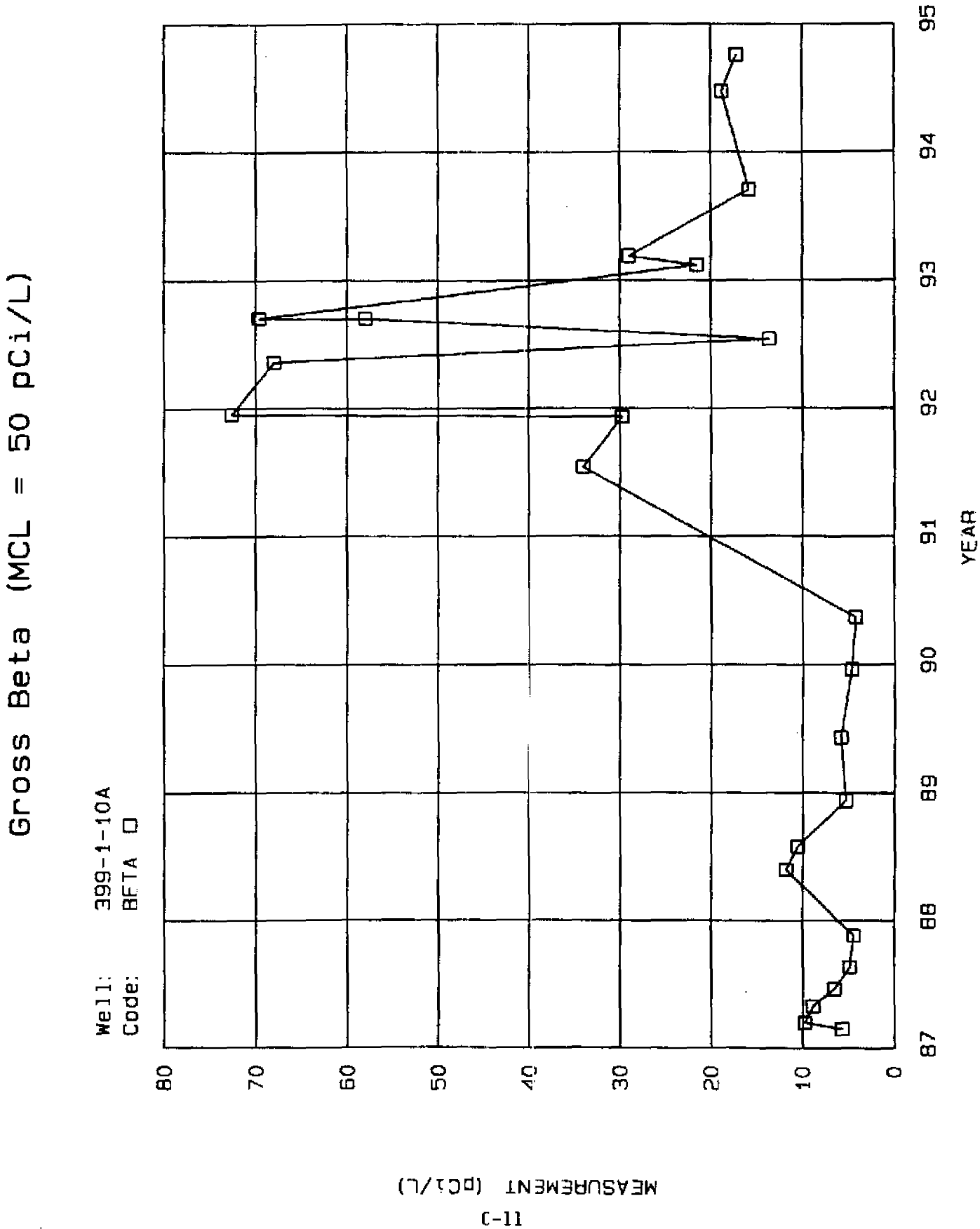
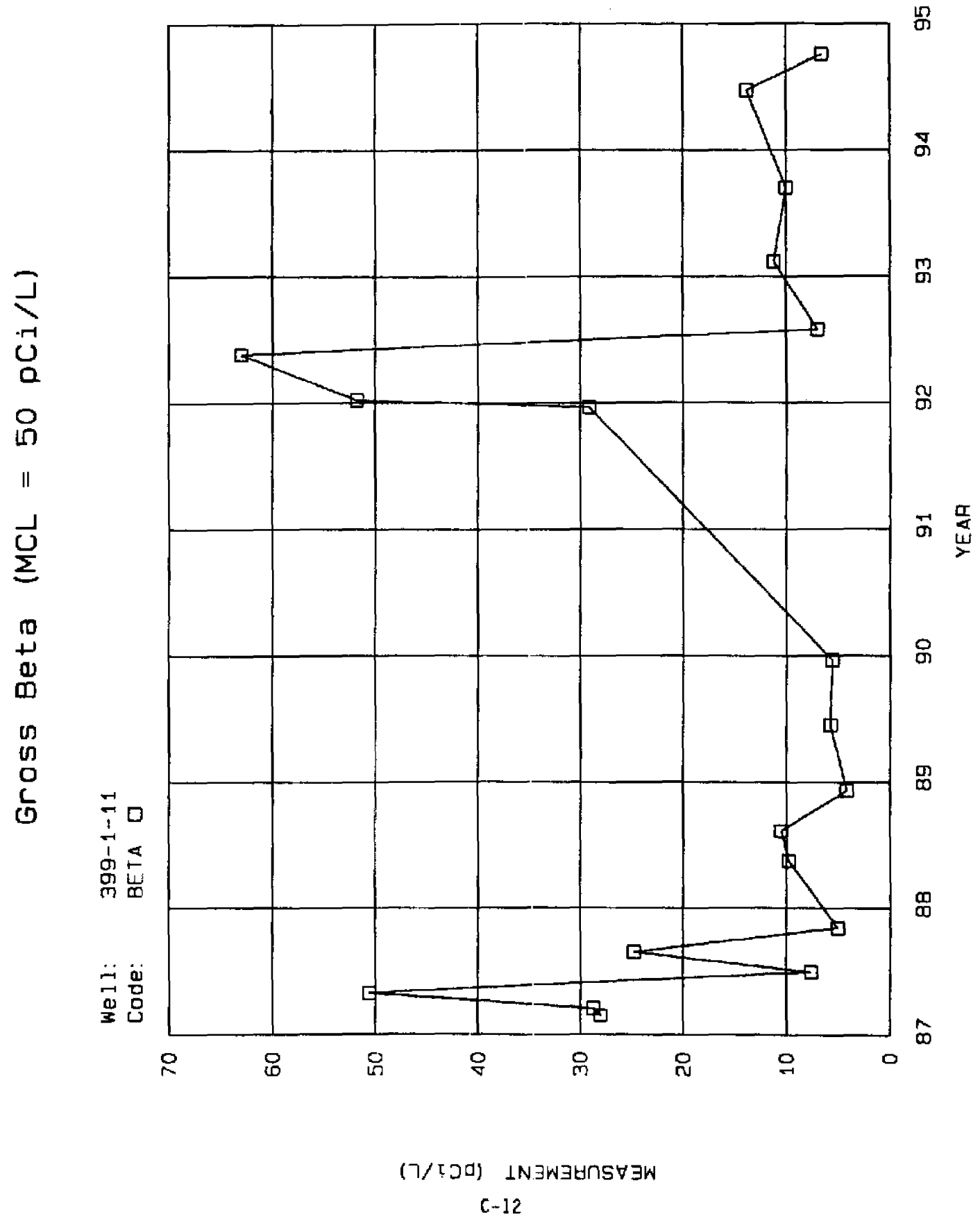
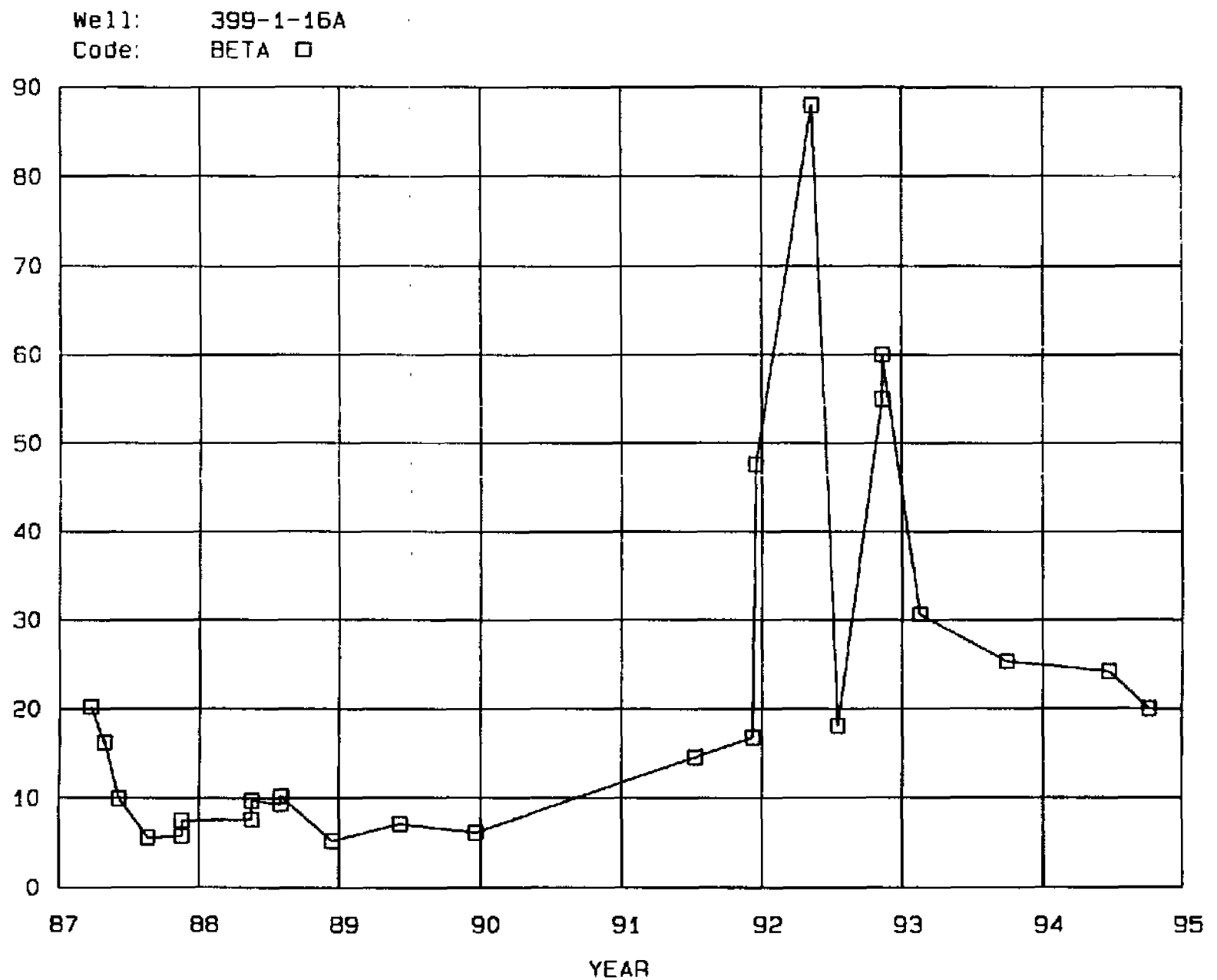
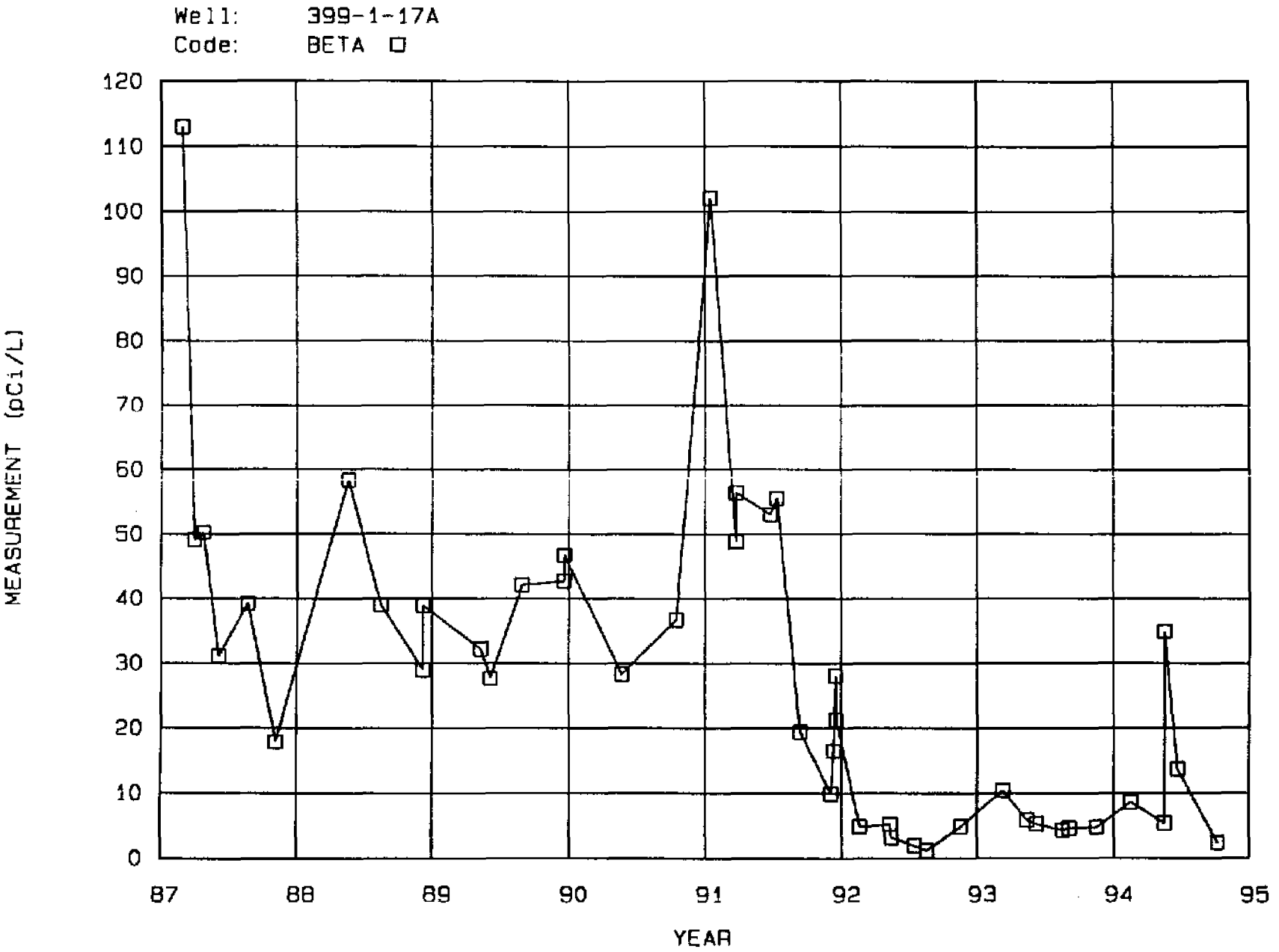

Gross Beta (MCL = 50 pCi/L)
Well: 399-1-10A
Code: BETA □
MEASUREMENT (pCi/L)
0
10
20
30
40
50
60
70
80
87
88
89
90
91
92
93
94
95
YEAR


Gross Beta (MCL = 50 pCi/L)
Well: 399-1-11
Code: BETA D
MEASUREMENT (pCi/L)
0
10
20
30
40
50
60
70
87
88
89
90
91
92
93
94
95
YEAR

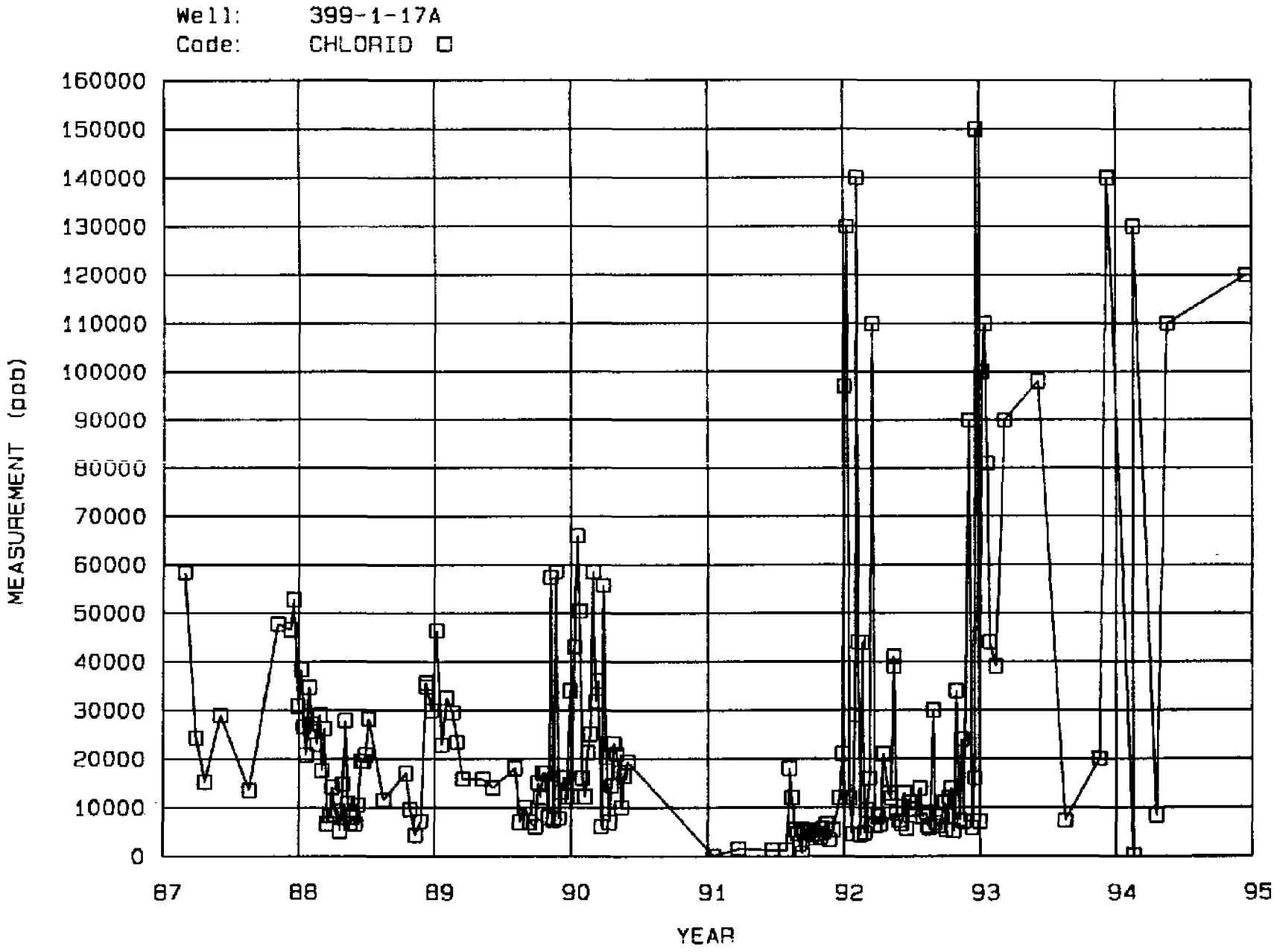
Gross Beta (MCL = 50 pCi/L)

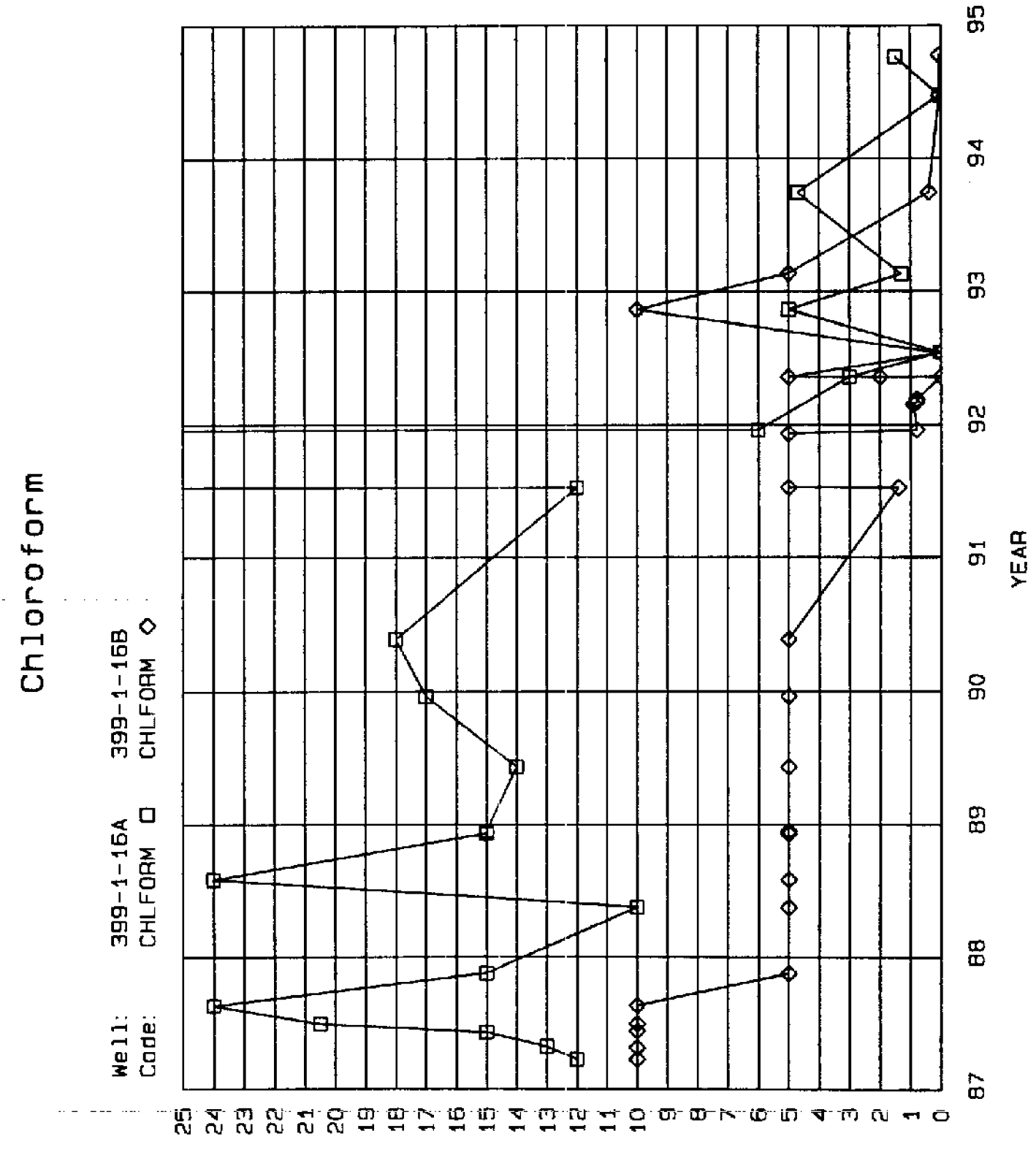


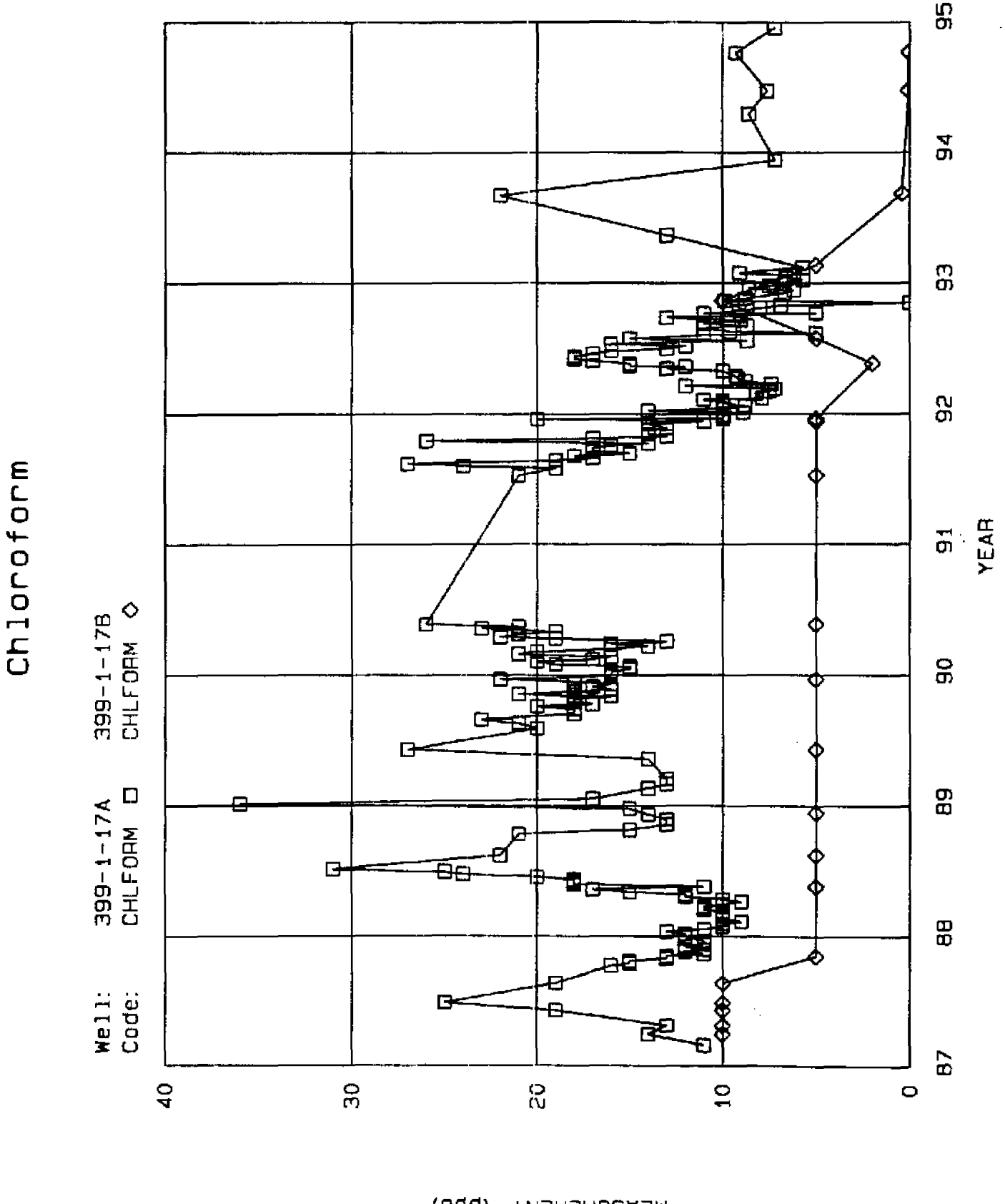
Gross Beta (MCL = 50 pCi/L)



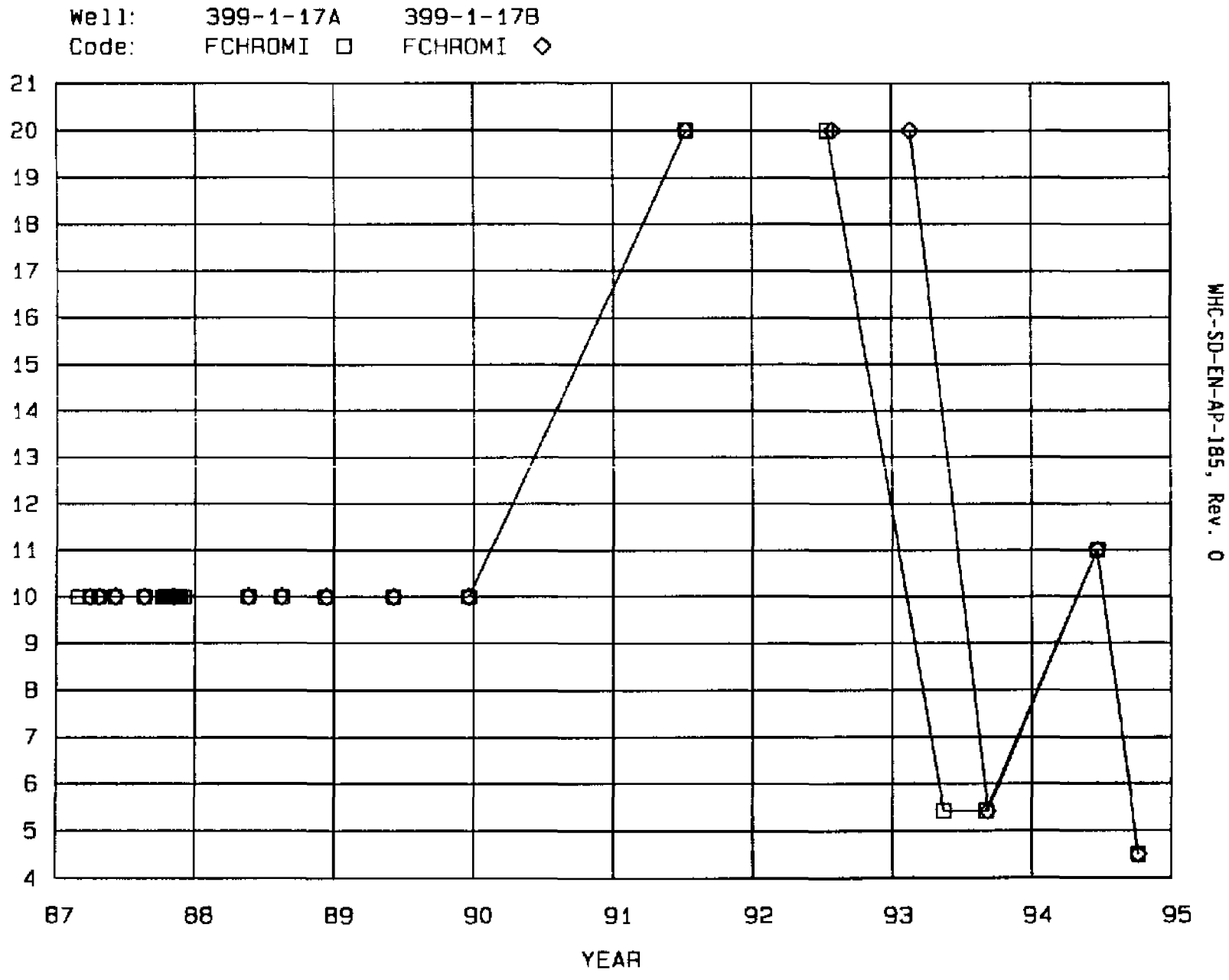
Chloride (MCL = 250000 ppb)

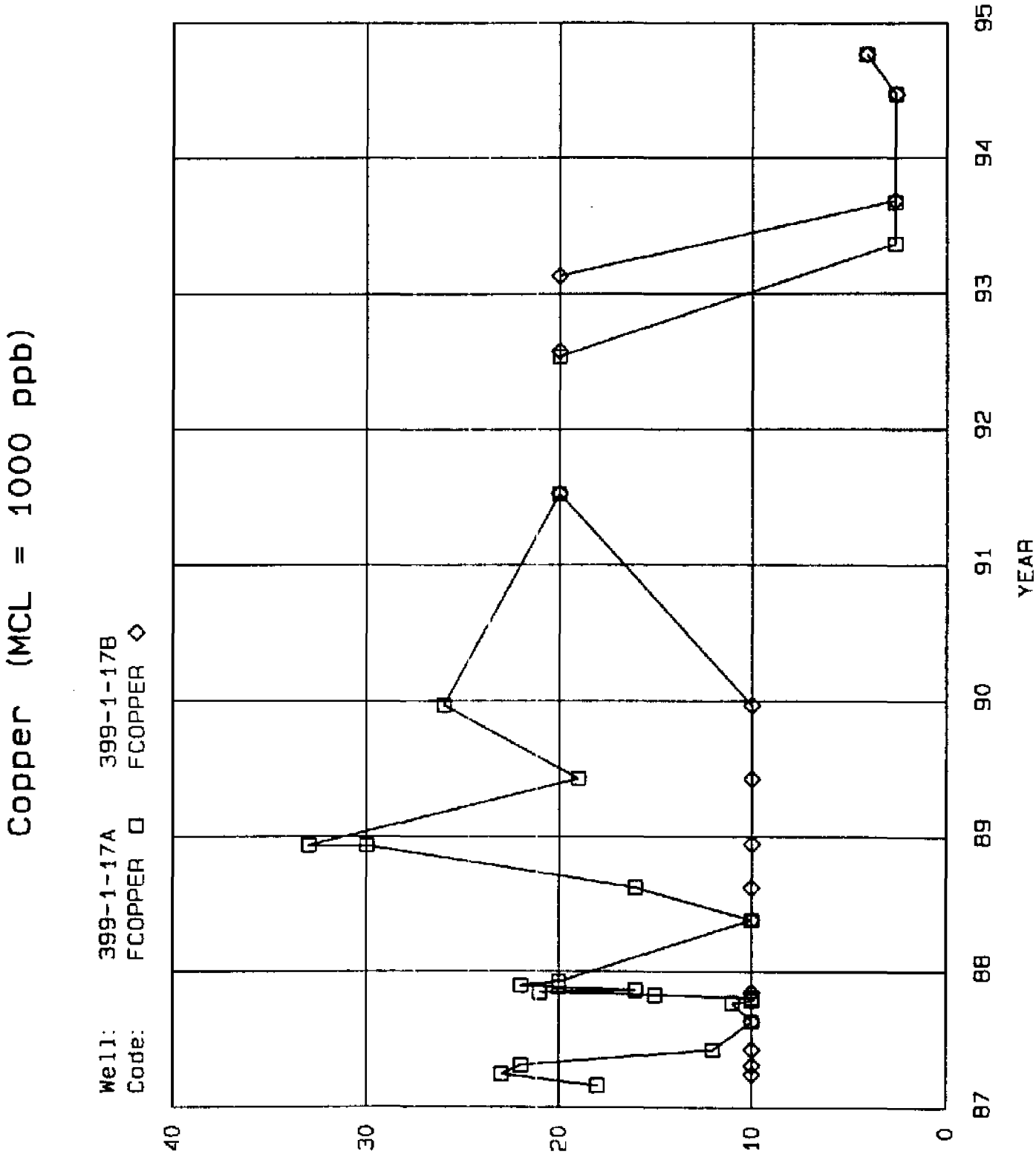



Chloroform
Well: 399-1-16A 399-1-16B
Code: CHLFORM □ CHLFORM ◇
MEASUREMENT (ppb)
YEAR
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
87 88 89 90 91 92 93 94 95

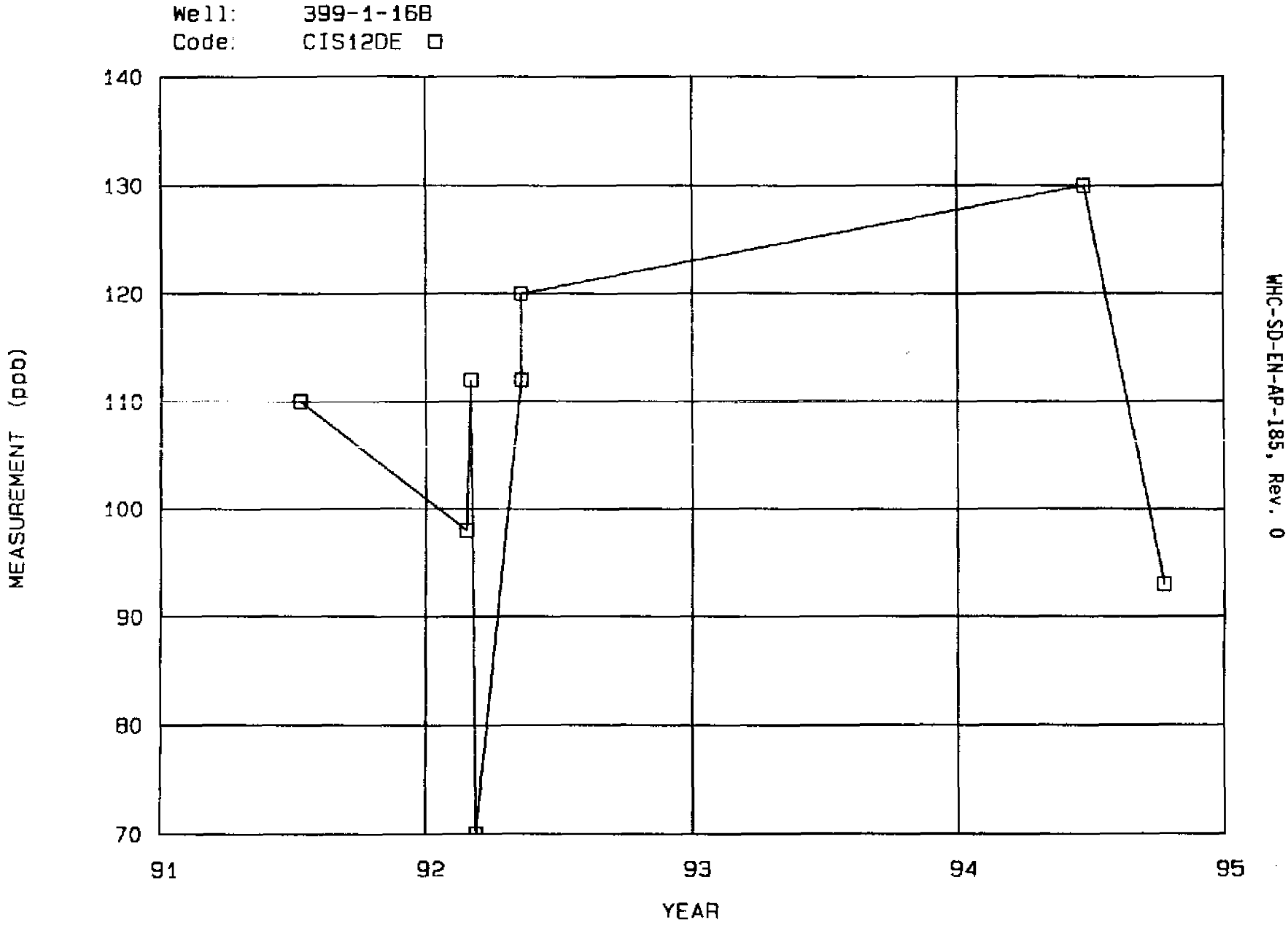

Chloroform
Well: 399-1-17A 399-1-17B
Code: CHLFORM □ CHLFORM ◇
MEASUREMENT (ppb)
0
10
20
30
40
YEAR
87
88
89
90
91
92
93
94
95

Chromium (MCL = 100 ppb)

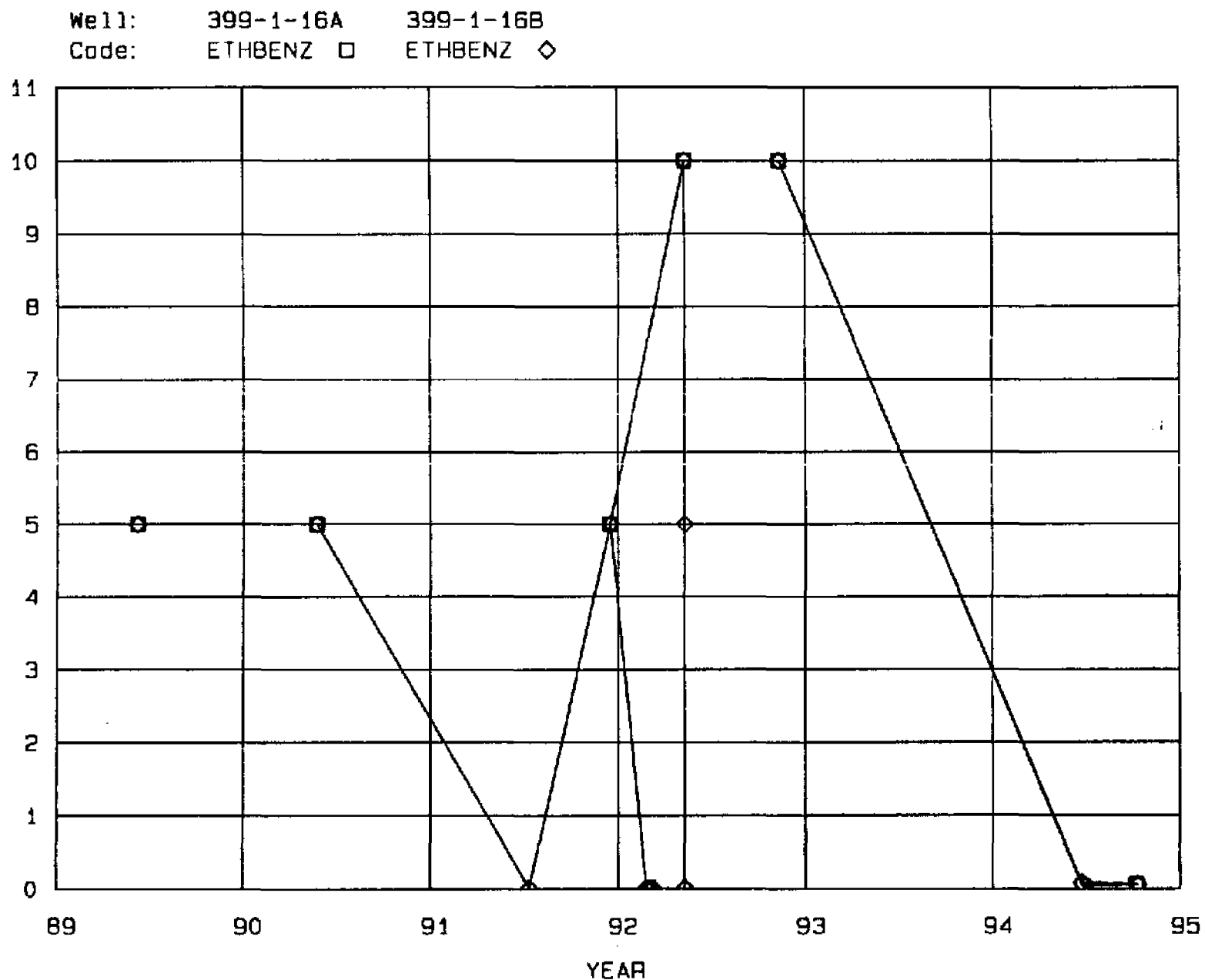


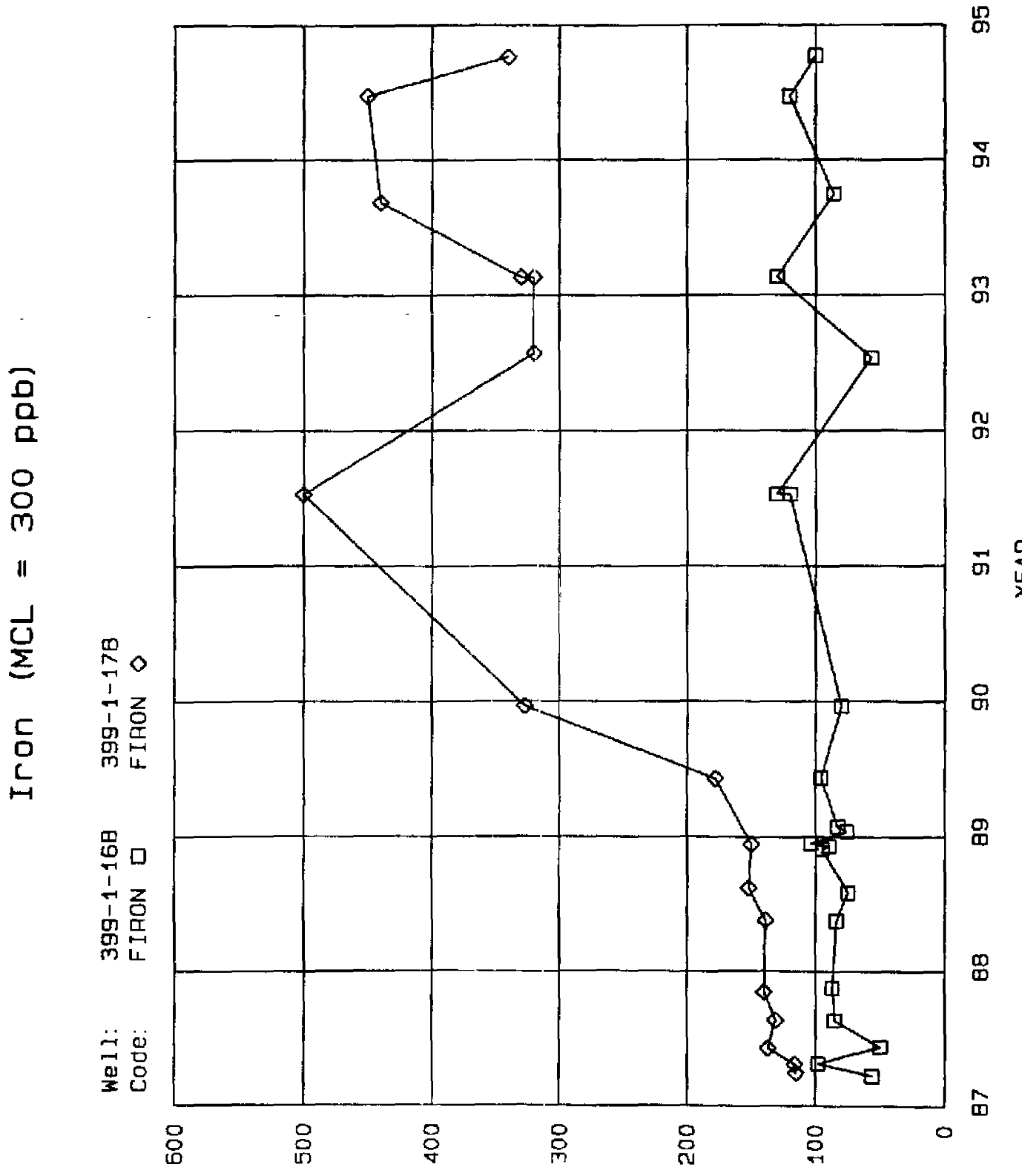

Copper (MCL = 1000 ppb)
Well: 399-1-17A 399-1-17B
Code: FCOPPER □ FCOPPER ◇
MEASUREMENT (ppb)
0
10
20
30
40
87
88
89
90
91
92
93
94
95
YEAR

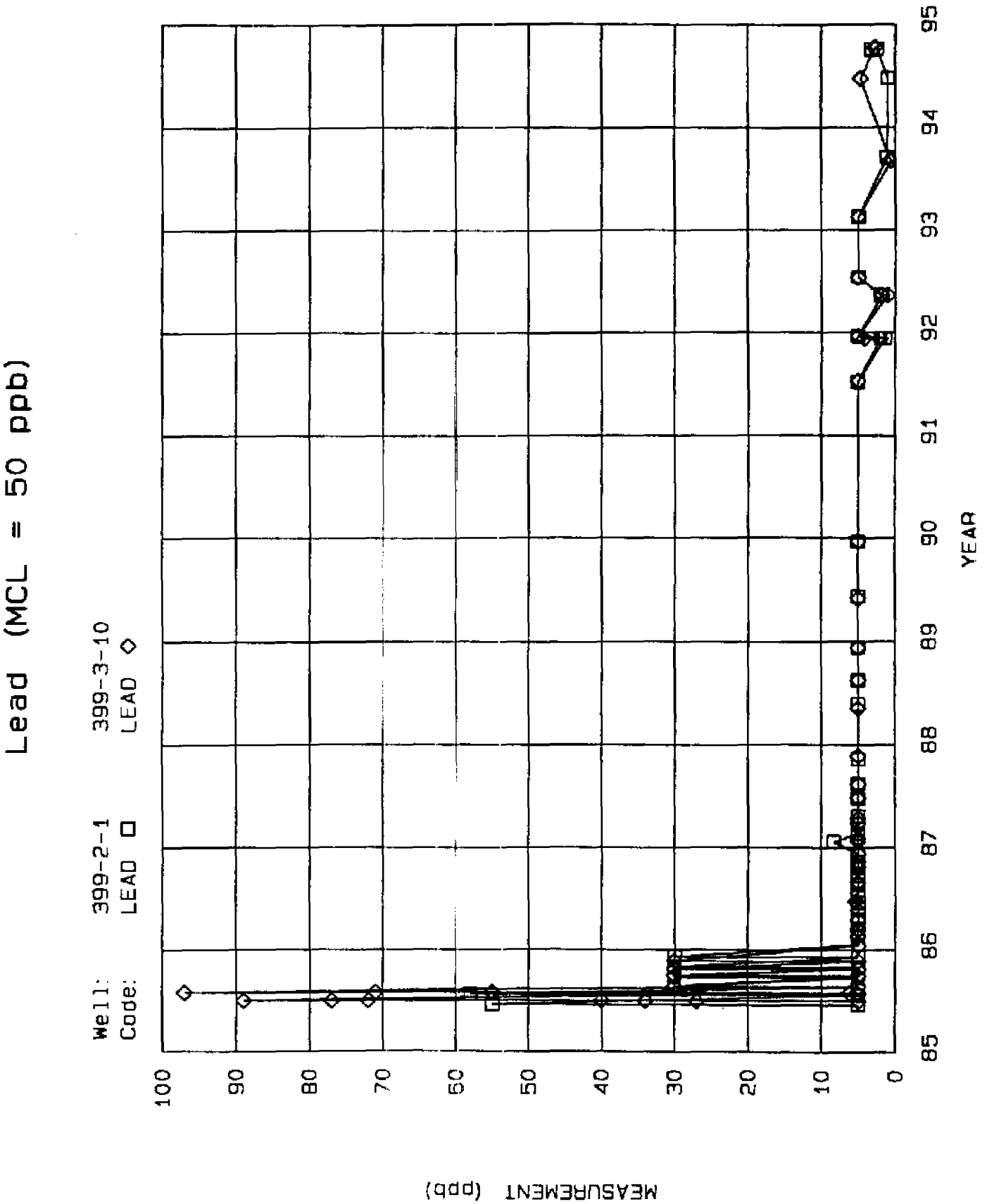
DCE Dichloroethylene (MCL = 70 ppb)



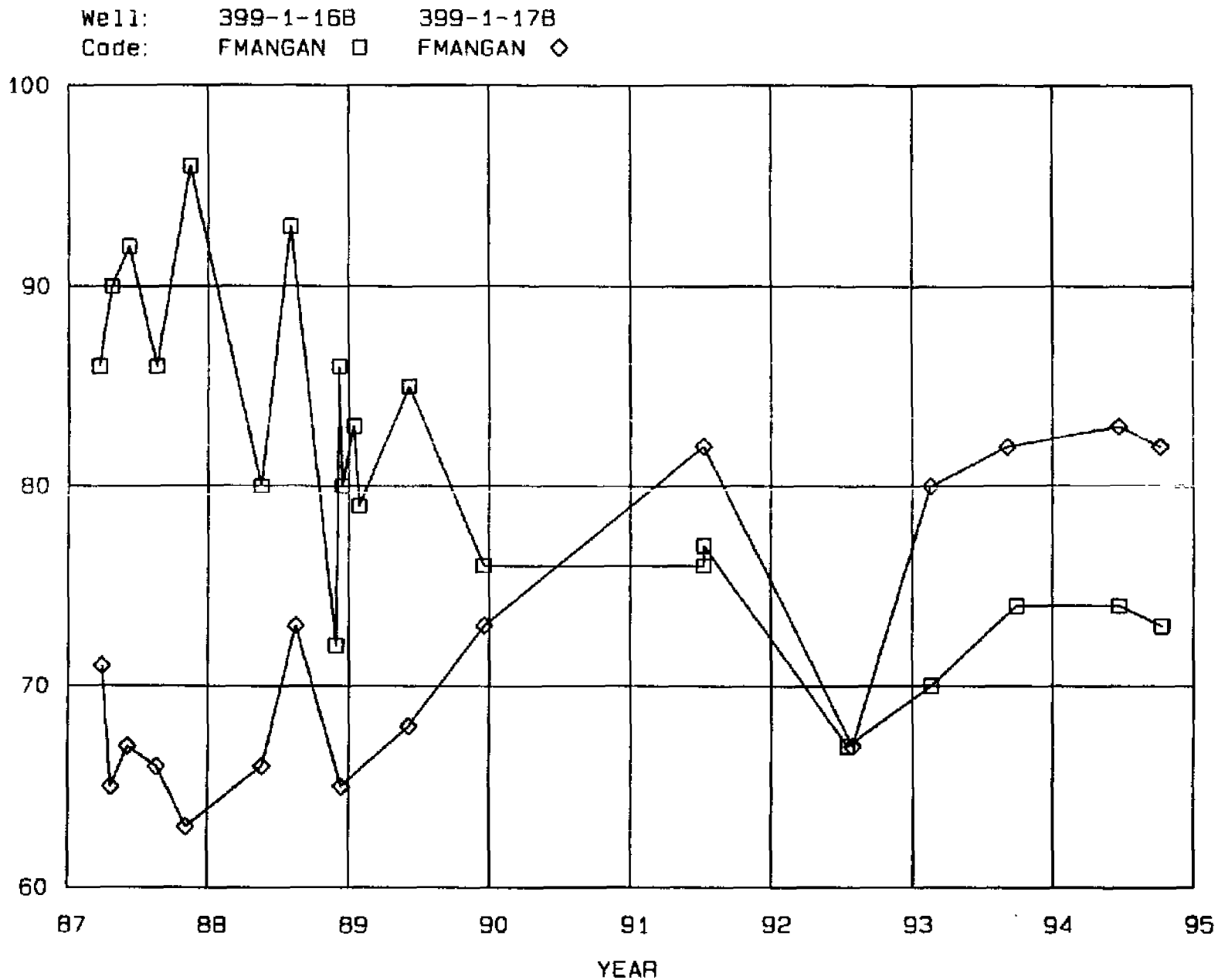
Ethylbenzene (MCL = 700 ppb)

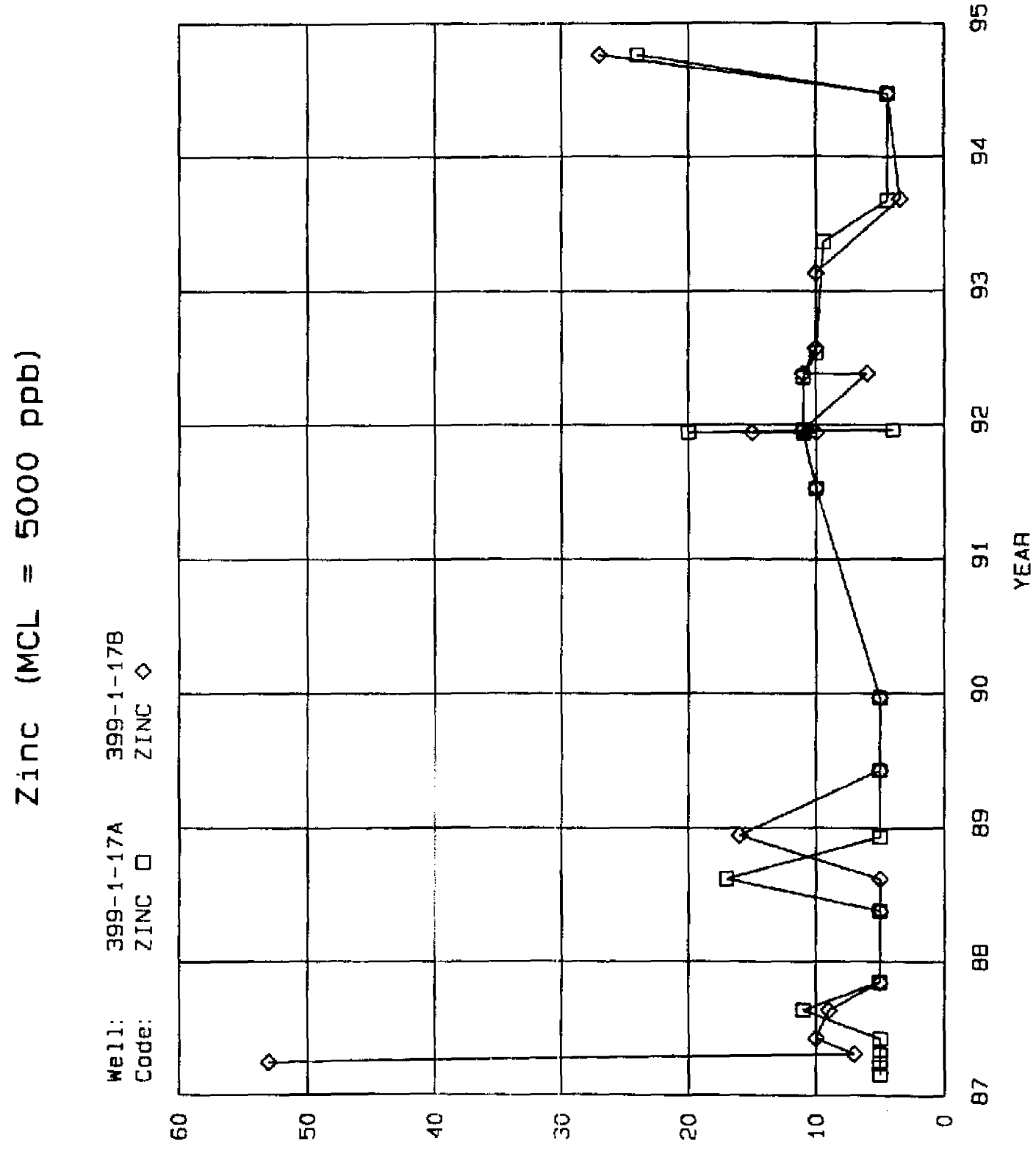



Iron (MCL = 300 ppb)
Well: 399-1-16B 399-1-17B
Code: FIRON □ FIRON ◇
600
500
400
300
200
100
0
MEASUREMENT (ppb)
87
88
89
90
91
92
93
94
95
YEAR

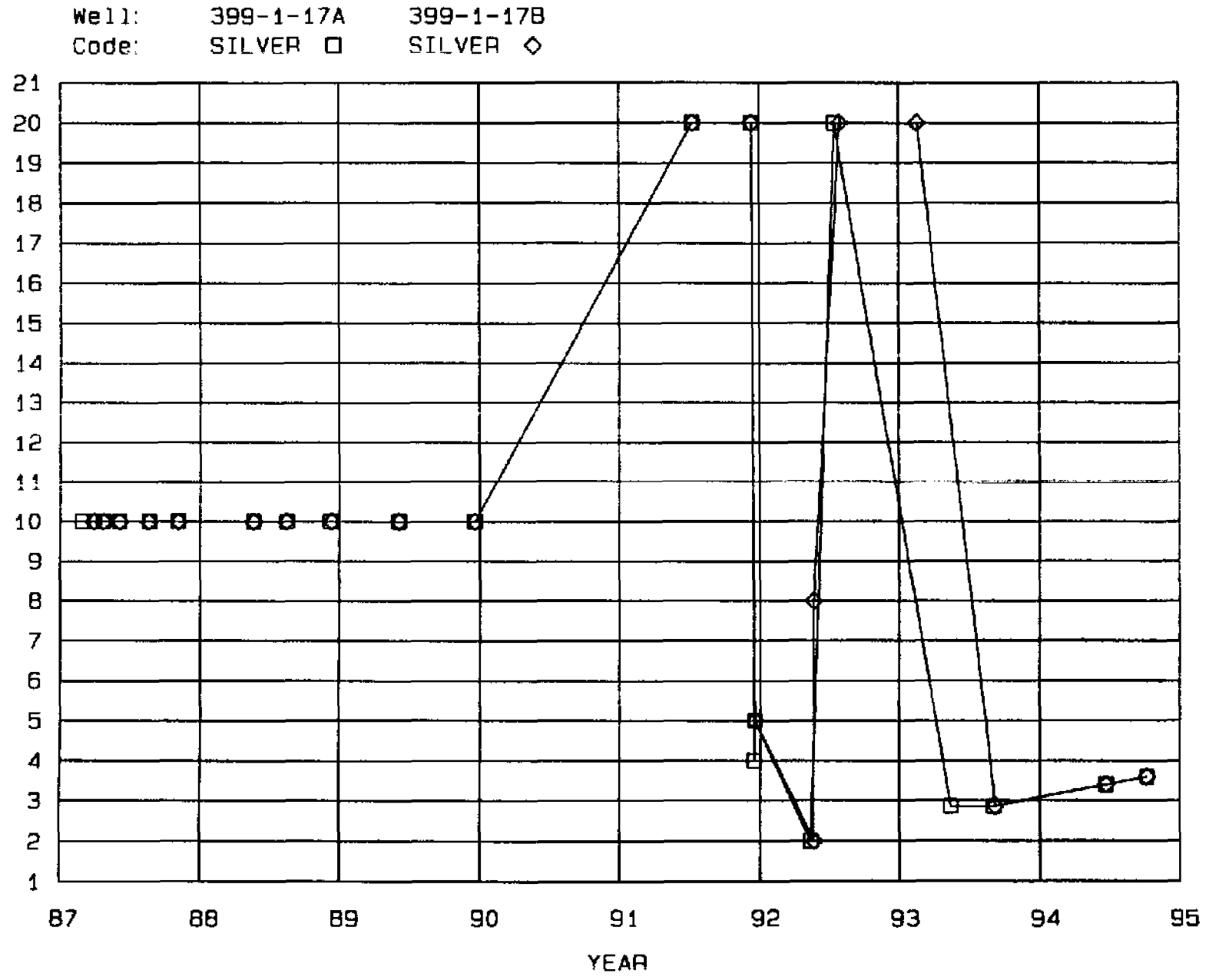

Lead (MCL = 50 ppb)
Well: 399-2-1 399-3-10
Code: LEAD □ LEAD ◇
MEASUREMENT (ppb)
100
90
80
70
60
50
40
30
20
10
0
85
86
87
88
89
90
91
92
93
94
95
YEAR

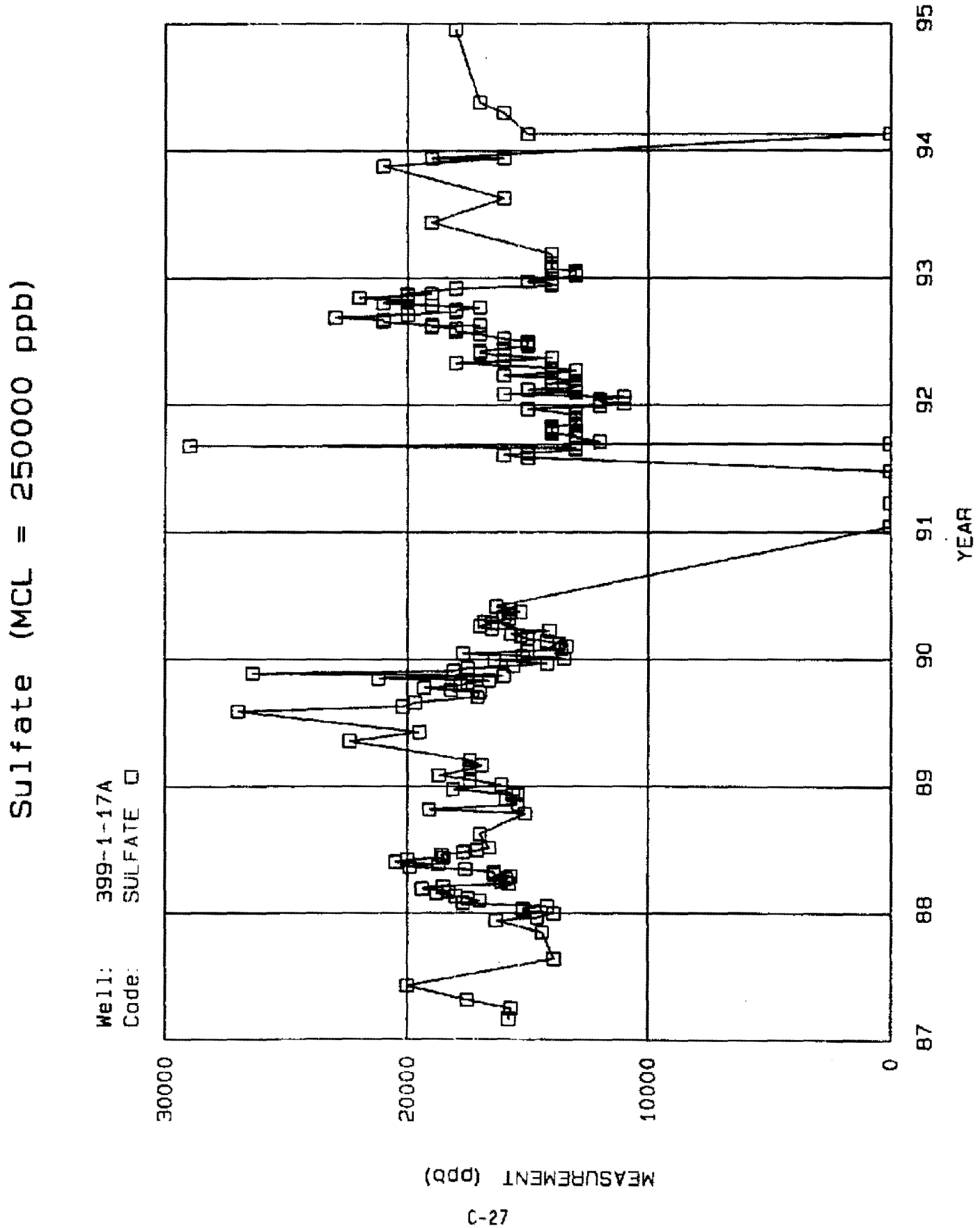
Manganese (MCL = 50 ppb)



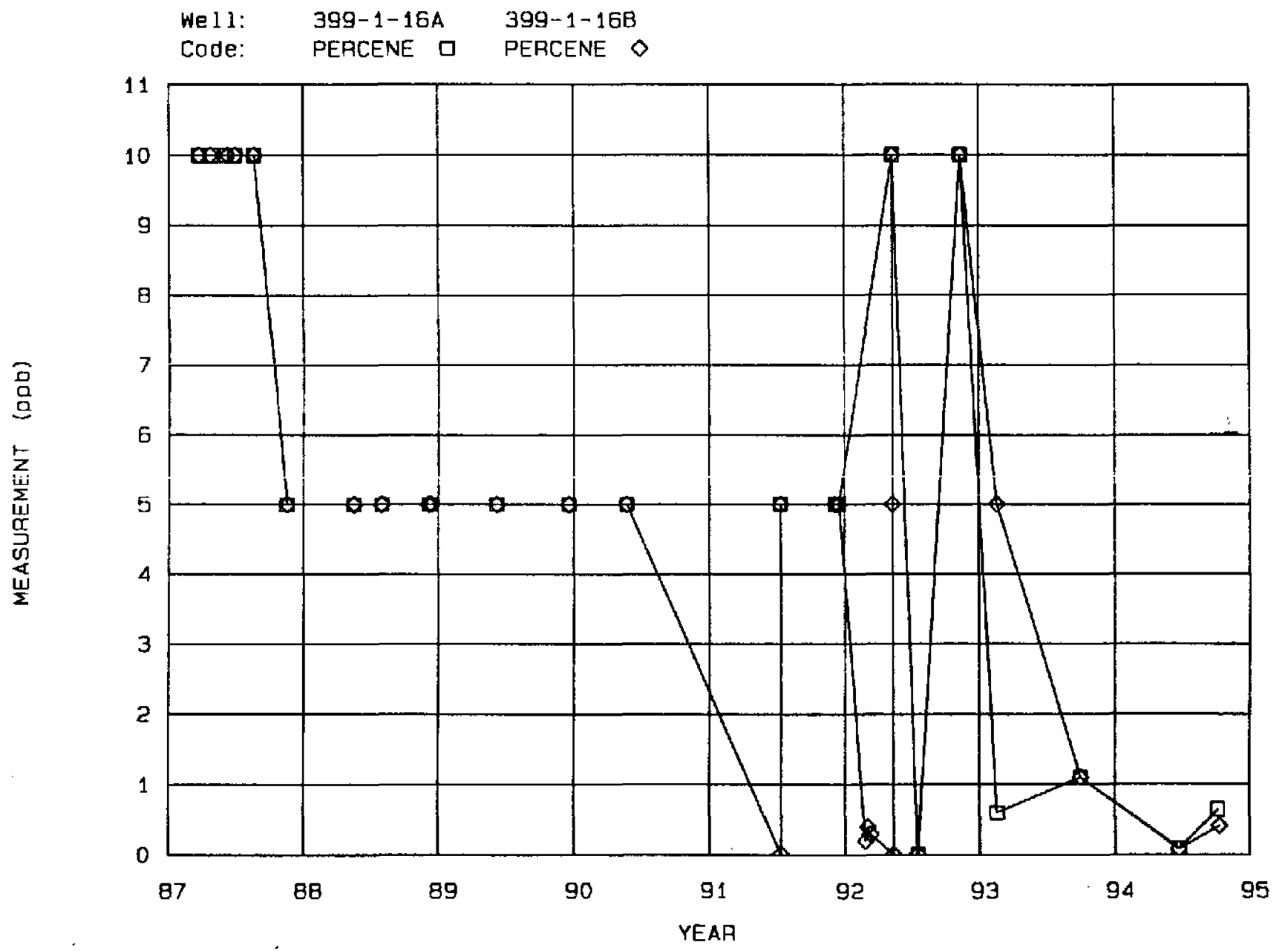

Zinc (MCL = 5000 ppb)
Well: 399-1-17A 399-1-17B
Code: ZINC □ ZINC ◇
MEASUREMENT (ppb)
60
50
40
30
20
10
0
87
88
89
90
91
92
93
94
95
YEAR

Silver (MCL = 50 ppb)

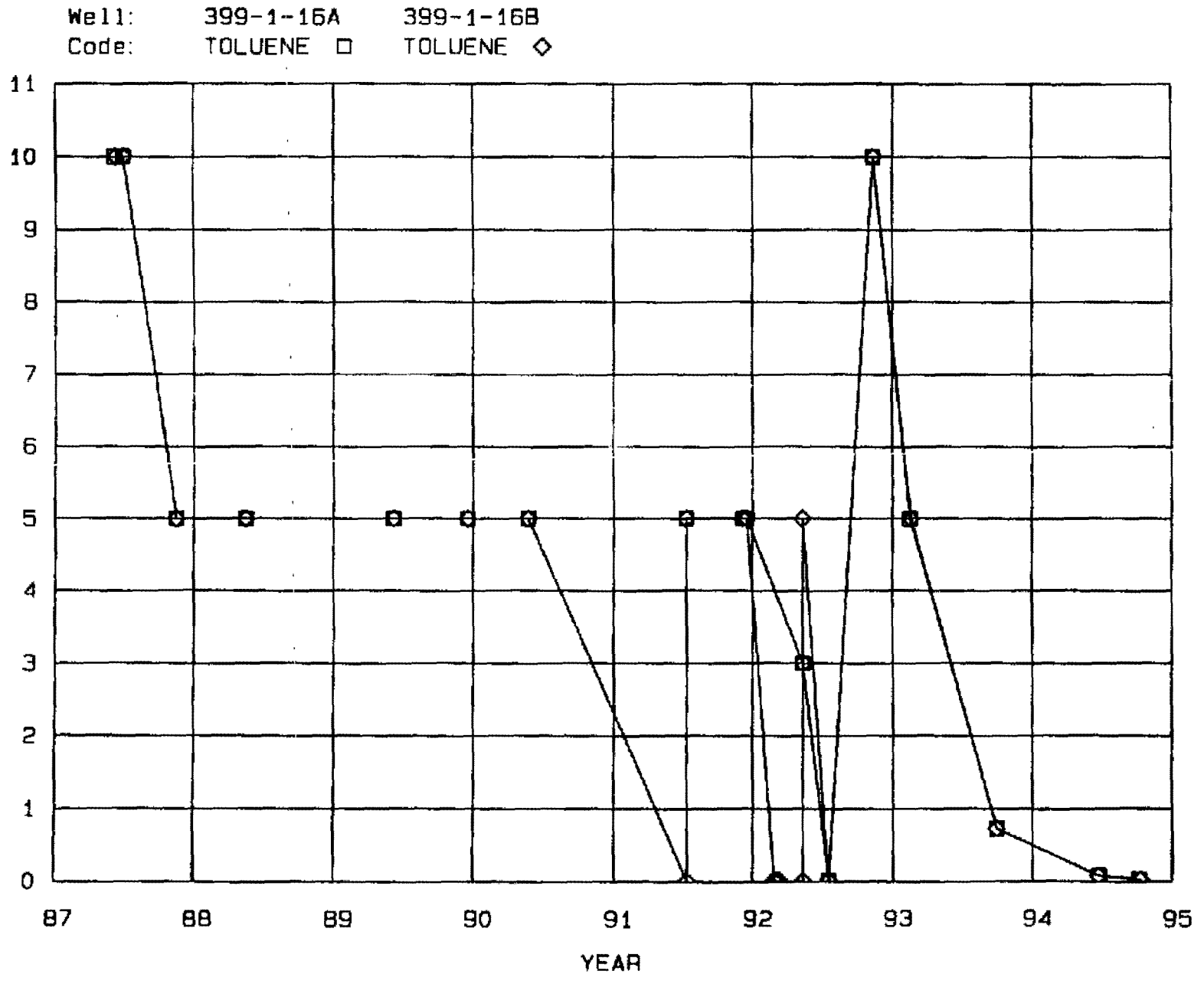


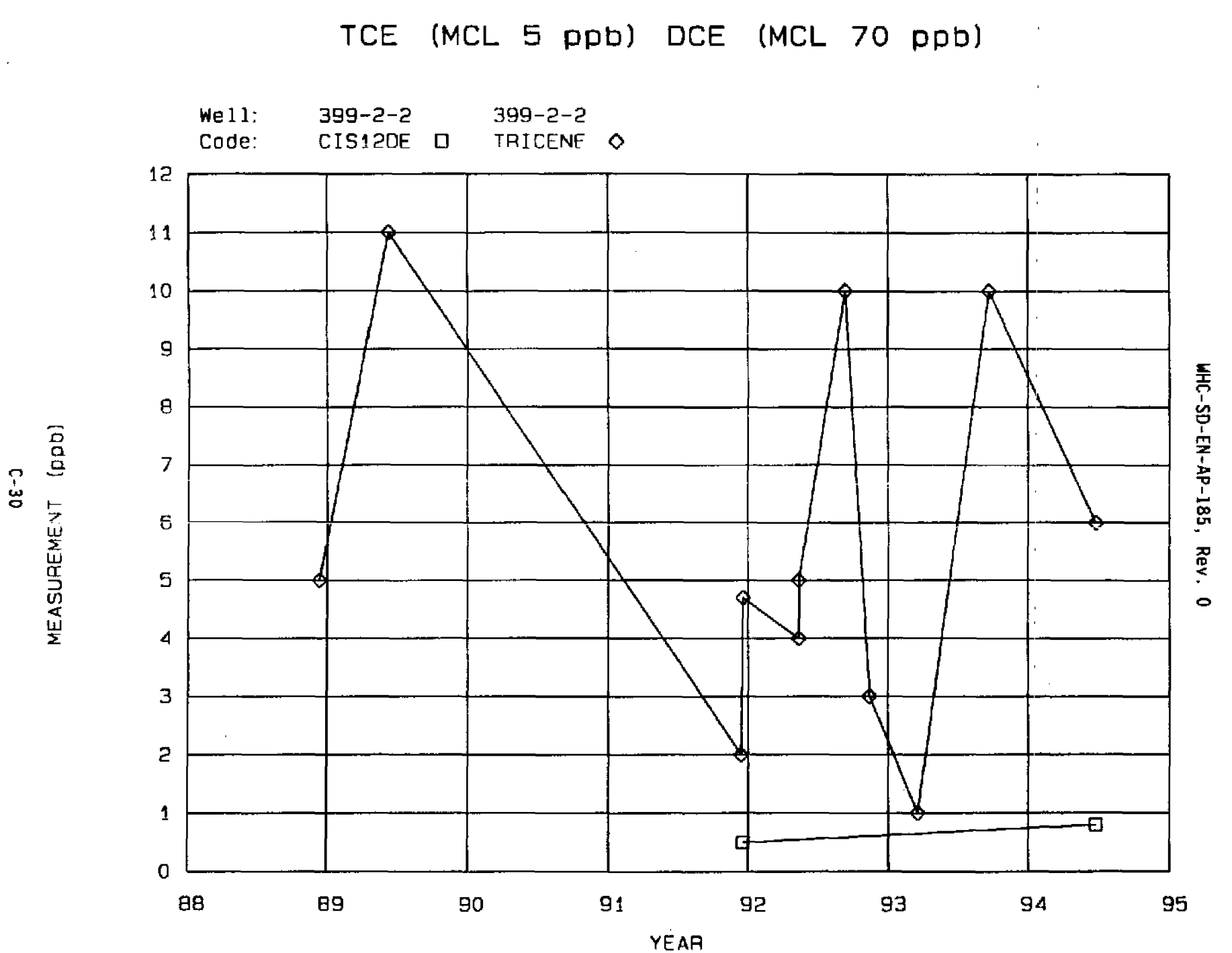

Sulfate (MCL = 250000 ppb)
Well: 399-1-17A
Code: SULFATE □
30000
20000
10000
0
MEASUREMENT (ppb)
87
88
89
90
91
92
93
94
95
YEAR

Tetrachloroethene (MCL = 5 ppb)

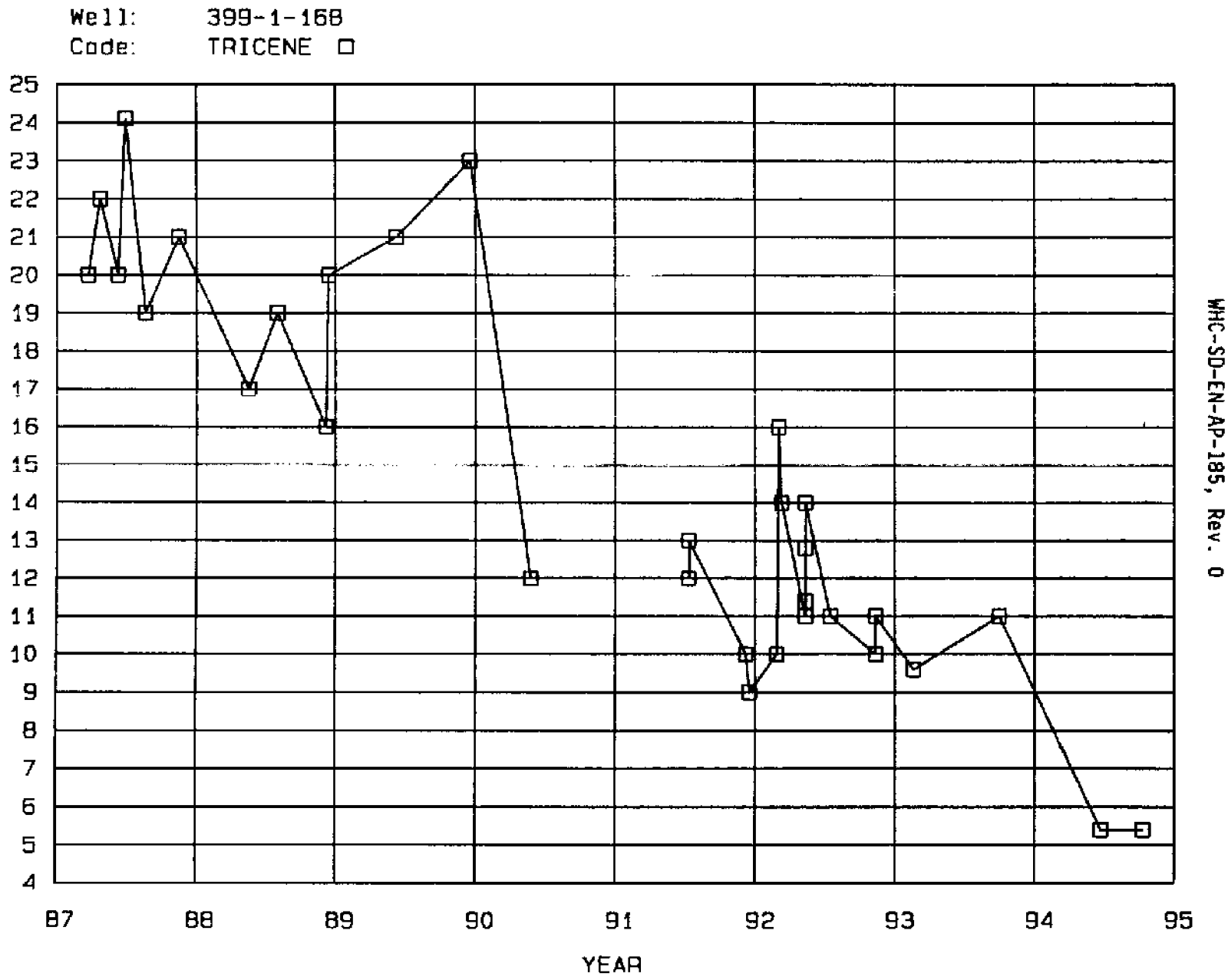


Toluene (MCL = 1000 ppb)

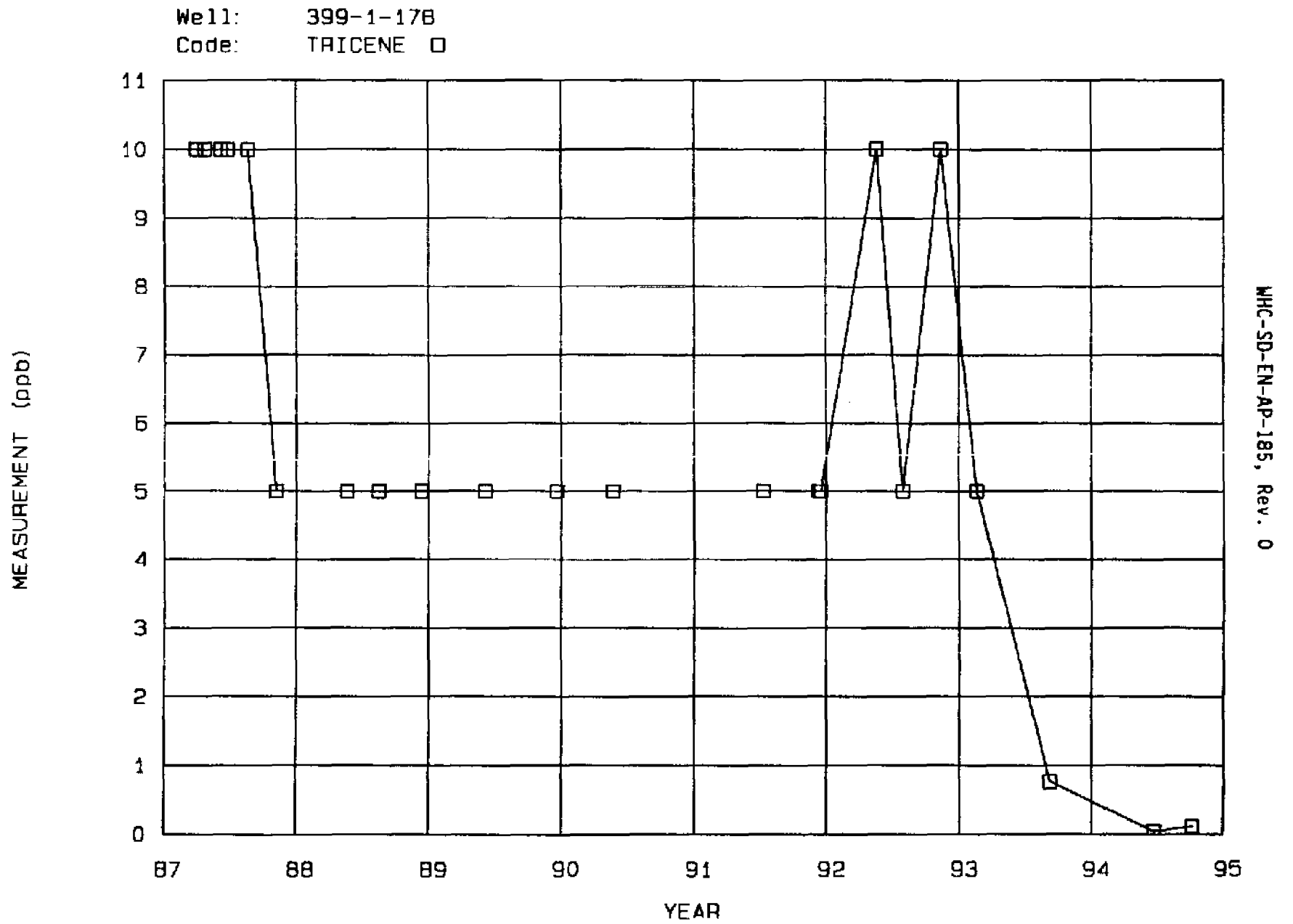


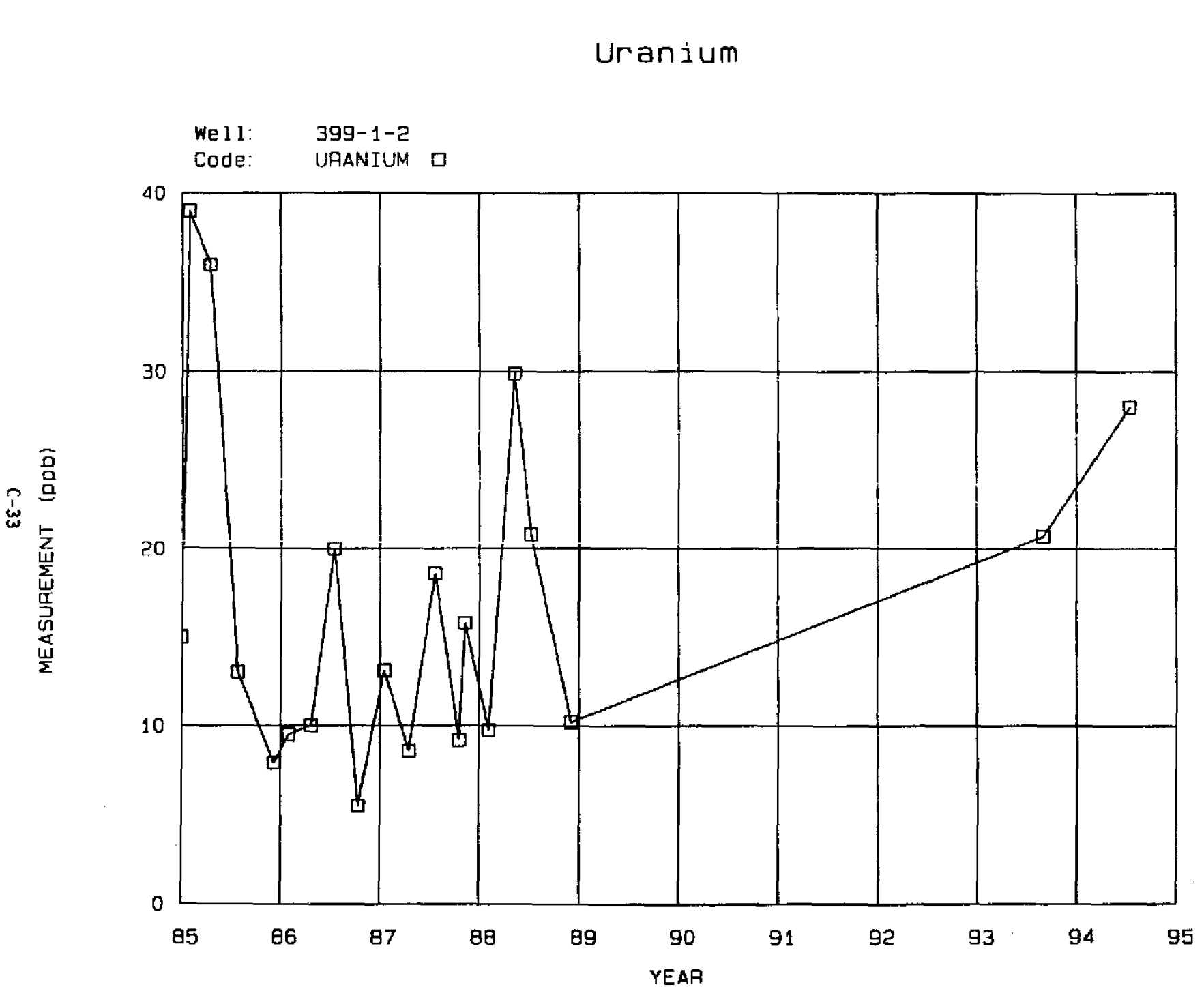

TCE (MCL 5 ppb) DCE (MCL 70 ppb)
Well: 399-2-2 399-2-2
Code: CIS12DE TRICENE
12
11
10
9
8
7
6
5
4
3
2
1
0
88
89
90
91
92
93
94
95
YEAR
MEASUREMENT (ppb)

Trichloroethene MCL = 5 ppb

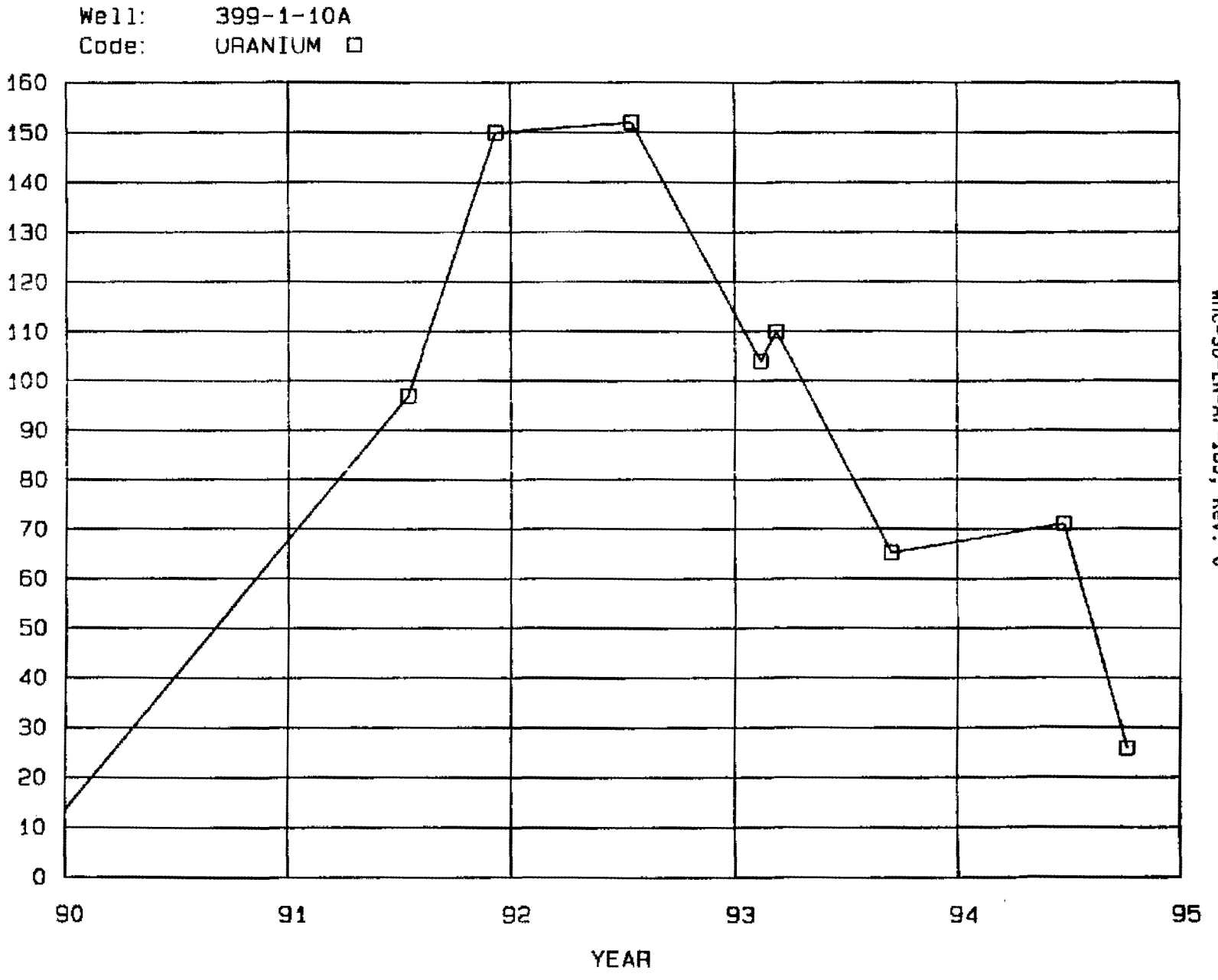


Trichloroethene (MCL = 5 ppb)

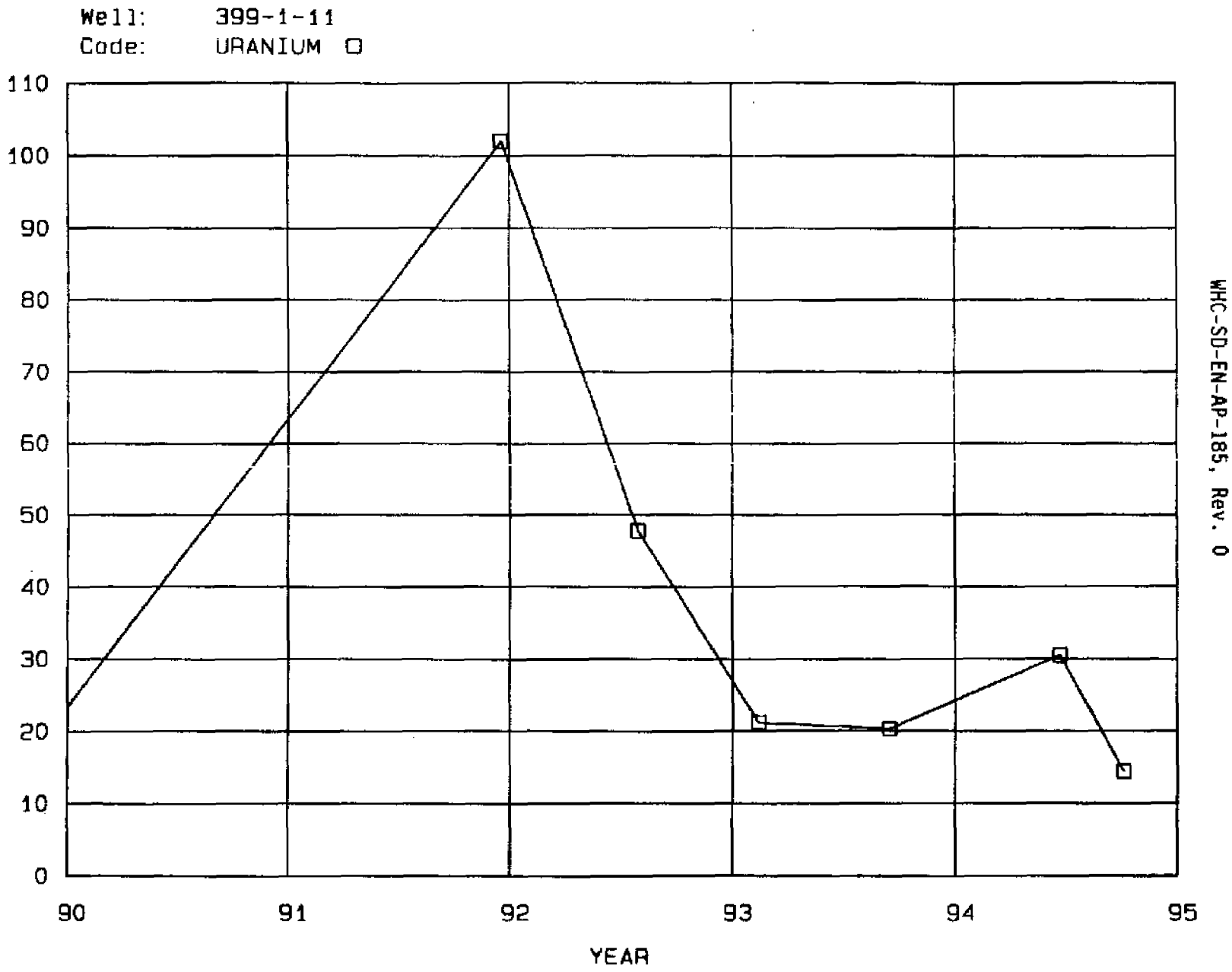


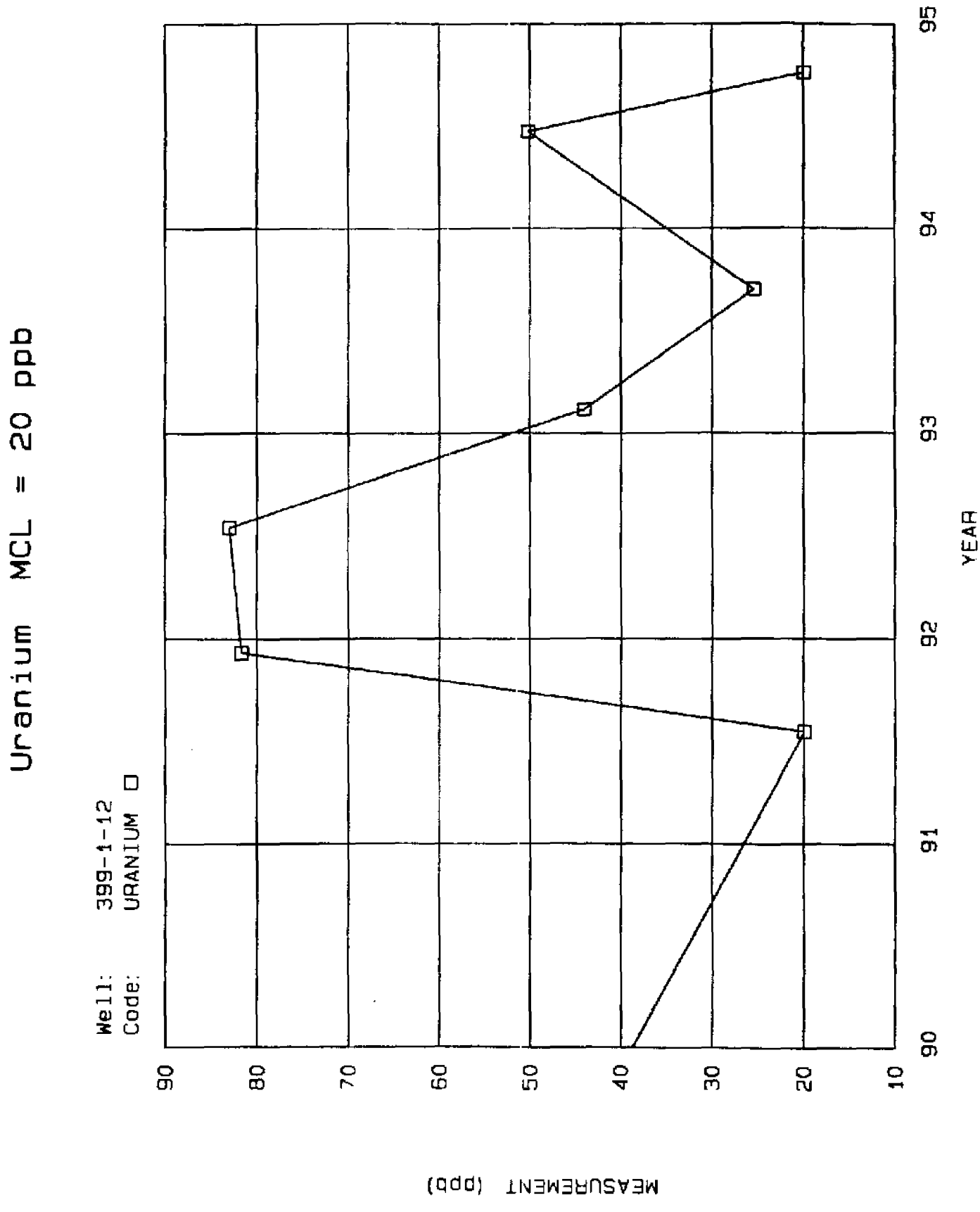

Uranium
Well: 399-1-2
Code: URANIUM
40
30
20
10
0
85
86
87
88
89
90
91
92
93
94
95
YEAR
MEASUREMENT (ppb)

Uranium MCL = 20 ppb

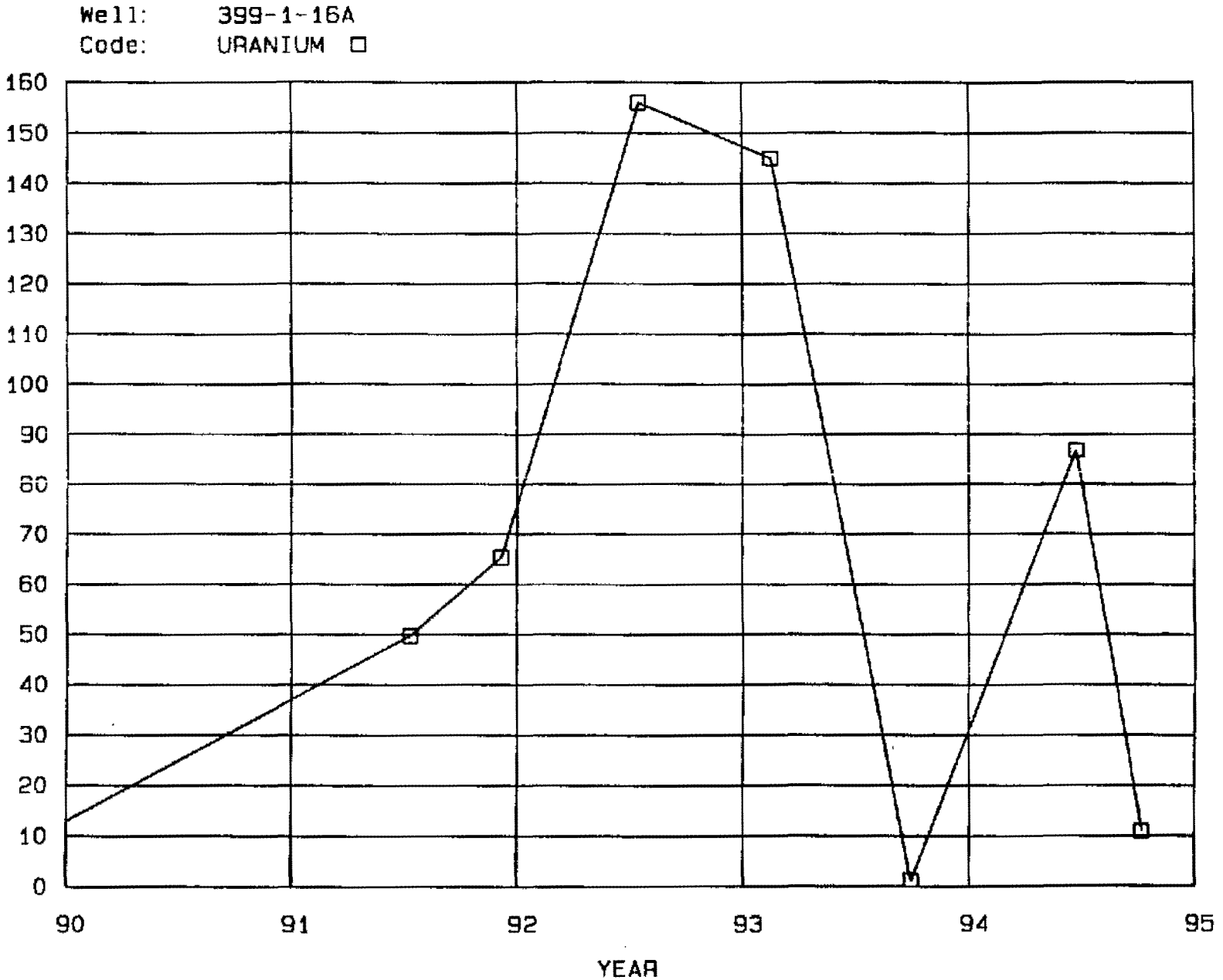


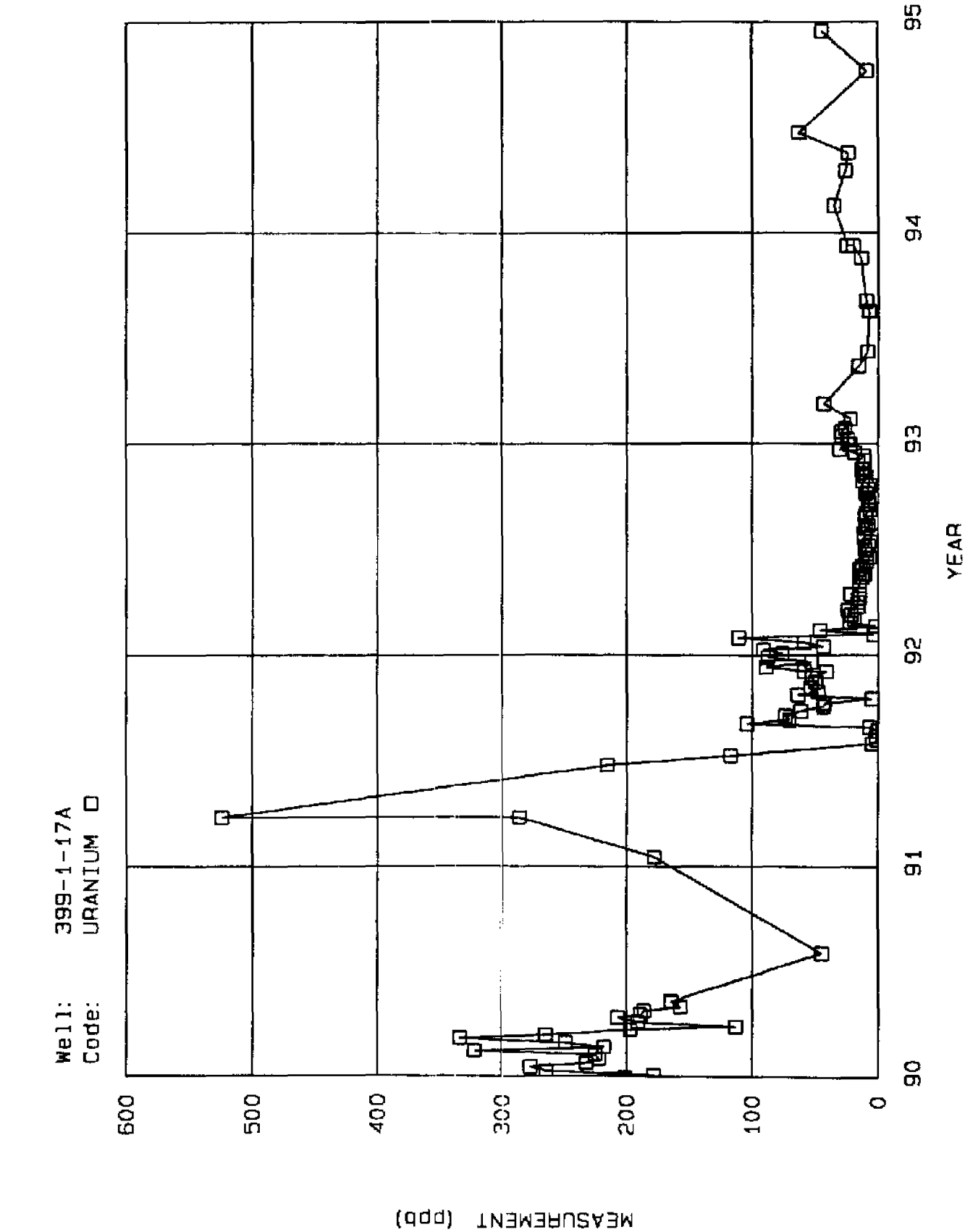
Uranium

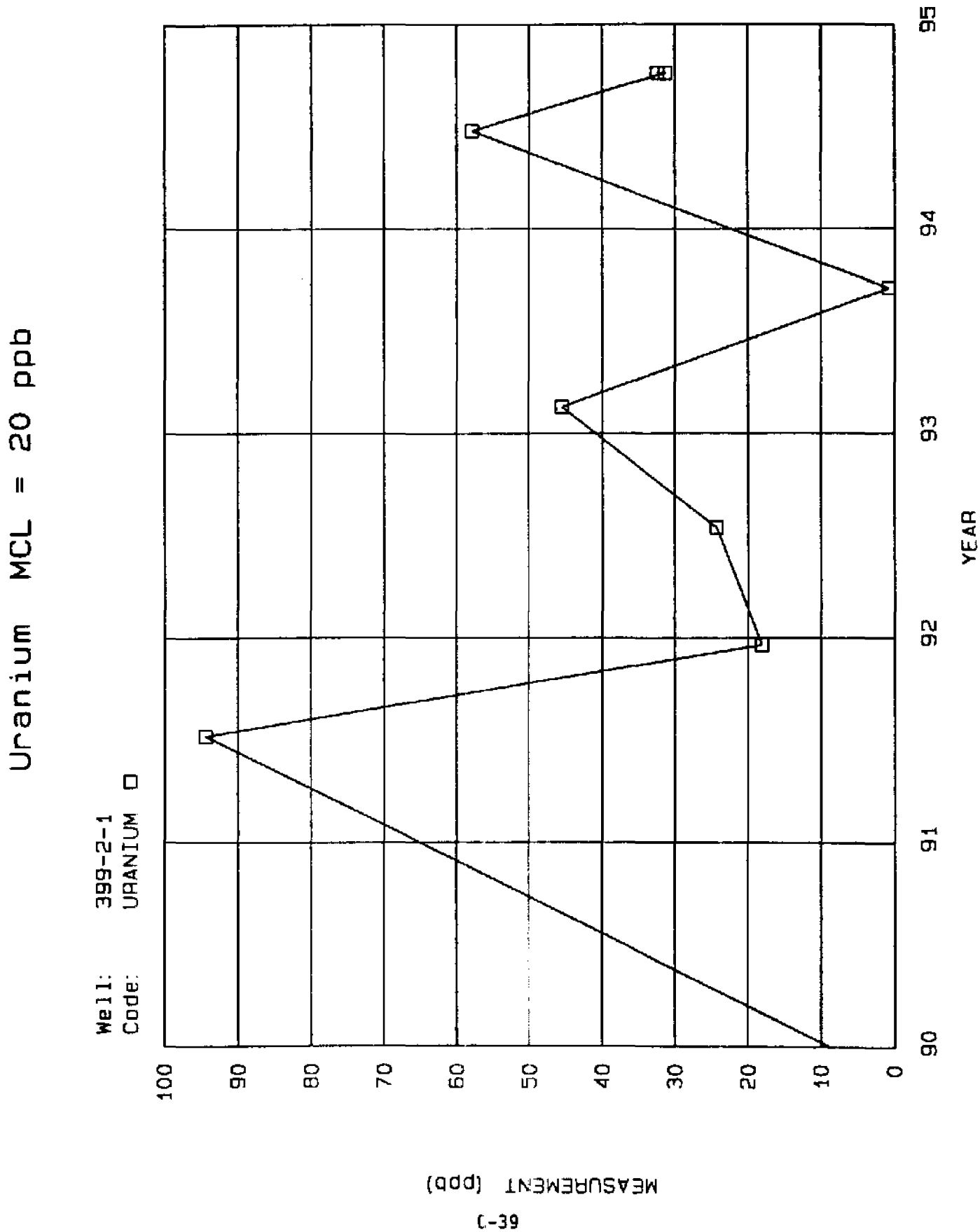

Well: 399-1-11
Code: URANIUM
110
100
90
80
70
60
50
40
30
20
10
0
90
91
92
93
94
95
YEAR
MEASUREMENT (ppb)

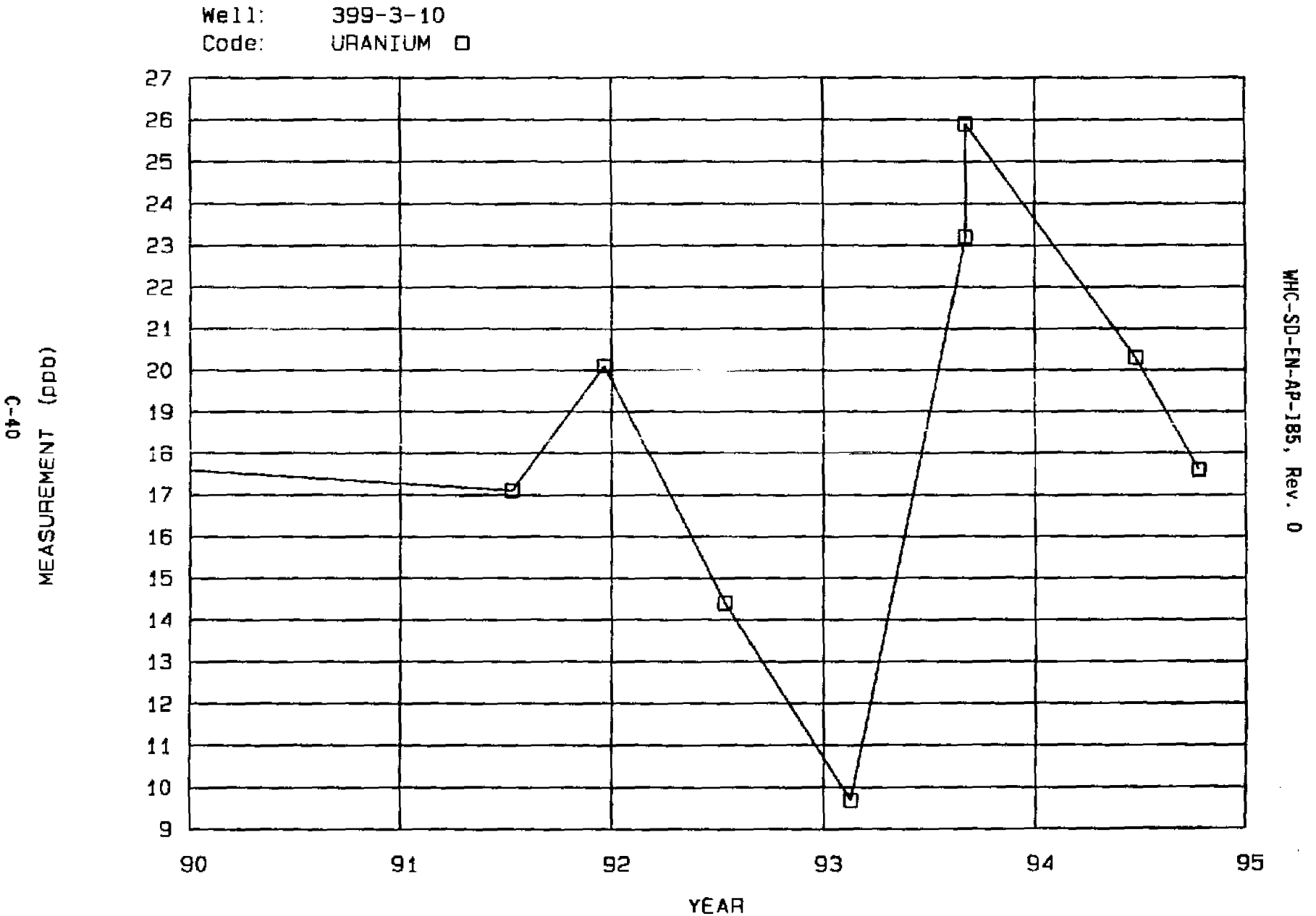

Uranium MCL = 20 ppb
Well: 399-1-12
Code: URANIUM □
MEASUREMENT (ppb)
90
80
70
60
50
40
30
20
10
90
91
92
93
94
95
YEAR

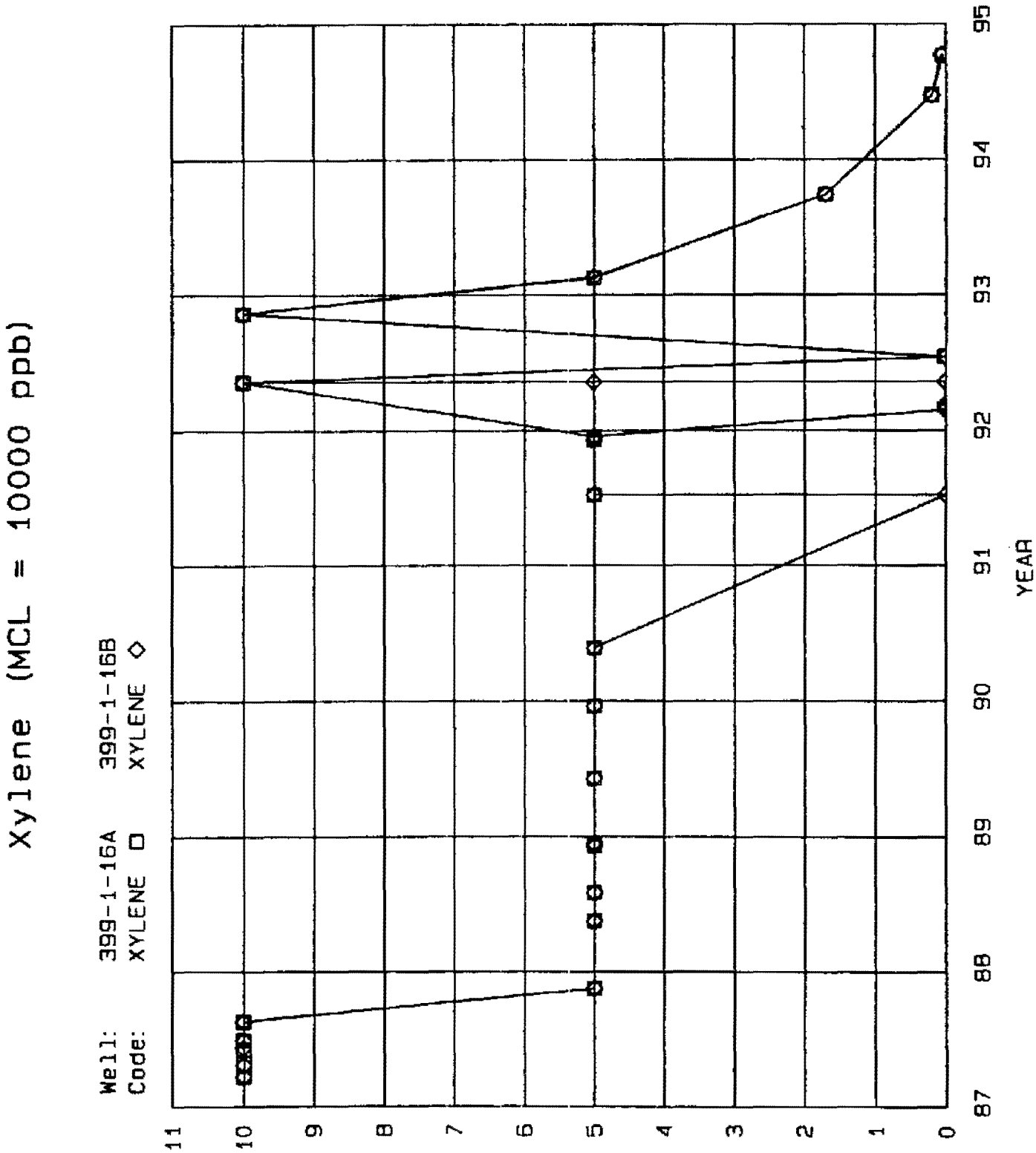
Uranium MCL = 20 ppb




Uranium MCL = 20 ppb
Well: 399-1-17A
Code: URANIUM D
600
500
400
300
200
100
0
MEASUREMENT (ppb)
90
91
92
93
94
95
YEAR


Uranium MCL = 20 ppb
Well: 399-2-1
Code: URANIUM D
MEASUREMENT (ppb)
100
90
80
70
60
50
40
30
20
10
0
90
91
92
93
94
95
YEAR


Uranium MCL = 20 ppb
Well: 399-3-10
Code: URANIUM
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
MEASUREMENT (ppb)
90
91
92
93
94
95
YEAR
WHC-SD-EN-AP-185, Rev. 0
C-40


Xylene (MCL = 10000 ppb)
Well: 399-1-16A 399-1-16B
Code: XYLENE □ XYLENE ◇
MEASUREMENT (ppb)
0
1
2
3
4
5
6
7
8
9
10
11
87
88
89
90
91
92
93
94
95
YEAR

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APPENDIX D

WELL CONSTRUCTION AND COMPLETION SUMMARIES

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WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Supply 300 Area Water
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 13Nov86
Date Complete: 22Nov86

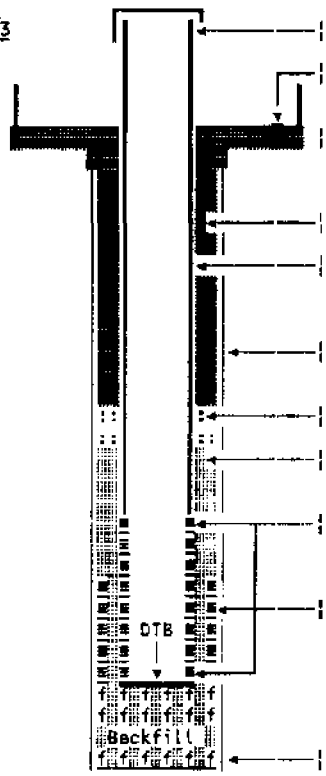
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:

WELL NUMBER: 399-1-10A
TEMPORARY WELL NO: S-3
Hanford Coordinates: N/S S 22,293 E/W E 14,413
State RN 57,083.8 RE 16,018.6
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 371.94-ft Brass cap

Depth to water: 29.0-ft Nov86
(Ground surface) 29.4-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-10: Coarse to medium SAND
10-20: Sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, sandy PEBBLES



Elevation of reference point: [373.65-ft]
(top of casing)
Height of reference point above ground surface [1.71-ft]

Depth of surface seal [0-13.5-ft]
Type of surface seal:
Portland cement 4-ft x 4-ft x 6-in(nom) extending 3-ft into annulus.
Bentonite crumbles to 13.5-ft

6-in ID stainless steel casing, +1.7-24.5-ft

Hole diameter, 0-45.0-ft, 11-in nominal

Volclay bentonite pellets, 13.5-18.5-ft

Silica sand pack, 18.5-39.5-ft, 8-12-mesh

6-in stainless steel screen 24.5-39.5-ft, #40-slot

10-in telescoping screen, 29.5-39.5-ft

DTB=Depth to bottom, 39.1-ft, 12Feb92

Borehole drilled depth: [45.0-ft]

Drawing By: RKL/3-01-10A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Raw water
Driller's Name: D Rossman
Drilling Company: Kaiser Engineers
Date Started: 06Sep91

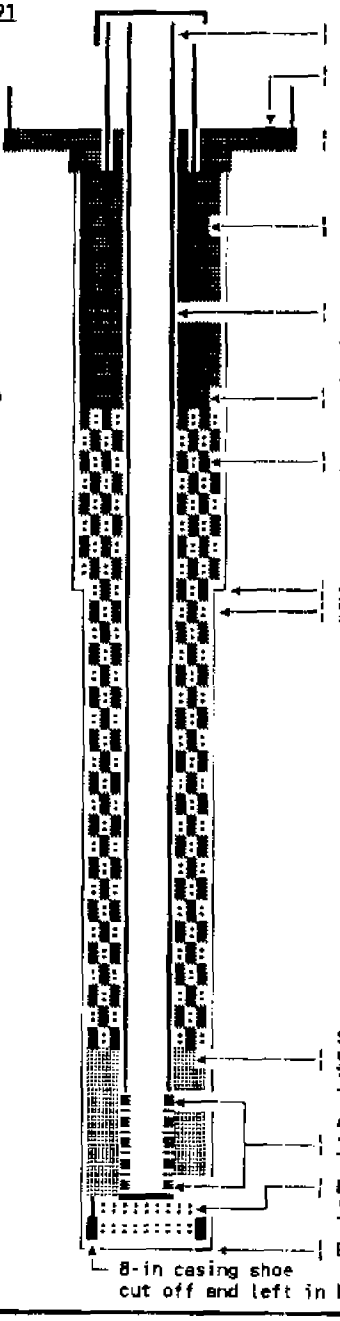
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 08Oct91

WELL NUMBER: 399-1-10B
TEMPORARY WELL NO: 1-10B
Hanford Coordinates: N/S Not documented E/W Not doc
State NAD83 RN 57,067.3 RE 16,033.3
Coordinates: N 116,729.06m E 594,351.09m
Start Card #: Not documented T ___ R ___ S ___
Elevation Ground surface: 372.47-ft Brass cap

Depth to water: 37.7-ft 08Oct91 (Ground surface)

GENERALIZED Geologist's STRATIGRAPHY Log

0-8: SAND
8-10: Silty SAND
10-35: Gravelly silty SAND
35-39.4: Sandy GRAVEL
39.4-49.6: Gravelly SAND
49.6-54.7: Sandy GRAVEL
54.7-72: Gravelly SAND
72-73: SILT
73-79.8: Gravelly SAND
79.8-80.1: Gravelly SILT
80.1-98: Gravelly SAND
98-109.8: Slightly gravelly SAND
109.8-113: Gravelly SAND
113-119: SILT



Elevation of reference point: [375.58-ft] (top of inner casing)
Height of reference point above ground surface [3.11-ft]
Depth of surface seal [0-20.3-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad extends 2.5-ft into annulus
Portland cement grout to 20.3-ft
4-in ID T304 stainless steel casing, +1.5-104.5-ft
Bentonite crumbles, 20.3-28.2-ft
Bentonite slurry, 28.2-99.0-ft
Hole diameter, 0-53.0-ft, 10.95-in
53.0-119.0-ft, 8.8-in
Silica sand pack, 99.0-100.8-ft, 40-100-mesh
100.8-114.4-ft, 20-40-mesh
4-in T304 stainless steel screen, 104.5-114.5-ft, #10-slot
Bentonite hole plug, 115.3-119.0-ft
Borehole drilled depth: [119.0-ft]
8-in casing shoe cut off and left in hole, ~117.0-119.0-ft

Drawing By: RKL/3-01-10B.ASB
Date : 31Jan94
Reference : HANFORD WELLS WHC-SD-EN-TI-052

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Supply
Driller's Name: Amos
Drilling Company: Associated Drillers
Date Started: 01Dec86

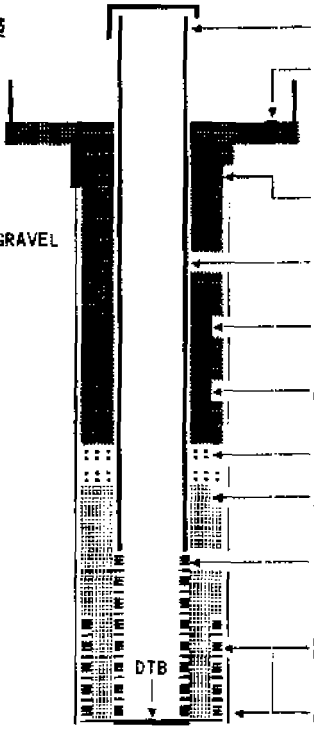
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1224
Company Location:
Date Complete: 04Dec86

WELL NUMBER: 399-1-16A
TEMPORARY WELL NO: C-1A
Hanford Coordinates: N/S S 23,341 E/W E 14,304
State RN 56,035.6 RE 15,910.1
Coordinates: N Not documented E Not documented
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 380.21-ft Brass cap

Depth to water: 40.0-ft Dec86
(Ground surface) 38.1-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-15: Silty, sandy GRAVEL
15-20: Clayey, sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, gravelly SAND
35-45: Silty SAND with CLAY and GRAVEL
45-TD: Silty, gravelly SAND



Elevation of reference point: [381.51-ft]
(top of casing)
Height of reference point above ground surface [1.30-ft]

Depth of surface seal [0-5.0-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 5.0-ft

6-in ID stainless steel casing,
+1.3-32.5-ft

Bentonite crumbles,
5.0-21.0-ft

Hole diameter,
0-47.5-ft, 11-in nominal

Bentonite pellets,
21.0-24.8-ft

Silica sand pack,
24.8-47.5-ft, 10-20-mesh

6-in stainless steel screen,
32.5-47.5-ft, #20-slot

10-in telescoping screen,
37.5-47.5-ft, #40-slot

Borehole drilled depth: [47.5-ft]

DTB=Depth to bottom,
47.8-ft, 04Dec90

Drawing By: RKL/3-01-16A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

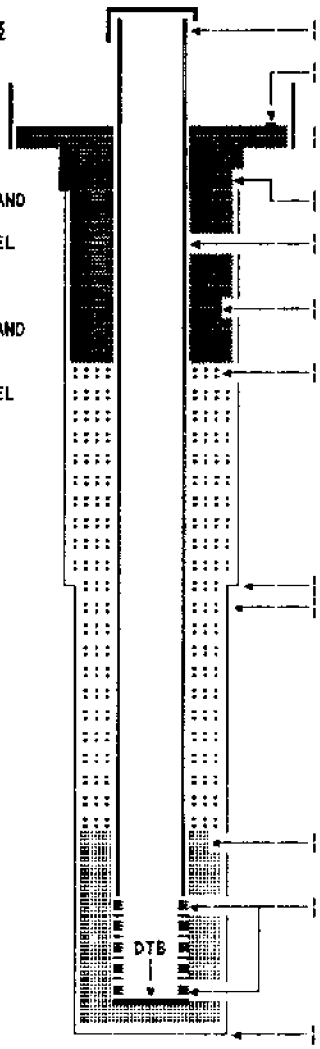
Drilling Method: Cable tool
Drilling Fluid Used: Supply 300 Area Water
Driller's Name: Cordon/Amos
Drilling Company: Associated Drillers
Date Started: 29Jan87
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1517/1224
Company Location:
Date Complete: 10Feb87

WELL NUMBER: 399-1-168
TEMPORARY WELL NO: C-1D
Hanford Coordinates: N/S S 23,350 E/W E 14,326
State RN 56,026.9 RE 15,951.6
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 380.03-ft Brass cap

Depth to water: 37.5-ft Feb87
(Ground surface) 37.8-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-10: Sandy GRAVEL
10-35: Silty, sandy GRAVEL
35-45: Gravelly, silty, clayey SAND
45-60: Silty, sandy GRAVEL
60-65: Clayey, silty, sandy GRAVEL
65-75: Silty, gravelly SAND
75-80: Silty, sandy GRAVEL
80-85: Clayey, sandy GRAVEL
85-90: Gravelly, silty, clayey SAND
90-95: Sandy GRAVEL
95-110: Silty, sandy GRAVEL
110-TD: Clayey, silty sandy GRAVEL



Elevation of reference point: [381.14-ft] (top of casing)
Height of reference point above ground surface [1.11-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal:
4-ft x 4-ft surface pad
Cement to 5.0-ft
6-in ID stainless steel casing, +1.1-105.0-ft
Bentonite crumbles, 5.0-26.0-ft
Volclay tablets, 26.0-99.7-ft
Hole diameter,
0-60.0-ft, 13-in nominal
60.0-118.0-ft, 11-in nominal
Silica sand pack, 99.7-118.0-ft, 8-12-mesh
6-in stainless steel screen, 105.0-115.0-ft, #20-slot
Borehole drilled depth: [118.0-ft]

DTB=Depth to bottom, 115.5-ft, 03Dec90

Drawing By: RKL/3-01-168.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 08Nov86 Date Complete: 13Nov86

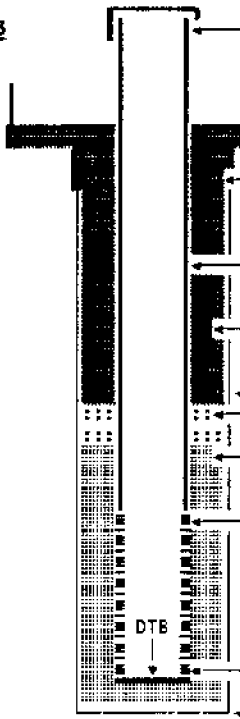
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:

WELL NUMBER: 399-1-17A
TEMPORARY WELL NO: C-2A
Hanford Coordinates: N/S S 23,331 E/W E 13,630
State RN 56,045.7 RE 15,236.2
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.13-ft Brass cap

Depth to water: 32.3-ft Nov86
(Ground surface) 33.2-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-10: Sandy GRAVEL
10-25: Silty, sandy GRAVEL
25-35: Silty, gravelly SAND
35-40: Silty SAND



Elevation of reference point: [377.47-ft]
(top of casing)
Height of reference point above ground surface [2.3-ft]

Depth of surface seal [0-5.0-ft]
Type of surface seal:
4-ft x 4-ft concrete pad.
Cement to 5.0-ft

6-in ID stainless steel casing,
5.0-25.0-ft

Bentonite crumbles,
5.0-19.4-ft

Hole diameter,
0-41.0-ft, 11-in nominal

Volclay bentonite pellets,
19.4-21.6-ft

Silica sand pack,
21.6-41.0-ft

6-in stainless steel screen,
25.0-40.0-ft, #40-slot

Borehole drilled depth: [41.0-ft]

DTB=Depth to bottom,
41.5-ft, 03Dec90

Drawing By: RKL/3-01-17A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 01Dec86

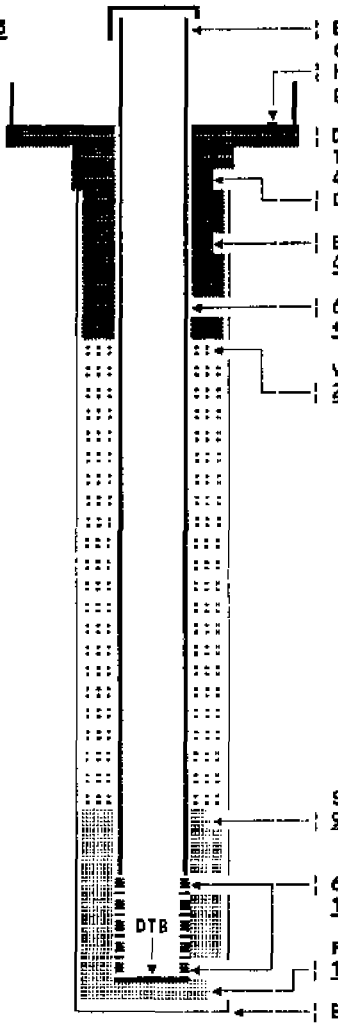
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1517
Company Location:
Date Complete: 19Dec86

WELL NUMBER: 399-1-17B
TEMPORARY WELL NO: C-2B
Hanford Coordinates: N/S S 23,317 E/W E 13,604
State Coordinates: N RN 56,059.5 E RE 15,210.3
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.48-ft Brass cap

Depth to water: 32.9-ft Dec86
(Ground surface) 33.3-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-5: Silty SAND
5-15: Silty, sandy PEBBLES
15-25: Sandy PEBBLES
25-30: Gravelly SAND
30-35: Sandy GRAVEL
35-40: Sandy PEBBLES
40-55: Sandy GRAVEL
55-70: Silty, sandy GRAVEL
70-85: Sandy GRAVEL
85-90: Silty, sandy GRAVEL
90-95: Sandy GRAVEL
95-105: Silty, sandy GRAVEL
105-110: Silty, gravelly SAND
110-115: Sandy, gravelly CLAY



Elevation of reference point: [377.87-ft]
(top of casing)
Height of reference point above ground surface [2.39-ft]

Depth of surface seal [0-4.0-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 4.0-ft

Bentonite crumbles,
4.0-28.0-ft

6-in ID stainless steel casing,
+2.4-100.0-ft

Volclay tablets,
20.8-95.0-ft

Silica sand pack,
95.0-113.5-ft, 8-12-mesh

6-in stainless steel screen, [100.0-ft]
100-110-ft, #40-slot

Fill,
113.5-115.0-ft

Borehole drilled depth: [115.0-ft]

DTB=Depth to bottom,
110.2-ft, 03Dec90

Drawing By: RKL/3-01-17B.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

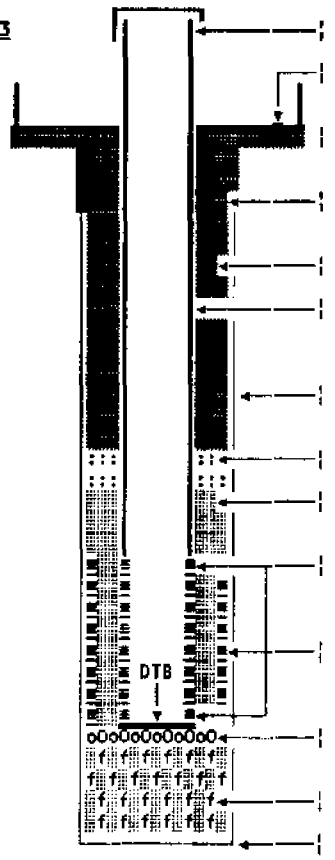
Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 06Nov86
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 12Nov86

WELL NUMBER: 399-1-18A
TEMPORARY WELL NO: C-3A
Hanford Coordinates: N/S N 20,407 E/W E 12,877
State RN 58,970.1 RE 14,483.3
Coordinates: N 384,928 E 2,308,254
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 387.77-ft Brass cap

Depth to water: 47.0-ft Nov86
(Ground surface) 44.9-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-5: No record
5-15: Silty SAND
15-35: Gravelly SAND
35-45: Silty, gravelly SAND
45-60: Gravelly SAND with trace of SILT
60-TD: Sandy GRAVEL with trace of SILT and CLAY



Elevation of reference point: [390.83-ft]
(top of casing)
Height of reference point above ground surface [3.06-ft]

Depth of surface seal [0-5.5-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 5.5-ft

Bentonite crumbles,
5.5-31.8-ft

6-in ID stainless steel casing,
+3.1-39.0-ft

Hole diameter,
0-63.0-ft, 11-in nominal

Volclay bentonite pellets,
31.8-34.0-ft

Silica sand pack,
34.0-54.0-ft, 8-12-mesh

6-in stainless steel screen,
39.0-54.0-ft, #40-slot

10-in telescoping screen,
39.0-54.0-ft

Gravel pack to 54.4-ft

Fill,
54.4-63.0-ft

Borehole drilled depth: [63.0-ft]

DTB=Depth to bottom,
53.8-ft, 06Nov90

Drawing By: RKL/3-01-18A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 13Nov86
Date Complete: 20Jan87

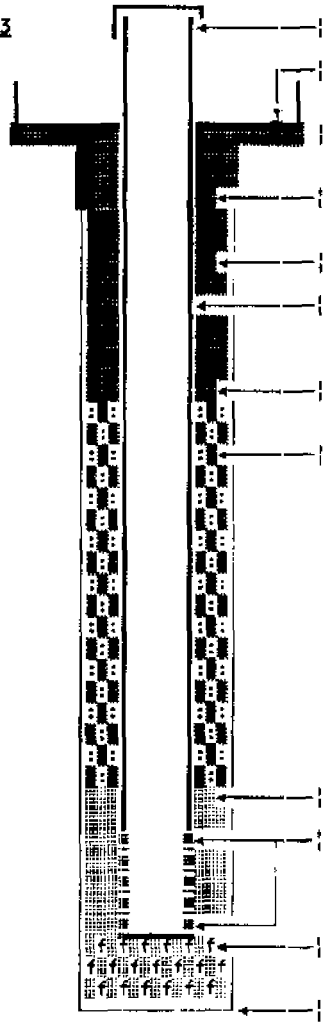
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:

WELL NUMBER: 399-1-188
TEMPORARY WELL NO: C-38
Hanford Coordinates: N/S S 20,420 E/W E 12,865
State RN 58,956.5 RE 14,470.8
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 387.24-ft Brass cap

Depth to water: 42.5-ft Jan87
(Ground surface) 44.0-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-5: Not documented
5-11: SAND
11-15: SAND and GRAVEL
15-25: Sandy GRAVEL
25-30: Silty, sandy GRAVEL
30-40: Sandy GRAVEL with trace of SILT
40-50: Silty, sandy GRAVEL
50-55: Pebbly SAND
55-60: Sandy, silty GRAVEL
60-65: Pebbly SAND
65-85: Silty, sandy GRAVEL
85-90: Sandy SILT
90-95: Silty, sandy GRAVEL
95-115: Sandy, silty GRAVEL
115-120: Silty, sandy GRAVEL
120-125: Sandy, clayey GRAVEL
125 : Sandy, gravelly CLAY



Elevation of reference point: [389.94 ft] (top of casing)
Height of reference point above ground surface [2.70-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad
Cement to 5.0-ft
Bentonite crumbles, 5.0-34.0-ft
6-in ID stainless steel casing, +2.7-108.5-ft
Hole diameter, 0-125.0-ft, 11-in nominal
Volclay grout, 34.0-105.0-ft
Silica sand pack, 105.0-118.0-ft, 8-12-mesh
6-in stainless steel screen, 108.5-118.5-ft, #40-slot
Fill, 118.0-125.0-ft
Borehole drilled depth: [125.0-ft]

Drawing By: RKL/3-01-188.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

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